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CONTACT DETAILS
Vincent Bignon, Banque de France
Email: vincent.bignon@banque-france.fr

Rui Esteves, University of Oxford
Email: rui.esteves@economics.ox.ac.uk

Alfonso Herranz-Loncán, University of Barcelona
Email: alfonso.herranz@ub.edu

Résumé

Les infrastructures ferroviaires ont été l'un des principaux moteurs de la croissance du commerce Latino-Américain avant 1914. Leur construction a souvent requis le soutien financier des gouvernements, et a donc dépendu de leurs ressources. Comme les ressources fiscales étaient principalement le produit des taxes à l'importation, ces économies ont été caractérisées par une boucle de rétroaction entre la capacité à générer des ressources fiscales et la taille du réseau de chemin de fer, créant ainsi la possibilité d'équilibres multiples. Les tests empiriques valident l'hypothèse d'une relation bidirectionnelle. Nous en concluons que la construction d'une capacité à lever les impôts et taxes était une condition nécessaire à l'expansion des infrastructures ferroviaires, et donc, du fait de la part de ce secteur dans ces économies, pour leur croissance économique. Ceci explique en partie les trajectoires de croissance divergentes entre pays d'Amérique Latine au 19ème siècle.

Codes J.E.L.: H54, N46, N76, O38, O54
Mots-clés : infrastructures, chemins de fer, Amérique Latine, Exportation, revenus fiscaux

Abstract

Railways were one of the main engines of the Latin American trade boom before 1914. Railway construction often required financial support from local governments, which depended on their fiscal capacity. But since the main government revenues were trade-related, this generated a two-way feedback between government revenues and railways with a potential for multiple equilibria. The empirical tests in this paper support the hypothesis of a positive two-way relationship. The main implication of our analysis is that the build-up of state capacity was a necessary condition for railway expansion and, given the importance of the export sector in these economies, for economic growth and divergence in the region.

J.E.L. codes: H54, N46, N76, O38, O54
KEYWORDS: Railways; Latin America; Export growth; Government revenues

Big Push or Big Grab?

Railways, Government Activism and Export Growth in Latin America, 1865-1913

Vincent Bignon[1]
Rui Esteves[2]
Alfonso Herranz-Loncán[3]

1. Introduction

State activism has often been identified as either a major force or a necessary condition for economic change in peripheral countries (Rosenstein-Rodan, 1943, 1961; Rostow, 1960; Gerschenkron, 1962; Murphy et al., 1989). This paper focuses on the role of states in the performance of Latin American economies during the first globalisation boom, through their effects on railway expansion. In the half century before 1914, Latin America as a whole experienced one of the fastest rates of economic growth in the world. According to Maddison's (2001) figures, the economies of the area grew well above the world average between 1870 and 1913, and their growth rate was comparable to that of the "Western Offshoots." To a large extent, this growth episode was triggered by the expansion of exports of primary products. Growth, however, was not equally shared by all Latin American economies. Although GDP per capita figures are available only for a handful of countries, and their reliability has often been questioned, they show a wide diversity of growth experiences.[4] Moreover, exports per capita, for which

[1] Banque de France, DGEI-DEMFI-Pomone 041-1422; email: vincent.bignon@banque-france.fr
[2] Department of Economics, University of Oxford; email: rui.esteves@economics.ox.ac.uk
[3] Department of Economic History and Institutions, University of Barcelona; email: alfonso.herranz@ub.edu

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[4] The yearly growth rates of the available Latin American GDP per capita estimates between 1870 and 1913 range from 0.2% (Brazil) to 2.3% (Argentina); data from Bértola and Ocampo (2010).

information is much more abundant, show even larger variation among countries, both in levels and in growth rates.[5]

One of the main variables explaining differences across countries in per capita exports (and, arguably, income) was railway development. The potential capacity of railways to transform the economies they served was much higher in Latin America than in the Western European countries, for two reasons. First, due to the scarcity of alternative transport infrastructure (especially waterways) in the region, railways often constituted the only available means to connect the hinterland with the international markets. Second, the growth of Latin American economies was mainly based on exports of natural resources. Therefore, for some authors, the growth potential of the region crucially depended on the spread of a good transport system throughout the largest possible portion of the territory. This has allowed Summerhill (2006: 297), for instance, to suggest that it "*seems unlikely that any other technological or institutional innovation was more important in the transition to economic growth in Latin America before 1930*".

Despite its high potential impact, railway investment did not spread evenly throughout the region. In many Latin American countries the development of rail transport was sluggish, the final network mileage was disappointingly low and, thus, the opportunity to take full advantage from the new technology might have been missed. Reasons behind that failure were diverse, but the literature has often stressed the essential role of governments' involvement in railway development. However, owing to the large dependence of Latin American governments on foreign trade taxes, public activism was limited in each country by the degree of trade openness. But, in turn, as has been indicated, the growth of exports often required the diffusion of the railway technology. This may have adversely affected some economies, and created a double feedback relation wherein railway construction depended on government revenues, these depended on export growth, and exports could only increase if the railway network expanded. Multiple equilibria were therefore a possibility, wherefore some Latin American countries were caught in a non-development trap in which foreign trade and government revenues did not grow enough due to insufficient railway development,

[5] In 1910-14, exports p.c. in the region, in thousand dollars of 1990, ranged from 17.7 (Ecuador) to 386.1 (Cuba). The yearly growth rate of exports p.c. between 1870 and 1913 went from -1.3% in Brazil to 5.8 in Dominican Republic; see Bértola and Ocampo (2010: 98).

but railways did not develop enough either, because of the low level of exports and subsequent scarcity of public resources.

The objective of this paper is to test the existence of such a bidirectional causality between government revenues and railway development. To that end we estimate a two equation model of government revenues and railway expansion for the Latin American countries between 1865 and 1913 and find supportive evidence of a positive two-way relationship between both variables. This is robust to several specifications and consistent with the division of the region between a group of economies where foreign trade, government revenues and railway expansion stagnated and another group of countries with significant export and railway dynamism. Even though we do not explore here the reasons for why each country fell in one category or the other, we suggest that a combination of structural features and short-term shocks may have explained the ultimate gaps among economies. Our analysis contributes to our understanding of the different ability of Latin American economies to reap the potential gains from globalisation, and contributes to explain the significant process of divergence within the region before 1914.

2. Infrastructure development and the state

There are several strands of literature that explain why government intervention is required to trigger infrastructure development. To start with, at least since Walras (1897) economists have thought of projects exhibiting substantial externalities as a case for state intervention, either to organize or to manage the provision of these goods under a monopoly. Coase (1974) challenged the conventional wisdom on the topic in his study of lighthouse provision in England during the 19th century, by showing that private individuals provided lighthouse services and made a profit out of them. This might be seen as an application of the Coase theorem, but later discussions of Coase's historical example concurred in showing that the operation of lighthouses also required British taxpayers money, forming a public-private partnership (Van Zandt 1993, Taylor 2001, Bertrand 2006, and Barnett and Block 2007).

Another strand of literature starts from the assumption that government involvement may be necessary to coordinate the actions and investments of private agents. Rosenstein-Rodan (1943) pioneered this idea, which is usually labeled the 'Big Push' hypothesis. Murphy et al. (1989) returned to Rosenstein-Rodan's thesis by showing that indivisibilities in the production function are sufficient to render government intervention necessary to coordinate private investment decisions. Coordination failures could be overcome through a 'Big Push' that would bring an economy from a low to a high level equilibrium. In this context, infrastructure in general and railways in particular have often been considered as a typical objective for Big Push policies (Rostow, 1960; Rosenstein-Rodan, 1961; Murphy et al., 1989).

Several qualifications to the Big Push hypothesis have recently been proposed. Berkovitz and Li (2000) suggest that the success of a Big Push is conditional on the proper organization of the tax system and, notably, on the coordination of the public authorities on the power to tax. Essentially, a disaggregated situation with many and possibly competing or unclear layers of authority with the power to tax investment is inferior to a concentrated tax authority. Fontenay (2004) complements this proposal by noting that the success of a Big Push policy may be affected by the market power of the entrepreneur chosen by the government to implement the Big Push. Because entrepreneurs can choose to hold up other investments by charging high prices for their services, the author argues that the success of a Big Push policy directly depended on the strength of institutions – particularly on their ability to enforce entrepreneurs' commitments. Bjorvatn and Coniglio (2012), however, show that, even if governments are less efficient than market entrepreneurs, a Big Push policy can still promote development. All this literature echoes Rodrik's (1995) argument that governments were helpful in removing coordination failures in investment in Taiwan and South Korea. In Sachs's (2005) version of the hypothesis, the Big Push was reframed as a discussion about the need for significant foreign capital to allow countries escaping a poverty trap. This view was in turn challenged by Easterly (2006), who emphasized poor governance over financial constraints as a greater source of entrenched poverty.

In all these contributions, the rationale for government intervention is the inability of the market to coordinate the actions of agents. Indivisibilities in demand, savings or production functions provide authorities with the possibility to implement Pareto-improving policies. However, another case for government intervention in infrastructure development can be connected to the domestic political equilibrium. In this regard Olson (2000) argues that the choice of the ruler to engage either in public goods provision or in extorting activities depends on its time horizon. Dalgic and Van Long (2006) show that this can generate a situation of multiple equilibria, one in which the country is locked in a poverty trap and another – unstable – in which the country grows without bound. They also show that transparency of the decision process and monitoring by voters make governments more willing to engage in growth-enhancing policies.

Politics may also affect the choice of implementing or not certain infrastructure projects because of their redistribution effects. For instance, the building of railways involved significant changes in the price of the surrounding land and in the degree of integration of labor and goods markets. This generated substantial changes in the distribution of gains from trade between regions and industries, while also destroying some local rents through increased competition. The redistributive consequences of infrastructure construction may generate resistance and induce losers to lobby against new infrastructure projects. This would be all the more significant in developing countries characterised by limited access orders, in which politics largely consists of distributing rents to ensure cooperation (North, Wallis and Weingast 2009). Consequently, the decision to build infrastructure may depend on the state redistributing part of the gains to the losers, in exchange for their approval, which would in turn require the state to build up sufficiently large streams of revenues to pay for those compensations.

Regardless of the mechanism justifying it – public good provision, coordination or redistribution –, these different strands of literature highlight the importance of the interrelation between infrastructure development and government resources. In this paper we attempt to test empirically for this relationship in the case of Latin American railways before 1914. Even though we cannot quantify the relative influence of the three mechanisms, the available historical evidence suggests that all of them might have been important.

