Profit and Productivity on Argentine Railroads, 1857-1913

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Very Preliminary Draft for Discussion

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From the last decades of the nineteenth century until the foreign trade disruptions accompanying the First World War Argentina experienced dramatic economic growth. Between 1875 and 1913 real GDP per capita increased faster than four percent each year[1]. Contemporary observers and economic historians agree that by the outbreak of the First World War Argentina's GDP per capita placed the country very close to the top tier of western nations. A vibrant national economy had emerged from a war-torn gaggle of provinces in only half a century.

Assessments of Argentina's transformation abound, and point to a complex admixture of causes. The relative political stability achieved in the 1860s made it possible to attract the resources required to complement the rich agricultural endowment of the interior.[2] Immigrants poured into the country, attracted by relatively high wages in pampean agriculture, and pushed by agricultural recession in southern Europe.[3] Investment in all sectors of the economy, financed heavily from abroad, grew rapidly as well.[4] Argentina eclipsed Brazil among all the South American countries as the favored destination of British capital as early as the 1880s.[5] Railroads, a favorite sector of British finance, expanded rapidly into the interior, linking the agricultural hinterland to major port cities (see Figure 1).[6] Newly opened lands were placed quickly into cultivation, with arable

[1] Real GDP per capita taken from Cortes Conde "Estimaciones del PBI en la Argentina 1876-1935".

[2] On the political settlement that permitted political integration and economic growth see Seigh, "The Rise of Argentina's Prosperity: An Institutional Analysis."

[3] Vasquez Presedo, *El Caso Argentino*, 87-111.

[4] Davis and Gallman, "Savings, Investment, and Argentine Economic Growth before World War I;" Taylor, "External Dependence, Demographic Burden and Argentine Economic Decline."

[5] Stone, "British Direct and Portfolio Investment in Latin America before 1914."

[6] Unless otherwise indicated, the background material on railroad expansion in Argentina is taken from *Argentine Year Book, 1914*; Bunge, *Ferrocarriles Argentinos*; Rebuelto, "Historia del Desarrollo de los Ferrocarriles

agriculture overtaking the traditional pastoral economy of the interior.[7] Interestingly, despite widespread attention to the ensemble of conditions that contributed to Argentine economic growth, there have been very few attempts to identify the relative importance of the various factors contributing to Argentina's economic success.[8]

Three areas of interest dominate the literature on the history of the Argentine economy, and the railroad's role therein, and each of these harbors it own puzzles. The first of these is the relative contribution of factor accumulation in Argentina's aggregate growth. Factor accumulation indeed proceeded rapidly through the turn of the century. From 1890 to 1913, real GDP grew at 6.6 percent per annum.[9] The real capital stock grew by 4.8 percent a year over the same period, while the population increased at a rate of 3.5 percent each year[10]. By taking population growth as a proxy for the increase in the stock of labor, and accepting Taylor's finding that labor's share in national income was about 0.5 in 1914, it is possible to conduct a crude growth-accounting exercise. Subtracting the weighted-average rate of growth of 4.15 percent per year for inputs from the growth of GDP leaves an unexplained residual of 2.45 percent a year. As such, Diaz-Alejandro's claim that the "residual" explains very little of Argentina's early twentieth-century growth cannot be accepted without qualification[11]. On the contrary, the best available data suggest

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Argentinos;" *Stock Exchange Official Intelligence for 1914*; *South American Year Book, 1914*; Regalsky, "Foreign Capital, Local Interests, and Railway Development in Argentina;" and Lewis, *British Railways in Argentina*.

[7] Amaral, *Rise of Capitalism on the Pampas*; Adelman, *Frontier Development*.

[8] But see Taylor, "Peopling the Pampa," which isolates the impact of immigration.

[9] Cortes Conde, ibid.

[10] Taylor, "External Dependence," 913.

[11] Diaz-Alejandro, *Essays*, 8-9.

that aggregate productivity growth may "explain" more than half again as much of the increase in real output accounted for by factor accumulation. Though the recent literature provides a much sharper view of the role of factor accumulation, much is still missing from the story. Sectoral, regional, and even firm-level studies remain necessary, since they can serve to identify the factors that raised the aggregate productivity of the Argentina's newly arrived labor and capital in the decades before 1914. The first hypothesis of this paper is that one candidate for such a role (though certainly not the only one) was Argentina's railroad sector.

The second area of inquiry is the question of Britain's "informal empire" in Argentina. Railroads figure prominently here as well. The core notion of informal empire is that British business, by investing and operating abroad, created a web of British influence and commercial advantage in independent nations that resembled the British role in its formal overseas possessions. Argentina is viewed by some as the poster-child of Britain's informal imperialism before 1914, although historians have disputed certain features of that characterization in a running debate.[12] If the proof of the claim that Britain enjoyed the benefits of an informal empire in Argentina can be located in the mere existence of large quantities of British capital, than there is little left to discuss or study. However, for the concept of informal empire to be analytically meaningful, it must be distinguished from simple "foreign investment." There is no ready guide of how to do so, but one reasonable inference is the following: if informal empire, or any other form of privileged position in the Argentine economy, was important to British firms, then it should be detectable in the profits

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[12] For the positions taken in this literature, which at various points overlap with the "dependency" literature as well, see Jones, "Business Imperialism and Argentina, 1875-1900;" Cain and Hopkins, *British Imperialism: Innovation and Expansion, 1688-1914*; Thompson, "Informal Empire? An Exploration in the History of Anglo-

earned by these firms. This serves as the second hypothesis of this paper: British-owned railroads in Argentina enjoyed, on average, high profits.

The third issue is specific to railroads. In light of the fact that many of the firms in Argentina were British-owned, and all of them relied on British inputs and technology, it is reasonable to conjecture that these firms existed in part to benefit owner and suppliers of inputs. An implication of this is that foreign-owned companies, in the interest of generating benefits for suppliers of the factors used in providing transport, conspired against "efficiency and good service.[13]" An inference of this is that productivity performance on Argentine railroads was poor. This comprises the third hypothesis of the paper.

To test these hypotheses, and tie together questions of growth, informal empire, and productivity, this paper focuses on Argentina's railroads in the period before 1914. The paper proceeds in four sections. The first section describes the main sources of data utilized in the paper. The second section uses this data set to examine the direct economic impact of railroads in Belle Époque Argentina. The third section turns to the profit records of the two largest British railroads. The fourth section examines the productivity performance of the railroad sector. The main findings run in the following terms. 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. As a second-order effect, capital formation in the railroad sector no doubt impelled an appreciable portion of the process of factor accumulation itself

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Argentine Relations, 1810-1914;" Hopkins, "Informal Empire in Argentina, an Alternative View;" Bendana, *British Capital and Argentine Dependence*; Schwartz, *In the Dominions of Debt*.

[13] Coatsworth, Growth Against Development.

before 1914. With respect to informal imperialism's economic consequences the results are ambiguous. British railroads, proxied by the two largest British-owned lines, certainly did earn profits that exceeded those of the railroad sector as a whole. But these were not much greater than the yields on government debt instruments at the end of the period of study. Moreover firms not involved in transport seem to have enjoyed higher—and in some cases much higher—profits than the British-owned lines. Productivity gains exhibited by the railroad sector as a whole suggest a steady rise in transport efficiency. The gains that railroads created in Argentina where thus enhanced, as increases in total factor productivity reduced the costs of providing transport services over time. The final section of the paper concludes.

I. Data

The analyses in this paper draw on a rich base of newly assembled evidence. The core of this is an original data set containing operating and financial figures for the Argentine railroad sector. These data include figures on track, capital, passengers, freight tons, revenues, and operating costs of every major railroad in operation from 1857 through 1913. Moreover, it includes freight revenues and output in ton-kilometers for every railroad after 1891. Finally, the data set has series of stock and bond prices, along with dividends, for every British-owned railroad in Argentina. Three main sources provided the raw evidence used in this paper. The first of these was the Argentine government's annual volume of railroad statistics, which first appeared in 1892.[14] Of all the sources, this one was the most complete, providing a wealth of detail on revenues, service, costs,

[14] Argentina, Ministerio de Obras Publicas, *Estadistica de los Ferrocarriles en Explotacion*.

and investment for all of the major railroads. These volumes also provide retrospective summaries of tonnage, passengers, capital, total revenue, operating costs, and track mileage back to 1857.