3. Railway expansion in Latin America before 1914

During the first globalisation boom railways were a key factor for trade growth in the Latin American economies. Due to the scarcity of alternative infrastructure and the limited reach of the available water routes in most of the region, domestic transport costs before the railways were too high to allow a sustained and rapid growth of exports, except in areas with good access to waterways or for commodities with very high value-to-weight ratios, such as gold or silver.

With a few exceptions, Latin American economies had thus to rely on overland transport for domestic trade. Only a few feasible navigable routes were available, such as the Amazonas in Brazil, the Magdalena in Colombia or the River Plate system in Uruguay and North-East Argentina, and even there conditions for navigation were not always favourable, as has been stressed in the case of the Magdalena River.[6] In addition, Latin American pre-railway overland transport was very precarious. Most roads were not accessible for carts, and a huge share of freight transport depended exclusively on pack animals.[7] The primitive character of Latin American road transport can be illustrated by the ratio between the average unit price of pre-railway (largely road) freight transport and the average rates of railway freight. Whereas in England and Wales by 1865, France by 1872 or the US by 1859 this ratio ranged from 2.6 to 3.3, it reached levels of 4 to 13 in Argentina, Brazil, Colombia, Mexico or Peru in the early 20th century. Only in Uruguay, due to the exceptional natural advantages of the country, was the ratio relatively comparable to the situation in Western Europe (3.7).[8]

Under these circumstances, in many countries railways became essential to allow the exploitation of natural resources out of the coastal areas, and to make long-term export expansion possible. A preliminary illustration of the close association between railway development and export growth is provided by Figure 1, which shows that those countries that reached higher levels of export per capita in 1913 also invested more resources per capita in railways. The relation was especially strong as Latin American railways were mainly specialised in freight, which accounted a large share of total railway revenues. By 1910-14, and in contrast with the situation in most industrialised economies, freight revenues were between 2 and 4 times as large as passenger revenues in Argentina, Brazil, Costa Rica, Mexico, Peru and Uruguay,[9] and a large share of railway freight in those countries consisted of exports (e.g. Coatsworth, 1981: 40; Zegarra, 2013).[10] More specifically, railways were indispensable for the growth of several export sectors, such as saltpetre in Chile (Thomson and Angerstein, 2000: 47),

6 Traffic through the Magdalena River was slow and highly dependent on weather conditions, and the route was only partially navigable; see Ramírez (2001: 88) or Safford (2010: 538-545).

7 On the state of pre-railway transport infrastructure in Spanish America see Gutiérrez Álvarez (1993), as well as Summerhill (2003:18-33) for Brazil, Clark (1995: 26-36) for Ecuador, Coatsworth (1981: 17-26) for México or Zegarra (2011: 364-380) for Peru. Actually, in some cases, such as Mexico, the transport system experienced an involution between the end of the colonial period and the 1870s, with a decrease in wheeled traffic and an increase in the use of pack animals (Riguzzi, 1996: 40-41).

8 Figures calculated from Herranz-Loncán (2011a) for Argentina, Summerhill (2003) for Brazil, Ramírez (2001) for Colombia; Coatsworth (1979) for Mexico, Zegarra (2013) for Peru; Herranz-Loncán (2011b) for Uruguay, Fishlow (1965) for the US, Hawke (1970) for England and Wales, and Caron (1983) for France.

9 See Coatsworth (1981), Zegarra (2013), Summerhill (2003), Quesada Monge (1983), and Herranz-Loncán (2011a and 2011b).

10 However, for Mexico Kuntz Ficker (1995) has also stressed the importance of domestic-oriented traffic within total railway freight transport.

coffee in Brazil (Summerhill, 2003: 140) sugar in Cuba (Zanetti Lecuona and García Álvarez, 1987: 108 and 227), silver and tin in Bolivia (Mitre, 1981 and 1993), or coffee, bananas and animal skins in Costa Rica (Quesada Monge, 1983: 103). Conversely, the lack of railways has been identified as one of the main reasons for the sluggish growth of Colombian coffee exports (Ocampo, 2010: 216-217), or Peruvian exports in general (Zegarra, 2011: 383-389).

Figure 1 here

Despite the essential role of rail transport in export growth, many countries failed to build an extensive railway system. The first railway line in the region was opened in Cuba in 1837, only 12 years after the inauguration of the first British steam-moved public railway, but Cuba would not be joined by any other Latin American economy until 1850. Only in the 1850s did railway construction start in Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Peru, gradually spreading thereafter to the rest of the region. By 1900, all Latin American countries had some railways in operation, but the length of the national networks was very uneven. Railway construction had been very intense in Argentina, Brazil and Mexico, which accounted for approximately 75 percent of the whole Latin American mileage since the late 1880s. When measured in relative terms, investment in railway infrastructure had also been remarkable in Chile, Uruguay, Cuba and Costa Rica, both in per capita terms and in relation to the surface area of the country, as may be seen in Table 1. Other countries, by contrast, clearly lagged behind this group.

Table 1 here

Table 1 may be taken as preliminary evidence of the different role that railways performed in the growth of each Latin American economy before 1914. Whereas some countries could benefit from relatively dense networks, in other cases the expansion of the new infrastructure was extremely slow and, by 1914, railways formed scarcely integrated systems, consisting just of a few isolated lines that connected specific production areas with the main ports, while hardly affecting large swathes of the territory. The social savings literature has confirmed that those Latin American countries that built extensive railway networks before 1914 obtained huge direct benefits from railway transport. Among those countries with large networks, social savings were only low in Uruguay, because the geography of this country provided it with some natural transport advantages which were exceptional in the region, making railways less indispensable (Herranz-Loncán, 2011b). In Argentina, Mexico and Brazil, where cheap transport alternatives were not as abundant, railways provided social savings amounting on average to ca. one quarter of GDP by 1910-13. By contrast, in Peru and Colombia, two countries in which railway development remained disappointingly slow, the estimates of the social savings of railway freight for 1918 and 1927, respectively, range from 2 to 8 percent of GDP.[11]

Given the high potential economic impact of railways in Latin America, analysing why railway development differed markedly across countries before 1914 may help to understand the reasons for the region's internal divergence. This requires an examination of the railway investors' decision making process. In Latin America, railway capital and entrepreneurial initiative came from three different origins: governments, domestic capitalists and foreign firms. The first two sources were relatively important at the beginning of the period, but gradually lost prominence. Already by 1899 governments owned just 16 percent, and domestic capital 13 percent of the total Latin American railway mileage, and those percentages had decreased even further by 1913.[12]

By far, the largest share of Latin American railway capital came from foreign investment, which entered the region mainly in the form of new construction initiatives, but also by taking over publicly-owned and domestic private firms.[13] The relevance of foreign capital increased since the 1880s, especially after the Baring crisis led to the failure of several local initiatives, and foreign enterprise ended up controlling almost 75% of the railway mileage in 1899, and an even higher percentage (80 to 90%) in the

[11] For Argentina, Summerhill (2000) and Herranz-Loncán (2011a); for Mexico, Coatsworth (1979); for Brazil, Summerhill (2003); for Colombia, Ramírez (2001); and, for Peru, Zegarra (2013).

[12] Public capital was especially important in some Central American economies and in Chile, although its presence was also significant in other countries, such as Colombia, Brazil and Argentina. In some economies (especially in Central America), public railways were largely financed by issuing external sovereign debt, which was used as a substitute for the absent foreign direct investment. By contrast, in large economies, such as Argentina and Chile, public investment was, to some extent, complementary to private undertakings, often financing lines that ran through poor and distant regions, as an instrument of political integration and with very low profitability prospects. Domestic private capital was especially present in Cuba (where it owned 40% of the network in 1899, but had controlled almost 100% until the 1880s), Puerto Rico, Brazil and Venezuela (with percentages of 20 to 30% in 1899), and also, to a certain extent, in Chile, and was highly connected with certain export activities, such as Cuban sugar, Brazilian coffee, or Chilean copper mining (Sanz Fernández, 1998; on the role of domestic capital see also Lewis, 1983b: 257-260).

[13] The process of privatization of pre-existing public lines was very important in some countries, such as Peru, where foreign capital bought a large percentage of public railways in 1890, and it was also relevant in Argentina and Mexico in the closing years of the 19th century.

years immediately before 1914. Among foreign investors, British capital was absolutely dominant during the late 19th century, accounting for 70% of the mileage under foreign operation in 1899. However, since 1900 the importance of US capital grew rapidly, being especially relevant in the US closest area of influence i.e. Mexico, the Caribbean and Central America (Sanz Fernández, 1998).

Since the majority of Latin American railway investment was financed by foreign capital, some factors must have made some destinations more attractive than others to foreign investors and hence may account for the differences in railway development among countries. Latin American railway historians have associated foreign investment and railway construction in each country with three main factors: i) the degree of institutional stability; ii) the government's financial capacity to subsidize construction or guarantee a certain level of profits; and iii) the growth of exports of one or several products of increasing world demand.[14] The first factor may explain why, in most countries, significant construction only started in the late 1860s or early 1870s, once post-independence political turmoil had sufficiently abated. The two main exceptions to late construction were Cuba and Chile, which were among the most institutionally stable countries after independence. Cuba, which remained linked to the Spanish Empire until 1898, was one of the first countries in the world to build railways, and in Chile construction was very active since the early 1850s. In both cases, primary exports were essential to justify railway construction.

Government involvement was also essential for railway development to take off, either through subsidies to private investment and different types of public-private partnership, or through direct public construction. Railway subsidies took different forms, such as interest guarantees (often at 7% of invested capital), or a fixed construction subsidy per mile (as in Mexico and Honduras), and they constituted a huge burden on many Latin American countries' public budgets.[15] Examples of the direct link between well-funded public support and the start of railway construction are abundant. In Chile, for instance, the completion of the Santiago-Valparaíso line in the 1850s was only achieved after the government entered the shareholder capital (Thomson and

[14] To be sure, the geographic characteristics of each country (e.g. ruggedness) also had a significant impact on cross-country differences in railway density through local construction costs. However, these characteristics did not change over time, and cannot explain the widening divergence in railway density between Latin American countries.

[15] For instance, in Argentina the guarantees amounted to more than 4.5 million pesos by 1890, whereas the total budget of the nation was 33.6 million pesos; see López (1994: 351-352); and in Mexico railway subsidies were one of the main factors behind the fiscal crisis of 1884-85 (Riguzzi, 1996: 74).