The second source consulted was the annual statistical volumes of the Argentine government, which appeared from the 1860s up through the 1880s.[15] This was the original source for the retrospective series presented in the 1890s volumes of railroad statistics. Whenever possible, the retrospective series were checked against the original figures presented in the annual statistical volumes to screen out typographical errors. While the government's annual statistical volumes provide greater detail on railroad operations than that found in the retrospective series that appeared later, they lack measures of output in units of ton-kilometers and passenger kilometers. As such, indirect techniques must be used to estimate the length of average haul for the years before 1892. The third source is the semester and annual reports to the shareholders of the major British-owned lines.[16] All companies that issued debt or equity on the London Stock Exchange were required to submit their semester and annual reports to shareholders to the exchange. For overseas railroads these reports have been preserved from approximately 1880 onward. They typically contain no more operating detail than is available in the government-published sources. But they do provide additional information on firm finances and the capital structure. They also give insights into the main regulatory questions of the day. Together with both sets of the official statistical volumes, the company reports provide a fairly comprehensive portrait of the quantitative aspects of railroad operations in Argentina.

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[15] Argentina, *Rejistro Estadistico de la Republica Argentina*.

II. The Direct Impact of Railroads

To gauge the direct economic consequences of Argentine railroads this section provides estimates of the social savings on railroad freight services in 1913. The question of interest is "how much did railroads contribute to Argentine GDP?" That question is impossible to answer directly, because the Argentine economy cannot be observed in 1913 without railroad transport. Instead, a related yet different question is pursued: "how much would it cost the Argentine economy if it were deprived of its railroads in 1913 and forced to rely on its next most efficient mode of transport?" The answer to the second question is not the answer to the first. But it does very reasonably inform us of what the answer to the first question might look like. The second question thus exploits a specific counterfactual scenario to infer the direct gains that railroads afforded the Argentine economy.

The social savings are defined as the costs to the economy of depriving it of railroads in 1913. All other features of the economy, save the output of the non-transport sector, are held fixed, including the stocks of resources.[17] The magnitude of the direct social savings depends on three components: the quantity of freight service required by the economy; the unit cost savings provided by the railroad in hauling freight, and the sensitivity of the former to the latter. Examining just the first two components provides a rough upper bound on the freight social savings.

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[16] Complete runs of these reports from 1880 onward are archived at Guildhall Library, Corporation of London.

[17]The most complete derivation of the social savings model is Metzer, "Railroad Development in Tsarist Russia," 3-32. Various assumptions are embedded in the model, including constant unit costs in transport, no increasing returns to scale, the non-transport activities are perfectly competitive with no distortions, and the like. In the interest of brevity, and because many readers are familiar with those issues along with others related to the railroad social savings debates, I elide the discussion of those issues here. In many cases, the direction of the bias created by these assumptions can be known. See O'Brien, *New Economic History of the Railways*; and also Fogel, "Notes on the Social Savings Controversy."

Incorporating explicitly the third component makes it possible to construct a lower bound estimate of the railroad's gains.

Table 1 presents measures of freight service output. In 1913 Argentine railroads carried more than 40 million metric tons of freight, producing nearly nine billion ton-kilometers in freight service. The average distance traveled by a ton of freight was about 214 kilometers. By Latin American standards Argentina's freight density was staggering, producing some seven times as much freight service per capita as Brazil, and roughly three times that of Mexico.[18] Moreover, freight output rose quickly over the preceding two decades; the sector's output in 1892 was less than one billion ton-kilometers. Track mileage also expanded quickly, rising from less than 14,000 kilometers to more than 32,000 kilometers over this period (See Figure 1). The charge for one ton-kilometer of freight service in 1913 was one gold centavo, and had fallen in a fairly steady fashion from 1.4 gold centavos in 1892.

Alternatives to railroad transport were two: overland post roads, and water shipment. Coastal steamers and sailboats provided freight service along the littoral and up the waterways of the Rio de la Plata. Large carts and mule trains provided overland freight service to the interior.[19] With a few exceptions, it was these interior routes the new railroads followed when they were constructed. And it was these traditional purveyors of overland freight service that the railroads displaced. Most rail lines radiated outward from Buenos Aires, almost in the shape of a fan. For occasional stretches, lines or their branches did parallel rivers that were by and large navigable. As

[18] For Brazilian freight density in 1913 see Summerhill, "Railroads and the Brazilian Economy." For the Mexican evidence, see Coatsworth, *Growth Against Development*.

[19] Burgin, *Economic Aspects*, 116-118;

such, in the absence of railroads, some of the freight would have shifted to riverboats and not to long-haul trips in carts. Using cartage as the relevant counterfactual mode of transport thus introduces some upward bias in the estimated social savings. Though it seems that unlikely likely that this bias is sufficiently large to alter the qualitative implications of the quantitative results below, it remains a topic of ongoing research.[20]

The cost of non-rail shipment may be taken as 8.3 centavos per ton kilometer.[21] The British consul provided a detailed report in 1862 on trade conditions in the interior, and noted the charges to haul freight along key routes.[22] Typical among these was movement of freight by cart and mule between Cordoba and Rosario, a journey of roughly 215 miles. In 1862 more than 10,000 cart and mule journeys were made between these two towns, to deliver more than 16,000 tons of goods, at a charge of some 50 pesos fuertes per 150 arrobas.[23] Converting these figures to a ton-kilometer basis reveals that shippers paid about 8.3 cents per unit of service.

Argentine railroads thus provided a unit cost savings to the economy of 7.3 cents per ton kilometer in 1913. The top panel of Table 2 presents the estimate of the upper bound direct social savings. The product of the unit savings and total freight output comes to 650 million pesos. This was a little more than 25 percent of Argentine GDP in 1913. By any metric one might wish to

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[20] See below for discussion of rough adjustments to the freight social savings to allow for waterway substitution. A more refined adjustment is in progress, along the lines of Fogel's technique for U.S. railroads.

[21] Overland freight charges were likely even higher in the early nineteenth century. Observations available for the 1820s run as high as 0.22 pesos per ton-kilometer. See Burgin, *Economic Aspects*, 117.

[22] Great Britain. Parliamentary Papers. "Commercial Reports." *Report on Argentine Trade for 1862*, p. 14.

[23] The pesos fuertes of the 1860s are valued the same as the gold pesos of the 1890s and later; see Cortes Conde, "Export Economy of Argentina, 1880-1914."

employ, the result suggests a very large impact of railroad freight services on the level of GDP.[24] On the surface this is surprising. Argentina's reasonably level terrain might have been expected to lead to lower non-rail overland transport costs. In this case, the combination of the unit cost savings, and the very large share of Argentine total production accounted for by transportables, combine to create a large social saving. Although a variety of hidden, non-rail costs are ignored (the savings on shipping time and resultant reduction of inventories, and the lower likelihood of losing merchandise in transit are examples), the estimate of Table 1 is still quite large. However, as a measure of the direct impact of Argentine railroads this figure requires some basic sensitivity tests. One way to do so is to remove the requirement that non-rail modes of transport produce all of the 1913 freight services. This permits the quantity of freight service in the economy to vary with the price of service. To construct a lower-bound estimate of the railroads' impact, however, requires information on how sensitive the demand for freight services was with respect to price. Here the price elasticity of demand for freight services is derived econometrically.

Estimating the demand for freight services draws on annual time series from 1892 through 1913 for six variables: freight output in ton kilometers (Q), the unit charge for one ton-kilometer of freight service (P), GDP (Y), national population (N), the length of track in service (T), and time

[24] It is of course appropriate to query here about the likely impact of waterway substitution on the magnitude of this estimate. The main railroad running parallel to a waterway over a significant distance was the Buenos Aires and Rosario line, a heavily trafficked railroad that fused with the Central Argentine Railway in 1907. A good portion of the former ran parallel to the Rio Parana. 1860s charges for long hauls on the Parana come to about 0.014 Brazilian silver mil-reis. The mil-reis was ½ a Spanish American peso. By this measure, the unit river charge was almost one half the average railroad charge in 1913. If that were the only component of cost, the Rosario line should not have attracted even a ton of freight Of course, a variety of hidden costs explain the railroad's edge over the river. For the sake of argument, assume that the Rosario line produced zero unit savings on freight service, because of the nearby waterway. The reduction this implies for the social saving estimate is appreciable, but leaves the qualitative results unaltered: the direct social saving comes to 593 million gold pesos, still more than 23 percent of GDP, despite this over-stated adjustment for river shipping costs.