Angerstein, 2000: 37-40). Similarly, no construction took place in Brazil until the government started supporting it 1852 (Summerhill, 2003: 36-44) and, in Argentina and Uruguay, provincial or central governments' financial support was granted since the arrival of the first railways (Gómez, 2011; Lewis, 1983a). The expansion of the Peruvian railway network between the 1850s and 1870s was also allowed for by the abundance of fiscal revenues (Zegarra, 2011: 367).

In contrast, the lack of central governments' resources is one of the factors that explain the delay in railway construction in Mexico before the *Porfiriato* or in Colombia until the 1880s (Riguzzi, 1996: 37-38; Safford, 2010), whereas the elimination of subsidies in Venezuela in 1892 was behind the sudden interruption in railway construction in this country (Sanz Fernández, 1998). The main exception to this dependence of railway construction on government resources was Cuba, where the early railways were built without government support on the basis of the sugar boom. Construction of railways in Cuba, however, stagnated in the 1860s and only accelerated again after independence, when subsidies were granted to new lines (Zanetti Lecuona and García Álvarez, 1987).

As mentioned in the previous section, there are several potential explanations as to why government resources were so crucial for the expansion of railway infrastructure. The most obvious is the presence of market failures and the need of government intervention to coordinate private investment. Given the high fixed costs, indivisible capital and long maturation periods of railway investment, investors required some guarantee of return, in order to compensate for the perceived uncertainty as to whether export activities would take off and make railway investment profitable.[16] In this context, as suggested by Berkovitz and Li (2000), situations of competing layers of tax authorities (such as Colombia in the 1880s or Mexico before the *Porfiriato*) hindered the ability of the government to coordinate private investment and substantially delayed railway construction.

Also as pointed out before, the costs of these coordination policies in terms of government resources increased with the market power of railway promoters. There were a limited number of railway promoters in Latin America before 1913, and governments often negotiated a large number of projects with a single agent. For instance, Wheelwright and the Clark brothers dominated railway construction in Chile

[16] See, for instance, Summerhill (2003: 34-44), or Lewis (1983a: 11).

and Argentina, Meiggs in Chile and Peru, Prados, Mauá and Mayrinck in Brazil, Cisneros in Colombia, Keith in Costa Rica or Drabble in Uruguay. Their connection with local governments proved invaluable to obtain concessions and public subsidies. As stressed by Lewis (1983a: 11) in the case of São Paulo, their position was reinforced by the authorities' "*need to preserve their financial credibility, which made them easy victims of less scrupulous railway promoters*", as well as by their lack of experience and the absence of financial or technical criteria to assess concessions and subsidies, especially at the beginning of the period (see e.g. Connolly, 1997: 65). In the smaller countries, railway promoters acquired almost limitless power to decide on many aspects of the economy, as happened in the case of Costa Rica with Keith and his collaborators (Quesada Monge, 1983: 114).

Finally, the dependence of railway construction on government resources also had political origins. Infrastructure development required political skills to negotiate the agreement of all parties involved and the redistribution associated to the decisions on the route of each line. In other words, governments needed to buy off the approval of local elites to railway projects. Sometimes, this also required investing resources (through subsidies) in some unprofitable railways. For instance, in the case of the Brazilian state of São Paulo, Lewis (1991: 19) suggests that

> "*it would be facile to argue that unprofitable railway building was simply a function of a weak state apparatus unable to arbitrate between the competing claims of different groups. Peculiar circumstances apart (...), paulistas recognised that only in the new coffee zone were railways likely to prove financially viable (...). However, there were pressing reasons why the province aspired to a more extensive network and why landowners were anxious to socialise construction costs, shifting to the Treasury the burden of unprofitable construction*."

The lack of resources to compensate losers or local elites provoked the failure of some projects, as in Colombia, where the plans of the government in 1871 to give priority to the *Ferrocarril del Norte*, which would favour the states of Cundinamarca, Bocayá and Santander at the expense of the West and the Caribbean, generated resentment and were one of the reasons of the civil war of 1876 (Safford, 2010: 557).[17]

Together with institutional stability and government support, the third explanatory factor for differences in railway development among Latin American countries was the

[17] A similar case of elites' blocking of infrastructure construction in 17-18th century Britain can be seen in Bogart (2011).

growth of exports. This explains, for instance, the early boom in Cuban railway construction, which was largely based on the growth of world demand for sugar. External trade dynamism, however, was not only important as an indicator of potential profits for foreign investors. In addition, it was the main source of revenue for local governments. The lion share of government's resources came either from the taxation of natural resource extraction or, more commonly, from customs tariffs.[18] According to Bulmer-Thomas (1994: 110):

> "*governments throughout the region relied heavily on import tariffs to generate public revenue. (…) Tax reform brought about the elimination of many taxes inherited from colonial times and a concentration on external trade taxes; by the time of the First World War no country received less than 50 percent of public revenue from custom duties, and in many cases the share was more than 70 percent.*"[19]

As a consequence, export crises had deeply negative consequences on railway investment, not just because they threatened the profitability of rail transport but also because they endangered the ability of governments to continue supporting railway construction.

Thus, railway expansion in Latin American was intimately dependent on the performance of exports through their impact on government revenues. For instance, in Ecuador, the Guayaquil-Quito railway (the main line of the system) could only be built after 1895, thanks not only to General Eloy Alfaro's political will but, specially, to rising custom revenues from cocoa exports (Clark, 1995: 19-20). In Peru, the slowdown of railway construction since the 1880s coincided with the loss of some guano deposits to Chile in the War of the Pacific, and from the exhaustion of those that remained in Peruvian territory. In a similar way, the expansion of the Peruvian railway system was only resumed in the two decades before 1914 thanks to the recovery of exports (Bulmer-Thomas, 1994: 64; Zegarra, 2011: 367). In Mexico, the dismal export performance of the country before the start of the *Porfiriato* is, together with the extreme regionalisation of the structure of the Mexican state, one of the main reasons for the country's delay in railway construction (Riguzzi, 1996, Bulmer-Thomas, 1994:

[18] This is partly explained by the difficulty in developing an alternative fiscal structure (Centeno, 1997).

[19] See also Coatsworth and Williamson (2004), Centeno (1997) and Rubio Varas (2006). An extreme case of concentration was Chile, were customs accounted for more than 90% of public revenues in 1913. By contrast, Paraguay represented an exception to the dependence on foreign trade taxes, due to its limited participation in world trade.

64). The same close association between exports, custom revenues and railway construction has been identified for El Salvador by Burns (1984) and for Chile by Soto (2010).

As mentioned previously, while railway expansion depended on government revenues and these, in turn, on export growth, the latter was also, to a large extent, a consequence of railway development. This mutual causation between, on the one hand, exports and government revenues and, on the other, railways, had the potential to generate multiple equilibria. The objective of the next sections is to test the existence of such equilibria by analysing the bidirectional causality between government revenues and railway development over the period.

4. Empirical strategy

This section presents a model aimed at exploring the two-way relationship between railways and government resources in the Latin American economies during the first globalisation boom. In order to test this hypothesis, we specify two equations in which railway development depends on government revenues and these, in turn, depend on foreign trade, which was to a large extent dependent on railway development. Given the mutual causation between railway development and government revenues that is involved in this specification, we need an identification strategy to analyse the connection among the main variables.

The equation for government revenue is:

$$G_{it} = \alpha + \beta\, T_{it} + \gamma\, Z_{it} + \chi_t + \eta_i + \varepsilon_{it} \qquad (1)$$

where *G* is government revenue, *T* is the volume of imports (the main source of public resources in the region at the time) and *Z* is a vector of covariates. We instrument for trade by using both railways and, as is customary in trade studies, the standard gravity controls, i.e. the product of the population of each country by the population of its main trade partners, and the effective distance between them. Railways are an appropriate instrument because, as has been indicated, they were a key factor for export (and therefore import) expansion. At the same time, they were not a direct source of public revenue, since taxes paid by private railway companies were negligible and the direct contribution of public lines to total revenues was very small or null. In other words, the instrument verifies the exclusion restriction. In vector *Z* we include population as control for each economy's size, and several indicators of political instability (number of changes in the executive and the presence of interstate wars or other wars) that disturbed the collection of government revenue in a given year.[20]

The second equation is based on a rational expectations model of partial adjustment of investment in Latin American railways. This assumes that there was an ideal size for each country's railway network conditional on the available information on a number of relevant variables. More specifically,

$$R_{it}^{*} = a + bG_{it} + cX_{it} + n_i + d_t + e_{it} \qquad (2)$$

where R^* is a latent variable representing the desired length of railways, G is government revenue and X a vector of covariates. Moreover, we model a partial adjustment mechanism, whereby investors (public or private) caught up each year with the desired network size. In other words, the growth rate of the railway network would be a fraction of the gap between its ideal level and the size of the inherited network:

$$\mathrm{R_{it}} - \mathrm{R_{i,t-1}} = \delta\left(\mathrm{R_{i,t-1}^{*}} - \mathrm{R_{i,t-1}}\right) \qquad (3)$$

Replacing (3) in (2), we obtain the equation to estimate:

$$R_{it} - R_{i,t-1} = \delta a - \delta R_{i,t-1} + \delta b G_{i,t-1} + \delta c X_{i,t-1} + \delta n_i + \delta d_{t-1} \delta e_{it-1} \qquad (4)$$

Since we are interested in the coefficients of equation (2) (i.e. the relationships between the covariates and the desired network density level), we recover them as $b = (\delta b)/\ \delta$, and $c = (\delta c)/\ \delta$.

To account for its potential endogeneity, we instrument for government revenue in this equation with two variables: each country's total level of diplomatic representation abroad, as compiled by Bayer (2006), and an index of legislative effectiveness of each government, taken from the Banks (1994) database. For the exclusion restriction to hold, these variables must be good predictors of government revenue but not of railroad mileage growth, at least directly. "Legislative effectiveness" was coded by Banks as an

[20] Other wars include civil wars as well as colonial conflicts in Cuba or Puerto Rico during the period of Spanish rule. We also included an indicator for border changes to control for exogenous variations in countries' scale, which takes the value of one for Chile, Bolivia and Peru in 1883 (Pacific war) and for Colombia in 1904, to account for the loss of Panama.

index of parliaments' autonomy and power, particularly of their "authority with regard to taxation and disbursement." The reason to use this instrument is that more effective legislatures would be better at raising government revenue inasmuch as they created the vehicle for a more consensual fiscal deal in society than, say, a confiscatory dictatorship. Arguably, more effective legislatures could also promote railway expansion faster than a dictatorship, but the evidence in Latin America offers some clear counter-examples, such as the railway boom after Porfirio Díaz's takeover in Mexico, or the railway expansion in Venezuela under General Antonio Guzmán Blanco (1870-88). In other words, railway investors and promoters could sometimes be agnostic about the nature of local political institutions, provided they were stable and predictable.

In the case of diplomatic representation, the exclusion restriction requires it to be correlated with the underlying ability of each government to tax and raise revenue, whilst only very indirectly affecting the rhythm of railway construction. To be sure, foreign representations could be opened abroad in order to publicise investment opportunities in the country, and so might be correlated with the error term of equation (4). However, by 1865 all Latin American countries in the sample already had some form of diplomatic representation in the UK, France, Germany or the US, which were the almost exclusive sources of foreign investment in railroad construction in Latin America.[21] Likewise, diplomatic representations might be opened abroad to promote trade with foreign countries and, since a large share of Latin American railway traffic was linked to foreign trade, the diplomatic instrument might then have a direct influence on the left-hand side variable. To take heed of this problem, we include in the vector of controls X two standard gravity variables (the product of the population of each country and its main trade partners, and the effective distance among them), under the assumption that cheaper access to the core markets would have increased the latent demand for transportation in Latin America. But since these are exogenous gravity variables, we do not expect them to correlate with the *total* size of the diplomatic corps.[22]

Regarding the other covariates in X, we consider a number of economic, political and financial variables that would have influenced railway development in each country.

[21] Cuba and Puerto Rico were, of course, exceptions, but this was compensated by their belonging to the Spanish colonial empire up to 1898, and by the American protectorate thereafter, which provided a favourable access to the American financial markets.

[22] So, if the diplomatic service was also driven by the same gravity forces, the instrument would be exogenous.

Among the economic variables, we include the evolution of the terms of trade, constructed by using international prices of the main articles of export of each country. As for the potential influence of political and institutional variables, we include again several indicators of political instability (number of changes in the executive, interstate and other wars), which might have been a deterrent to railway investment, both directly (i.e. through the lower friendliness of the business environment) and indirectly, because of the difficulty to reach consensus on taxes and therefore to increase government capacity to subsidise railway construction.[23]

We also take into account the potential for financial rationing in the international capital markets, particularly as a consequence of sovereign defaults. According to both historical and contemporary evidence, the corporate sector suffers a big penalty from sovereign defaults in rationed access to external finance (Bergquist, 1978; Arteta and Hale, 2008; Esteves and Jalles 2013). In addition, some defaults might have been related to the use of public money to subsidize unprofitable railways or unscrupulous foreign railway promoters, which would be a deterrent for additional investment. Having tried several proxies of access to foreign capital, namely sovereign spreads, we decided to use a simple measure of market memory of defaults, dependent on the number of years elapsed since the last default.[24] We did so for two reasons: one, because this memory variable is a good predictor of spreads and, two, because we can compute it for the whole sample, whereas the availability of market yields for the debts of Latin American countries was more limited.[25] As additional financial variable, we also include each country's exchange rate regime, since Latin American countries on silver or with paper currencies had to face persistent depreciation against the gold standard countries for most of period. Since they imported the bulk of their railway inputs (rails and rolling stock) from gold countries this depreciation increased construction and running costs in domestic currency. Finally, we also include an index of global liquidity (the yield on British consols), as an approximation to variations in the international financial climate.

[23] We also included the same border changes marker of equation (1).

[24] Actually, we use a non-linear transformation of this variable because some countries never defaulted. Therefore, we computed the variable $y = x/(x+1)$, where x is the number of years since the last default, and which decreases with distance from last default and converges to 1 for countries that never defaulted.

[25] Moreover, for the sub-sample for which spreads are available the tenor of the results does not change when we substitute spreads for the non-linear memory variable.

The summary statistics for the variables included in the two equations, as well as the instruments, for the estimated samples are listed in Table 2. Their sources are detailed in the Data Appendix at the end of the paper.

Table 2 here

5. Results

Table 3 shows the results of estimating equation (1) by 2SLS. All the variables (bar the dummies) are converted to logs and to allay any further concerns about endogeneity we lagged all right-hand side variables by a year. As has been indicated, other than railway mileage, we included in the instruments list two gravity variables – mass (product of populations of each country and its trading partners in Europe and the US) and effective distance. To improve power, we also included a quadratic term of railway length.

Table 3 here

Generally, all the significant variables have the expected signs, with a few exceptions. The instruments pass the tests of under-identification (Kleinberg-Paap and Anderson canonical correlation) and weakness (Cragg-Donald and Stock-Wright). However, apart from the last specification, there are problems with the test of overidentification (Sargan and Hansen J). There is some variation in the size of the coefficients of our variable of interest (the share of the variation of imports explained by railroads and the gravity variables) when we introduce country fixed effects in the last two columns. It is probably safe to say that the elasticity of government revenues with respect to trade hovered between 0.3 and 0.4. In the last column the population variable is highly significant, confirming the expected size effect on government revenues. Since the estimated elasticity is greater than one that would imply increasing returns to scale, which is a plausible case. However, the coefficient estimates for this variable are not stable across models and it is therefore unclear how much weight we should give to this result.[26] Finally, the political marker is only significant in the regressions without country fixed effects, suggesting that Latin American countries systematically differed

[26] The negative and significant coefficient of the population variable in model (2) is puzzling. But it disappears with FE (country or year), meaning that it might be actually capturing the effect of less populated countries (e.g. Southern Cone) having more government revenues per capita.

in their levels of political stability across the whole period, as this variable has no explanatory power of the within variation of government revenues.[27]

Table 4 shows the result of estimating equation (4) also by 2SLS. The instruments pass all tests and in all specifications. The coefficient of lagged railway mileage, which stands for the (symmetric of the) velocity of adjustment of railway construction, is always significant, negative and lower than 1. This is consistent with the partial adjustment model presented in equation (3) and implies an adjustment speed of up to 10% per year. The size of our coefficient of interest is not entirely stable but, apart from column (6), hovers close to but below 0.2. Bearing in mind that the structural parameter is estimated as the division between the coefficient of government revenues and the velocity of adjustment, the implied long-term elasticity of railways to revenue is always above one and possibly as high as three.

Table 4 here

Although often correctly signed, the coefficients of the controls are mostly remarkable for their lack of statistical significance, except when country and year fixed effects are included. In the later specification, distance has the expected negative sign, arguably working through trade, but the sign of the mass variable is counterintuitive. Further, being at war with other states adversely impacted railways construction. The insignificance of the 'off gold' variable may suggest that higher construction costs over the short run did not dissuade investors from committing funds to the development of railways in countries with sound economic and financial prospects.

Institutional variables are also rarely significant, but have the expected sign when they are. It is possible that political differences across Latin American nations were sufficiently stable throughout the sample such that they have no explanatory power of the within variation, but are significant in explaining it between countries. Finally higher world interest rates do not seem to have dampened the rhythm of railway construction in Latin America, possibly because the recessionary effects of world financial crises are already captured by government revenues.[28]

In conclusion, the evidence in Tables 3 and 4 supports the hypothesis under test, i.e. that government intervention was crucial in the construction of Latin American railways

[27] On the other hand, the positive effect of wars in models 3 and 5 might reflect the efforts of governments to raise revenues during wars.

[28] The consol variable drops from model (7) probably because of collinearity with the year fixed effects.

and that these were, in turn, a key element in both the integration of these nations in the flows of world trade and their subsequent fiscal development prior to 1913. Given that we estimated a double feedback system it would be interesting to study its dynamic stability. With linear functional forms, the stability condition resumes to a comparison of the slopes of the two functions: government revenues as a function of railways and railways as a function of government revenues. Stability requires that the first slope be smaller than the second, which is the case in the regressions with country and country/ year fixed effects. This is represented in Figure 2, where the two lines were drawn by using the estimated coefficients and the sample averages of all the right-hand side variables. An exogenous shock to revenues or to railways in a particular country would therefore build up and converge to permanently higher levels of railway density and government revenues.

Figure 2 here

6. Robustness

There are several alternatives to pursue in testing the robustness of the results of Tables 3 and 4. We consider three here. The first has to do with the estimation method. Even though we are estimating a double-feedback relation between railways and government revenues we chose to estimate the two equations by 2SLS. This guarantees consistent estimates of the structural parameters, but we can try and improve efficiency by using system estimates. Table 5 does just that by estimating the two equations jointly through 3SLS. Even thought the tenor of the results is similar to the 2SLS estimates, the size and significance of the coefficient of government revenues in the second equation are reduced and the overall quality of the adjustment is actually worse than the single equation models, as confirmed by the very low or even *negative* R-squared. As system estimation requires more stringent assumptions to yield consistent estimators than 2SLS, all in all we prefer the latter results (Wooldridge 2002).

As an alternative treatment of endogeneity, now focusing specifically in the railway equation (4), we use dynamic panels (Arellano-Bond) methods. Results are in Table 6. The main advantage of this method is to provide a large number of estimators consistent with the rational expectations component of our partial adjustment model of railway construction, which might address the problem of our instruments for government expenditures not being strong enough. However, the Arellano-Bond method has constraints of its own, namely that its properties depend on having large cross-sections relative to the time dimension, which is not the case of our sample.

Table 6 here

The estimate for the velocity of adjustment in Table 6 is slightly higher than that of Table 4, but government revenues are no longer significant. However, since both regressions fail to pass the over-identification test once more we prefer the 2SLS results.

As a third variation on the issue of estimation methodology, we ran cointegrated panel models which were specifically developed to deal with the possibility of non-stationarity in large N and large T dynamic panels (Pesaran and Smith 1995; Pesaran, Shin and Smith 1997, 1999). We preliminarily tested for panel cointegration using the four tests proposed by Westerlund (2004). Even though we could not reject the absence of cointegration between our variables, we are aware of the low power of these tests with relatively short time dimensions for each individual cross section unit. Consequently, we still estimated our model as a cointegrated panel in Table 7.

Table 7 here

The Table includes two sets of results dependent on the constraints imposed on the short-run coefficients. In choosing the lag lengths we had to trade between quality of fit and degrees of freedom. As a compromise, we set a maximum lag of two years and used the individual lags that minimized the usual information criteria for model selection (AIC and BIC). In the dynamic fixed effects model (DFE), despite the inclusion of country fixed effects, we constrain the short-run coefficients to be the same across countries. In the pooled mean group specification (PMG) we allow them to vary between countries. In both specifications we impose the same long-run coefficients. The tenor of the estimates of the long-run coefficients is again similar to our preferred results, although government revenues are only significant in the more flexible PMG model. The size of the long-run estimate of this elasticity is also lower than the corresponding estimate in Table 4, though still barely above one. However, the adjustment speed is cut to about half of the estimates in Table 4.

Our second robustness check also deals with the stability of the results through time, as it is possible that the results are weaker in the whole sample than in sub-periods. The 50-odd years covered by the regressions witnessed substantial transformations in terms of trade patterns and specialisation, state capacity and financial market integration that could change the strength of the empirical relation under study. Focusing again in the railway equation (4), Figure 3 shows the coefficients of government revenues that result from dropping from the estimation the last years of the sample, starting from 1880 onwards.

Figure 3 here

This Figure reveals an interesting result, although it has the problem that the estimates for the smaller samples are very imprecise, due to the drop of the majority of the observations.[29] In any case, Figure 3 implies that there was a clear breakpoint between 1890 and 1893. In between these two years the coefficient of government revenues increases in size and becomes statistically significant. Arguably, this is an expression of the fallout from the Baring crisis, which reduced the ability of Latin American countries to borrow from abroad. Under more stringent credit constraints, the collateral of government revenues became binding for railway construction. By contrast, during periods of credit expansion and railway investment booms, it was easy for governments to borrow, even without revenues that would justify it. In fact, the size of the coefficient was lower just before 1890 and had been falling throughout the 1880s. Similarly, after rising to a maximum of 0.55 in 1890, the elasticity of railway construction to government revenues fell systematically until 1910 (except for a hiccup in 1907, no doubt associated with the US stock market crisis) before rising again until the eve of World War I. By the early teens the coefficient had fallen to close to 0.13. Despite this decrease, the coefficient remains significant after 1893, as shown in the second panel of Figure 3. Hence, our results, although influenced by the cyclical nature of world investment booms and busts, are not entirely driven by them.

A final robustness consideration relates to the specification of the railway investment model that underlies equation (4). This rational expectations model assumes that investment decisions adjusted seamlessly to the acquisition of new information for

[29] For instance, by dropping all years from 1880 on we only retain 96 observations of the original sample of 480.

railway prospects. However, as is well known on the theoretical and empirical literature on investment functions, simple accelerator models similar to equation (4) often fail empirically because of not accounting for the option value of waiting (Dixit 1992, Pindyck 1991). In the face of uncertainty, rational investors have an option to wait for more confirming information before investing, what generates excessive inertia of investment to new information in equations such as (4). To try and account for this we ran the same model with longer lags and indeed obtained better fits. With lags up to three years more control variables become significant (Table 8).

Table 8 here

The size of the elasticity of railways to government revenues falls by 10 per cent relative to Table 4, but the difference is not statistically significant. In the end, as the length of the waiting period for railway investments in Latin America is not observable, we prefer to report the results with one year lags of Table 4.

7. Interpretation

Our estimation results indicate the presence of a double feedback relation between railways construction and government capacity in pre-war Latin America intermediated through foreign trade. Such relation is consistent with the 'big push' and 'poverty trap' variety of models, and with the possibility for some Latin American countries becoming stuck in a non-development trap in which the economy (and government revenues) did not grow enough due to insufficient railway development, and simultaneously railway development was stunted because of the low level of exports and the consequent scarcity of public resources. These results contribute to our understanding of the growing differences that opened up across Latin American economies during the first globalisation period. For instance, the prolonged stagnation of railway construction in Colombia, which originated in the specific difficulties that this country faced to increase exports and government revenues, contrasts with the sustained expansion of the rail systems of Argentina, Uruguay, or Mexico since 1879, closely associated to their growing involvement in world trade.

The main fundamental drivers of Latin American export divergence before 1914 have already been identified in the growth literature. An unfavourable geography (e.g.

ruggedness, or landlockedness), inadequate institutions (largely associated to the difficulties of building the state apparatus after independence), or bad luck in the "commodity lottery", are among the main suspects that prevented some countries to take full advantage of the opportunities provided by the world trade boom and the railway technology. Rather than exploring the particular reasons that explain the evolution of each country, we suggest here some clues about the specific channels through which those factors affected the Latin American economies in the period. Our results indicate that countries with unfavourable circumstances not only had difficulty in exporting but could also not build the infrastructure that would allow them to remove their external trade constraints, due to the impossibility to expand government resources.

In addition, our results also highlight the importance of short-term shocks in the long-term evolution of each economy. The impact of wars, sudden changes in the terms of trade or institutional changes affecting the ability of the government to collect resources also had a bearing on the future expansion of the railway system and the economy. In order to quantify the economic significance of our results Table 9 presents four counterfactual exercises whereby we investigate the required increase in government revenues for a given country to attain the same railway density (measured in km per km^2) as another country with a more developed network by 1913. For instance, in the first row we consider the possibility of Colombia reaching the same railway density as Argentina in 1913 (12.10 km per 1,000 km^2, rather than the actual 0.94). The push variable in these counterfactuals is the size of government revenues, which we introduced in a dynamic simulation of the size of the network by using the system of equations (1) and (4), while assuming that all other variables were kept at their historical levels. We consider two alternative scenarios: one where we add a permanent percentage increase to government revenues each year between 1865 and 1913; and the other where we shock revenues only once at the beginning of the period.

Table 9 here

The table shows that the required amounts to move each country to a different long-run path vary from modest to moderate. Focusing on the first line, the cumulated impact of a permanent 3 per cent annual increase in revenue since 1865 would be required to bridge the gap between the densities of the Colombian and Argentinean networks.

Alternatively, an initial injection of slightly less than 108% of the Colombian revenue in 1865, representing just over £1.5 million, would also achieve the same result. Very similar numbers would be required for Colombia to match the slightly denser Uruguayan network. The last two cases in Table 9 involve countries of relatively similar size but ultimately different railway development. The figures for a Honduran convergence to the Costa Rican density in 1913 are much smaller than the Colombian ones, whereas the Peru-to-Mexico scenario would demand values in between these two cases.

We report this exercise mostly for illustration and as a way of gauging the economic significance of the impact of government support to railway development in Latin America. Interpreted literally, these figures suggest that a modest capital injection would be sufficient to achieve higher levels of network density. However, the counterfactual estimates are conditional on the *cæteris paribus* assumption and we can imagine many reasons why a permanent increase in government revenue might be hard to sustain over 50 years. But any mitigating reasons do not ultimately detract from the importance of the public-private partnership link we establish in our analysis.

Finally, our estimates also allow identifying those cases in which countries deviated from the evolution of the rail network that is predicted by the model. Figure 4 compares the evolution of the actual railway length of each Latin American economy with the rail mileage predicted by the model over time, according to the level of the underlying variables and the dynamics of the model.[30] Whereas in most countries the predicted railway length follows closely the size of the actual network, there are some interesting outliers. The most remarkable cases are, for different reasons, Chile and Colombia. Chile before the War of the Pacific (1879-83) is the main case of railway "overbuilding" in the region. Although our estimates predict the stagnation of the Chilean network at least until the end of the war,[31] in fact the country expanded its network at good pace even before the war and the saltpetre export boom. To a large extent, this might partly be explained by the pioneering involvement of the Chilean government in the expansion of the railway network since the early 1850s.

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[30] Notice that all the predicted series coincide with the actual railway mileage in 1913 because the dependent variable in equation (4) is the growth in railway mileage and the property of least squares estimators that the sum of error terms is zero.

[31] Nothing prevents the predicted railway mileage from decreasing. However, since the closing down of lines was very rare during the period, we consider that a decrease in the predicted mileage would be consistent with stagnation in the actual length.

Figure 4 here

The opposite case is represented by countries such as Ecuador, Honduras and Colombia, where railway construction was much slower than predicted. In these countries, whereas the relatively low level of exports and government revenues did not allow for massive railway construction, the large divergence between the predicted and the actual mileage indicate that there were other additional obstacles to the expansion of the rail network. The Colombian case is the most striking, and the inability of this country to expand its railway system was probably associated to the difficulties to reach stable national consensus in the field of railway policy.

8. Conclusions

This paper has analysed the interplay between government revenues, railway expansion and the development of exports in Latin America during the period of the first globalisation. Our results show that increasing government revenues triggered railway infrastructure development, therefore boosting the export sector. In turn, the growth of exports helped increasing government revenues, which made the guarantees and subsidies to railways companies sustainable. We also found that the relationship between government revenues and railway expansion weakened during periods of easy international credit. A direct implication of our results is that, during the period under consideration, some countries might have been trapped in a non-development equilibrium, in which railways were not built because of insufficient government revenues, but these did not grow enough due to insufficient transport infrastructure and its negative effects on foreign trade.

In an export-led growth context, this positive two-way relationship between exports and government revenues on the one hand and railway expansion on the other is consistent with a Big Push hypothesis, in which government intervention was necessary to bring an economy from a low to a high level equilibrium. There are several possible reasons why government resources were an absolute requirement for railway infrastructure expansion. Previous research on the Big Push hypothesis has emphasized the government's role in overcoming market and coordination failures. In addition, governments might have been able to secure their countries' access to railway construction market only by agreeing to pay monopoly rents to railways promoters. And an additional rationale for the boost in government spending is the need to grease the wheels of politics by facilitating the consent of powerful regional elites to the redistributional consequences of railways development. We leave to future research the task to try and disentangle the relative importance of each of these mechanisms. The main implication of our analysis is that the build-up of state capacity was a necessary condition for railway expansion and, therefore, in many countries, for export development and economic growth. Although we cannot explore here in detail the reasons for why some countries took full advantage of the potential gains from railway technology, while others failed to act on it, our results are informative of the growing divergence between economies of the region during this period.

9. Appendix: data sources

Railway data

Yearly railway mileage has been taken from Mitchell (2003) and Sanz Fernández (1998), except in the following cases: Argentina (from Dirección General de Ferrocarriles, *Estadística de los Ferrocarriles en Explotación*, 1892-1913); Brazil (from www.ibge.gov.br); Chile (before 1870, own estimation from Marín Vicuña, 1901, and Alliende Edwards, 1993; from 1870 onwards, Braun et al., 2000); Cuba (from Zanetti Lecuona and García Álvarez, 1987); México (from *Estadísticas Históricas de México*; http://biblioteca.itam.mx/recursos/ehm.html); and Uruguay (own estimation from the country's statistical yearbooks).

Population

Population figures for Latin American countries have been taken from Yáñez, Rivero, Badia-Miró and Carreras-Marín (2012); except for Puerto Rico, from Mitchell (2003), and Bolivia, for which we have used our own figures (see Herranz-Loncán and Peres-Cajías, 2011). Population of the main trade partners (UK and US) has been taken from Maddison (2003).

Effective distance to the core markets

We estimated effective distance following Clemens and Williamson (2004)'s procedure, i.e. we coded this variable as the product of a measure of geographic distance and an index of cost of shipping between each country and its main trade partners (UK and US). For most countries, geographical distance has been taken as the pre-Panama canal distance between the main port of each country and London or New York (or San Francisco in the case of the countries with the main port in the Pacific), as listed in Philip (1914) and National Imagery and Mapping Agency (2001). For the majority of nations we have used the index of tramp shipping freight charges from Isserlis (1938: 122), with base year 1869 = 100.

Imports, government revenues and exchange rates

Import data were kindly provided by Béatrice Dedinger. Some gaps in her data have been filled in with information taken from Mitchell (2003), the Correlates of War database, Schoonover (1978) and Puerto Rico official trade statistics. Total government revenue, in local currency units were obtained from Accominotti et al. (2011) for the period 1880-1913. For the earlier period or countries not covered in this database, information was gathered from the following sources: Argentina from Cortés Conde (1989); Brazil from Motta et al. (1990) and several issues of the Brazilian budget laws; Chile from Wagner et al. (2000) and the *Sinópsis Estadística* (1918); Colombia from Mitchell (2003) and Kalmanovitz (2010); Cuba from the official public budgets (various years), Mexico from El Colegio de Mexico (1960), Wilkie (1967) and Mitchell (2003); Peru from Mitchell (2003) and Tantaleán Arbulú (1983); and Uruguay from Millot and Bertino (1996, 2005) and the Uruguayan Statistical Yearbooks. The majority of the exchange rate (local currency units per pound sterling) data comes from the compilation by Schneider et al. (1911) or Accominotti et al. (2011) with the following exceptions: Argentina from Cortés Conde (1989); Brazil from Motta et al. (1990); Colombia from Ocampo (1984) and the MOxLAD database at http://oxlad.qeh.ox.ac.uk/; Costa Rica from Soley Güell (1949); Cuba from the MOxLAD database; Guatemala, Honduras and Nicaragua from Young (1925); Peru from Ministerio de Fomento (1918).

Terms of trade

For those countries included in the database by Christopher Blattman et al., and given that the UK was by far the main trading partner of Latin American countries throughout the period under analysis, we have used the ratio between a trade-weighted index of commodity export prices and an index of UK export prices, as compiled by Blattman et al. (2007). For other countries, we have computed the ratio between the price of the main export and an index of UK export prices. Each country's main exports is taken from Mitchell (2003) and the evolution of its price comes also from Blattman et al. (2007).

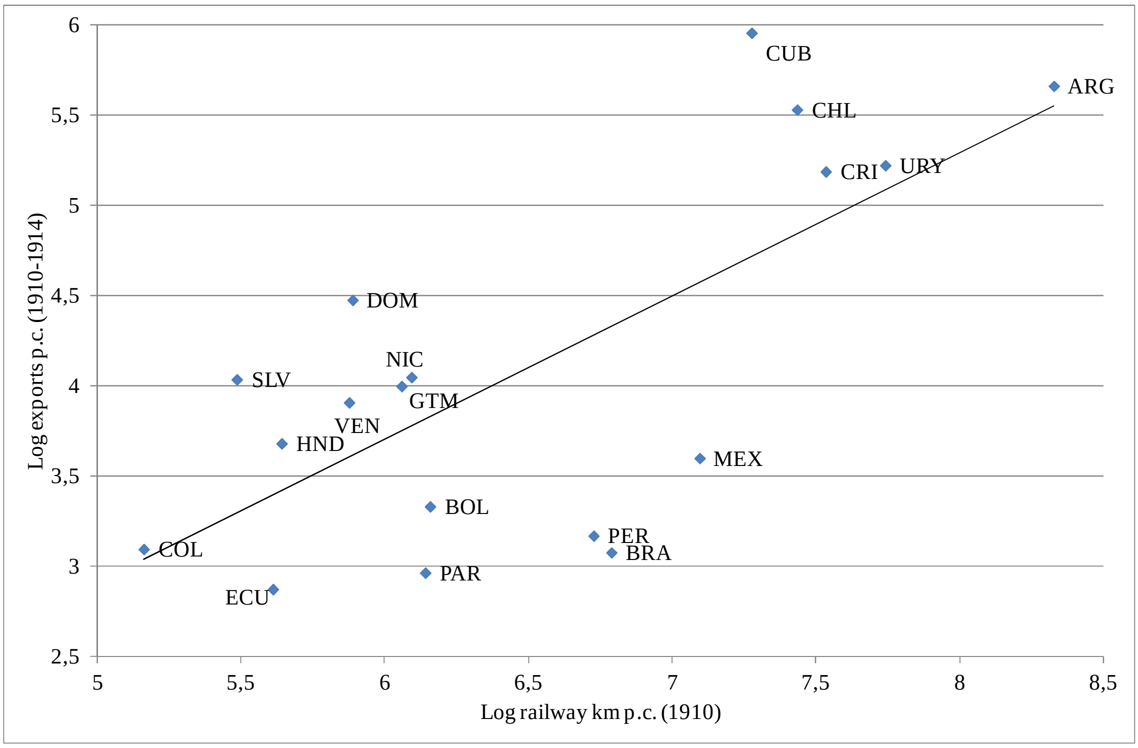
Defaults, spreads and exchange rate regimes

Default histories were coded from Esteves (2007b) and Suter (1990); the yields on British consols come from Accominotti et al. (2011) and Homer and Sylla (2005); spreads over British consols use mostly four sources: Accominotti et al. (2011), Ferguson and Schularick (2006), Esteves (2007b) and Clemens and Williamson (2004); exchange rate regimes (gold and silver/bimetallic standards) were coded from a number of sources: Accominotti et al. (2011), Bae and Bailey (2003), Esteves (2007a), Ferguson and Schularick (2006), Leavens (1939), Meissner (2005), Sédillot (1971), and Young (1925).

Wars, changes in the executive, legislative effectiveness and diplomatic representation

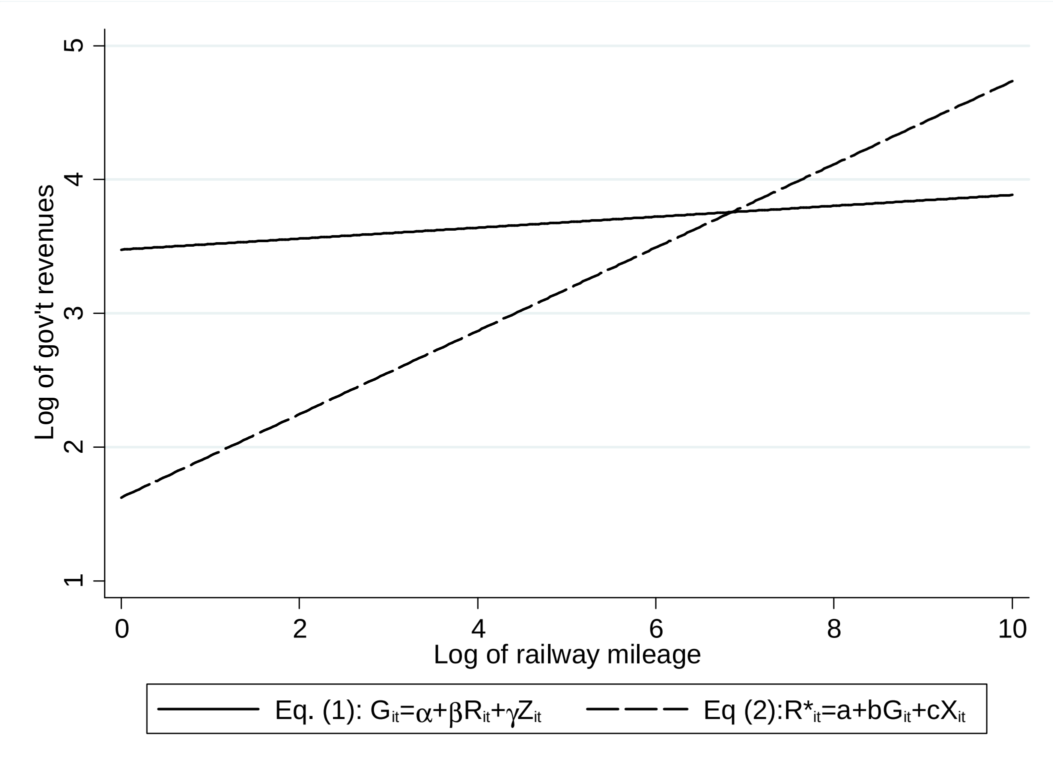
The numbers of international and other wars that affected each country were compiled from the Correlates of War database. The number of changes in the executive and the index of "legislative effectiveness" were taken from Banks (1994). Finally, the aggregate level of diplomatic representation was worked out from Bayer's (2006) database that lists 5 levels of bilateral representation. We added up these indices for all the representations abroad of each Latin American country and used the sum as an instrument for government revenues.

Figure 1: Railway p.c. and exports p.c. in Latin American economies in 1910.



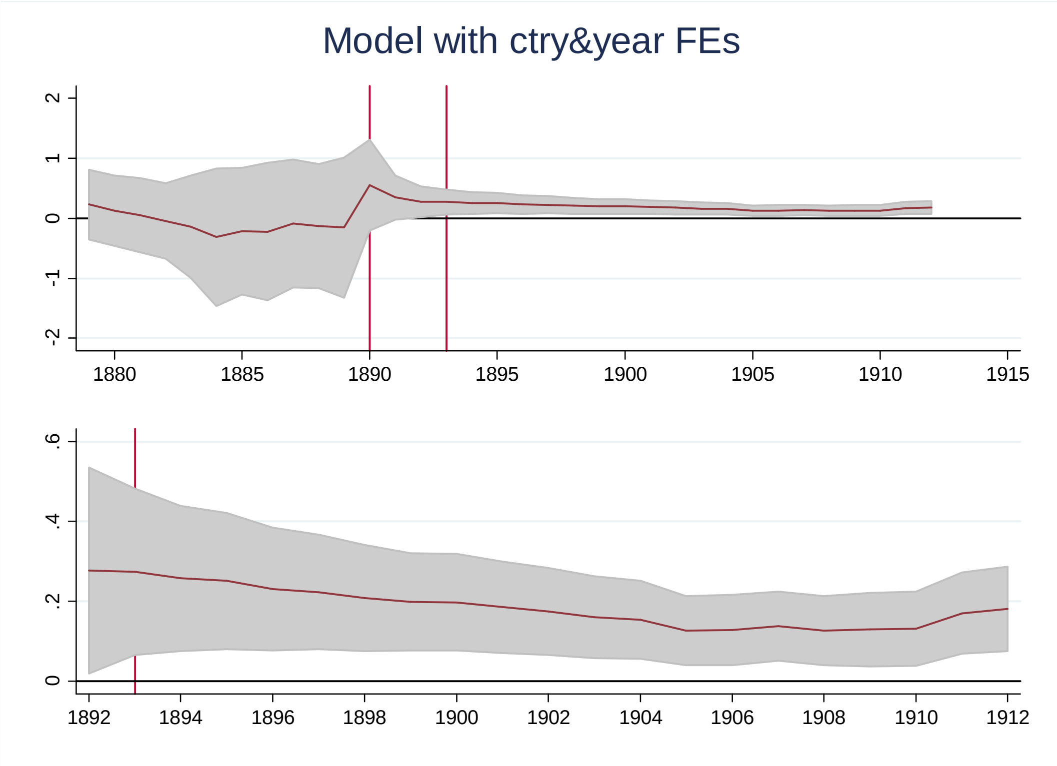
Source: Export p.c. from Bértola and Ocampo (2010: 98); for railways p.c., see the Appendix.

Figure 2: Estimated linear relation between government revenues and railways



Note: the Figure represents the model with country fixed effects. Whereas the slope b = 3.2 is obtained directly from Table 4, for β we multiplied the estimate of the elasticity of government revenues to trade from Table 3 (0.337) by the estimated coefficient of railways in the first stage. The system is stable because this estimate for β = 0.04 is smaller than b. Likewise, in the model with country and year fixed effects, b = 2.0 and β = 0.1.

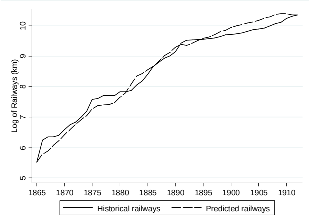
Figure 3: Coefficients and 90% confidence intervals of Log government revenues



Note: for each observation, the year indicates the end of the sample.

Figure 4: Actual vs. predicted mileage of the Latin American railway networks (in logs)

ARGENTINA



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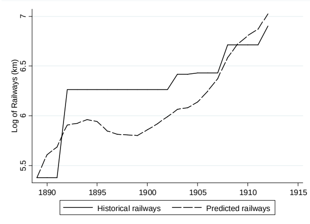

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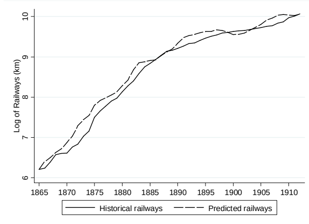

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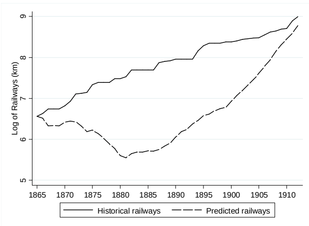

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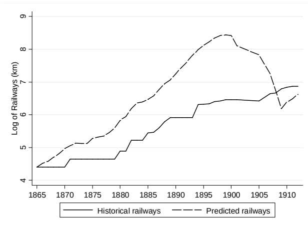

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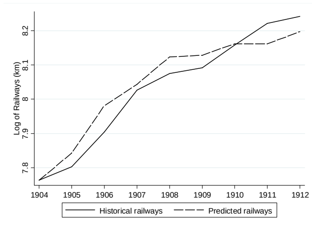
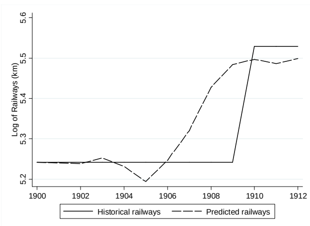


DOMINICAN R.



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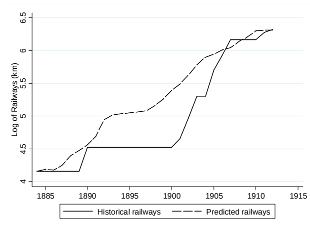

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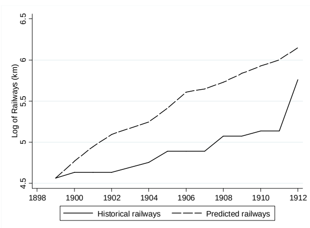

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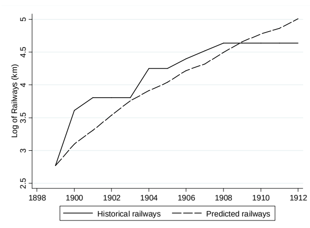

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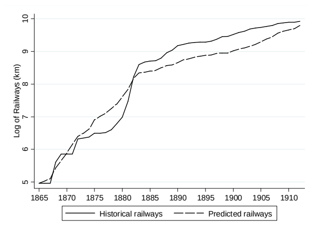

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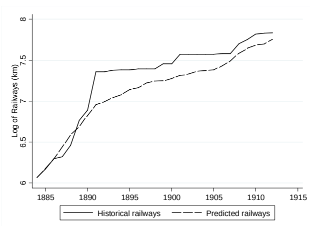

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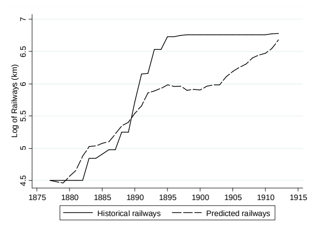

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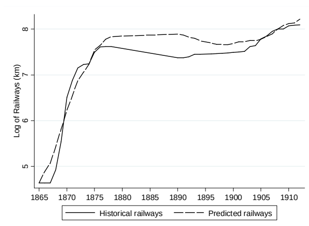

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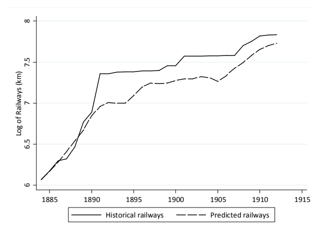

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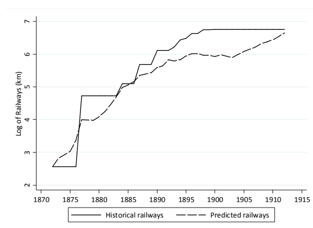

Table 1: Railway mileage in Latin America in 1913

	Total length (km)		Km per 10,000 km^2		Km per 1,000 pop.
Argentina	32,494	Puerto Rico	672.23	Argentina	4.27
Brazil	24,614	Cuba	339.94	Chile	2.19
Mexico	20,447	Uruguay	186.48	Uruguay	2.19
Chile	8,070	Costa Rica	134.36	Costa Rica	1.77
Cuba	3,874	Salvador	120.66	Cuba	1.47
Peru	3,317	Argentina	114.89	Mexico	1.27
Uruguay	2,576	Chile	109.71	Brazil	0.94
Bolivia	1,346	Mexico	103.74	Honduras	0.84
Colombia	965	Guatemala	85.13	Peru	0.83
Venezuela	890	Haiti	63.18	Bolivia	0.67
Guatemala	926	Dominican R.	51.21	Paraguay	0.61
Costa Rica	696	Honduras	47.77	Panama	0.57
Puerto Rico	612	Brazil	28.92	Puerto Rico	0.52
Ecuador	606	Panama	28.89	Guatemala	0.46
Honduras	532	Paraguay	26.96	Nicaragua	0.42
Paraguay	433	Peru	23.37	Venezuela	0.36
Nicaragua	294	Nicaragua	22.70	Ecuador	0.33
Dominican R.	252	Ecuador	21.27	Dominican R.	0.32
El Salvador	250	Bolivia	10.41	Salvador	0.22
Panama	217	Venezuela	9.76	Colombia	0.17
Haiti	180	Colombia	9.41	Haiti	0.10
Total	103,591	Weighted avg.	51.76	Weighted avg..	1.26

Source: See the Appendix.

Table 2: Summary statistics of variables included in the model

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Imports	513	-0.540	2.530	-13.564	5.412
Railways mileage	513	6.858	1.648	2.773	10.357
Pop×Pop trading partners	513	39.012	2.179	33.811	44.219
Effect. distance to UK	513	1.411	0.396	0.556	2.462
Effect. distance to US	513	0.728	0.626	-0.617	1.927
Population	513	7.792	1.100	5.321	10.144
No. of exec. changes	513	0.347	0.597	0.000	3.000
Interstate wars	513	0.055	0.227	0.000	1.000
Other Wars	513	0.066	0.249	0.000	1.000
Gov't Revenues	479	0.797	1.292	-4.023	3.724
Ambassadors	479	3.263	0.658	0.693	4.454
Legis. Effectiveness	479	1.762	0.777	0.000	3.000
Terms of Trade	479	4.736	0.235	4.223	5.406
Years since last default	479	0.655	0.402	0.000	1.000
British consol yields	479	1.043	0.107	0.815	1.227
Off Gold	479	0.701	0.458	0.000	1.000

Table 3: The determinants of government revenues in Latin American countries (1865-1913)

	(1)	(2)	(3)	(4)	(5)
Log imports (t-1)	0.516***	0.564***	0.513***	0.337***	0.292***
	(0.013)	(0.033)	(0.027)	(0.082)	(0.079)
Log population(t-1)		-0.165***	-0.070	0.445	1.391***
		(0.061)	(0.049)	(0.282)	(0.345)
No. of exec. changes(t-1)		-0.215***	-0.243***	0.065	0.048
		(0.077)	(0.073)	(0.040)	(0.042)
Interstate wars(t-1)		0.182	0.521***	0.007	0.221*
		(0.129)	(0.192)	(0.097)	(0.124)
Other wars(t-1)		-0.137	-0.184	-0.101	-0.075
		(0.157)	(0.149)	(0.083)	(0.086)
Year FE	No	No	Yes	No	Yes
Country FE	No	No	No	Yes	Yes
Observations	513	513	513	513	513
Over-id *p-value*	0.000	0.000	0.000	0.010	0.483
Under-id *p-value*	0.000	0.000	0.000	0.000	0.000
F stat (1st stage)	358.3	73.36	108.24	11.03	18.25
Anderson-Rubin *p-value*	0.000	0.000	0.000	0.000	0.002
Stock-Wright *p-value*	0.000			0.000	0.002

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Omitted coefficients: constant, border changes and fixed effects.

Table 4: The determinants of railway development in Latin American economies (1865-1913)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log gov't revenues (t-1)	0.112***	0.109*	0.131**	0.090	0.143**	0.305**	0.181***
	(0.033)	(0.057)	(0.055)	(0.059)	(0.062)	(0.119)	(0.064)
Log railway mileage (t-1)	-0.080***	-0.068***	-0.091***	-0.059**	-0.083***	-0.095***	-0.092***
	(0.021)	(0.026)	(0.032)	(0.025)	(0.030)	(0.025)	(0.023)
Log terms of trade (t-1)	0.033	0.050	-0.006	0.050	0.018	-0.149	-0.038
	(0.044)	(0.053)	(0.065)	(0.066)	(0.068)	(0.121)	(0.077)
Log pop×pop trad partners (t-1)		-0.011		-0.009	-0.017	-0.091*	-0.233***
		(0.011)		(0.012)	(0.010)	(0.051)	(0.083)
Log effect distance to UK (t-1)		0.007		0.004	0.017	-0.087	-1.104**
		(0.022)		(0.021)	(0.026)	(0.399)	(0.509)
Log effect distance to US (t-1)		-0.023		-0.010	-0.012	-0.078	1.205**
		(0.028)		(0.026)	(0.018)	(0.396)	(0.542)
No. of exec. changes (t-1)			0.002	-0.001	0.008	-0.019	-0.004
			(0.011)	(0.012)	(0.014)	(0.021)	(0.016)
Interstate wars (t-1)			-0.051	-0.030	-0.060*	-0.016	-0.102**
			(0.041)	(0.034)	(0.034)	(0.049)	(0.042)
Other wars (t-1)			0.013	0.014	0.031	0.062	0.006
			(0.023)	(0.024)	(0.026)	(0.042)	(0.029)
Years since last default			-0.015	0.000	-0.018	-0.014	-0.014
			(0.027)	(0.023)	(0.024)	(0.032)	(0.026)
British consol yields			-0.159	-0.035	0.317	-0.226	
			(0.153)	(0.125)	(1.602)	(0.143)	
Off gold			0.026*	0.022	0.058	0.068	0.048
			(0.016)	(0.030)	(0.039)	(0.050)	(0.038)
Year FE	No	No	No	No	Yes	No	Yes
Country FE	No	No	No	No	No	Yes	Yes
Observations	479	479	479	479	479	479	479
Over-id *p-value*	0.502	0.219	0.246	0.093	0.504	0.805	0.307
Under-id *p-value*	0.000	0.002	0.000	0.001	0.001	0.004	0.000
F stat (1^{st} stage)	15.65	6.500	7.650	7.240	7.390	5.55	13.26
Anderson-Rubin *p-value*	0.008	0.078	0.007	0.110	0.031	0.001	0.001
Stock-Wright *p-value*	0.009	0.089	0.007	0.119	0.040	0.006	0.001

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Omitted coefficients: constant, border changes and fixed effects.

Table 5: 3SLS Estimates of government revenues and railways

	(1) Gov Rev	(2) RRs	(3) Gov Rev	(4) RRs	(5) Gov Rev	(6) RRs	(7) Gv Rev	(8) RRs
Log imports (t-1)	0.438***		0.410***		0.424***		0.231***	
	(0.026)		(0.033)		(0.070)		(0.078)	
Log population(t-1)	0.012		0.084		0.04		1.489***	
	(0.063)		(0.078)		(0.317)		(0.510)	
No. exec. changes(t-1)	-0.289***	-0.005	-0.309***	-0.006	0.095*	-0.035	0.036	-0.009
	(0.059)	(0.011)	(0.076)	(0.018)	(0.054)	(0.045)	(0.046)	(0.034)
Interstate wars(t-1)	0.066	-0.032	-0.482	0.025	-0.334	0.291	0.179	0.447
	(0.236)	(0.101)	(0.543)	(0.255)	(0.217)	(0.281)	(0.326)	(0.477)
Other wars(t-1)	-0.221*	-0.002	-0.227	-0.009	-0.099	0.048	-0.091	0.001
	(0.132)	(0.030)	(0.170)	(0.048)	(0.099)	(0.078)	(0.081)	(0.062)
Log rail mileage (t-1)		-0.051***		-0.031		-0.045		-0.047
		(0.017)		(0.034)		(0.051)		(0.060)
Log gov’t revenues (t-1)		0.069**		0.031		0.143		-0.079
		(0.029)		(0.099)		(0.098)		(0.266)
Log terms of trade (t-1)		-0.029		-0.049		0.478*		-0.107
		(0.120)		(0.200)		(0.289)		(0.281)
Log pop×pop trd part (t-1)		-0.001		0.004		-0.052		0.256
		(0.009)		(0.027)		(0.072)		(0.451)
Log effect dist to UK (t-1)		0.024		0.034		-0.496		0.043
		(0.039)		(0.076)		(0.696)		(1.213)
Log effect dist to US (t-1)		-0.007		0.014		0.414		-0.142
		(0.024)		(0.035)		(0.685)		(0.433)
Years since last default		-0.014		-0.004		-0.147		-0.076
		(0.040)		(0.055)		(0.150)		(0.108)
British consol yields		-0.004		0.222		-0.057		
		(0.079)		(0.536)		(0.210)		
Off gold		0.013		0.004		-0.067		0.018
		(0.021)		(0.058)		(0.060)		(0.063)
Year FE	No	No	Yes	Yes	No	No	Yes	Yes
Country FE	No	No	No	No	Yes	Yes	Yes	Yes
Observations	429	429	429	429	429	429	429	429
R-squared	0.665	0.107	0.498	-0.073	0.822	-5.564	0.9	-7.587

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Omitted coefficients: constant, border changes and fixed effects.

Table 6: Arellano-Bond estimates

	(1)	(2)
Log railway mileage (t-1)	0.891***	0.865***
	(0.015)	(0.018)
Log gov't revenues (t-1)	0.014	0.007
	(0.017)	(0.018)
Log terms of trade (t-1)	0.056**	0.004
	(0.028)	(0.035)
Log pop×pop trade partners (t-1)	0.053**	-0.056
	(0.022)	(0.039)
Log effect distance to UK (t-1)	0.076	-0.402
	(0.290)	(0.405)
Log effect distance to US (t-1)	-0.074	2.859**
	(0.287)	(1.340)
No. of exec. changes (t-1)	0.012	0.018
	(0.011)	(0.012)
Interstate wars (t-1)	-0.098***	-0.105***
	(0.030)	(0.036)
Other wars (t-1)	-0.000	-0.023
	(0.025)	(0.027)
Years since last default	0.022	0.025
	(0.020)	(0.021)
Off gold	-0.038*	-0.025
	(0.020)	(0.021)
Year FE	Yes	Yes
Country FE	No	Yes
Observations	567	567
Over-ID *p-value*	0.017	.

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Omitted coefficients: constant, border changes and fixed effects.

Table 7: Non-stationary panel estimates

Short-run coefficients	DFE	PMG	Long-run coefficients	DFE	PMG
			Error correction	-0.041**	-0.050***
				(0.018)	(0.012)
Δ Log railway mileage (t-1)	0.472***	0.435***			
	(0.011)	(0.030)			
Δ Log gov't revenue (t-1)	0.025	-0.019	Log gov't revenue (t-1)	0.955	1.072***
	(0.023)	(0.048)		(0.630)	(0.131)
Δ Log terms of trade (t-1)	-0.131**	-0.095	Log terms of trade (t-1)	1.114	-1.433***
	(0.057)	(0.085)		(1.676)	(0.386)
Δ Log terms of trade (t-2)	0.068*	-0.003			
	(0.037)	(0.059)			
Δ no. of exec. changes (t-1)	-0.002	-0.009	No. of exec. changes (t-1)	0.511	0.968***
	(0.011)	(0.013)		(0.390)	(0.258)
Δ no. of exec. changes (t-2)	0.007	0.022**			
	(0.008)	(0.009)			
Δ interstate wars (t-1)	-0.004	-0.014	Interstate wars (t-1)	-1.685*	-0.914*
	(0.025)	(0.010)		(0.896)	(0.523)
Δ other wars (t-1)	-0.012	-0.005	Other wars (t-1)	-0.055	-0.174
	(0.016)	(0.013)		(0.244)	(0.168)
Δ years since last default (t-1)	-0.124***	2.482	Years since last default (t-1)	0.84	1.259***
	(0.032)	(2.552)		(0.635)	(0.312)
Δ years since last default (t-2)	0.070**	-0.704			
	(0.029)	(0.763)			
Δ British consol yields (t-1)	0.139	-0.229	British consol yields (t-1)	2.206	-0.06
	(0.295)	(0.307)		(1.621)	(0.546)
Δ British consol yields (t-2)	-0.164	0.101			
	(0.213)	(0.172)			
Δ off gold (t-1)	0.03	0.063***	Off gold (t-1)	-0.928	-0.441*
	(0.021)	(0.018)		(0.692)	(0.226)
Observations	543	543		543	543

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Omitted coefficients: constant, border changes, gravity controls and fixed effects.

Table 8: Elasticity estimates for different waiting periods

Lag (years)	1	2	3
ε(R*,G)	1.967***	1.749***	1.764***
	(0.543)	(0.428)	(0.413)

*** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses computed from the so-called Delta method.

Table 9: Counterfactuals for government revenues

Counterfactual	$R_{0,1913}$	$R_{1,1913}$	Permanent	Once	
			%	%	£'000
COL⇒ARG	0.94	12.1	2.96	107.80	1522.1
COL⇒URY	0.94	13.81	3.10	113.26	1651.2
PER⇒MEX	2.34	10.37	1.42	51.61	1819.3
HND⇒CRI	2.16	11.95	1.03	37.52	455.3

$R_{0,1913}$ ($R_{1,1913}$) stands for the actual (counterfactual) railway density in 1913, expressed in km per 1,000 km^2.

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