(YEAR).[25] Because freight rates were set by regulators they are taken here as exogenous. As such, no supply function is estimated. Ordinary least squares regressions of various specifications of the demand function yielded unsatisfactory Durbin-Watson statistics, indicating a problem with serial correlation. To correct for this I employed a Cochrane-Orcutt transformation. Variables that failed to take on statistical significance in any specification were dropped. The final estimates, with t statistics in parentheses, are:

$$\ln Q = -100 - 0.49 \ln P + 0.60 \ln Y + 0.06 \text{ YEAR}$$
$$(-6.9) \quad (-2.4) \qquad (5.6) \qquad (7.4)$$

R-sq 0.98
D-W 1.84
Rho 0.56

The parameter estimate on ln P is the elasticity of demand, and it shows the demand for freight services to be relatively inelastic with respect to price. The lower part of Table 2 presents the estimate of the lower bound freight social savings. Applying this elasticity and integrating the demand function with respect to price yields the lower-bound measure of the social savings. The resulting figure is 339 million pesos, which was a little more than thirteen percent of Argentine GDP in 1913.

[25] Output, unit charge, and track derive from the railroad data set. Population comes from the estimates of Vasquez-Presedo, *El Caso Argentino*, 92. Real GDP is taken from Cortes Conde, "Estimaciones del PBI." To render the GDP figures comparable with the railroad figures requires that GDP be converted from a paper money to a gold peso basis. This is done using the rate of 2.27 paper pesos per gold peso.

A second lower-bound estimate provides a simple check on this figure. It uses a linear demand schedule for freight services instead of the constant-elasticity form. The demand schedule intersects the Price axis at the unit charge for non-rail shipment, and intersects the price-quantity point observed in 1913. This is tantamount to assuming that no freight service was produced at the prevailing non-rail unit charge. Although clearly a downward biased measure, the resulting figure is only slightly less than the lower bound estimated in the preceding paragraph (328 million pesos, which is still at 12 percent of GDP).

In summary then, one can be reasonably confident that the direct social savings from railroads ran somewhere between 12 and 26 percent of Argentine GDP in 1913. As such, the railroad's impact on the Argentine economy on par with the total economic impact of immigration to Argentina in this period.[26] Of special interest, however, in the Argentine case is the amount of the "residual" that can be explained by the social savings. Table 3 shows the rise in the upper and lower bound estimates of freight social savings between 1892 and 1913. From those series it seems quite likely that the bulk of the railroad-induced benefits came after 1890. Two different approaches to the extent of overall productivity growth that can be assigned to the railroad are pursued here, and they yield roughly similar answers. Consider, first, how much of the increase in output per capita between 1892 and 1913 can be assigned to the railroad. Argentine GDP grew from 0.62 billion gold pesos in 1892 to 2.51 billion gold pesos in 1913. Population, however, grew from 3.7 million persons to 7.8 million over the same period. The increase in productivity was thus about 1.2 billion pesos. The social savings account for somewhere between 27 percent and 55

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[26] Taylor, "Peopling the Pampa," 120-121.

percent of this aggregate productivity gain. Consider, second, the unexplained residual in the increase in GDP between 1890 and 1913. If GDP were restricted to grow from 1890 to 1913 only as fast as factors accumulated, with no aggregate productivity increase in the economy, then the gap between the counterfactual and actual levels of income in 1913 would be about 1.1 billion gold pesos. The railroad's freight social savings in this case again accounts for anywhere from 31 percent and 60 percent of the residual's increment to GDP in 1913. By either measure, the railroad's contribution to Argentine economic success in 1913 was considerable.

III. British Railroads and Informal Empire

British firms, merchants, and investors occupied a prominent position in Argentina's economic transformation. Because of this, Argentina is often cited as one of the major cases of "informal empire." If, however, such an occult imperial relationship meant much, it should translate into some sort of an advantage for British business. "Informal empire" clearly merits evaluations in terms of its observable consequences. Of course, informality potentially renders many aspects of the phenomenon invisible. Even so, consequences that cannot be observed directly can still be reasonably inferred. This section provides one variety of such an evaluation. It does so by examining the profitability of the leading British-owned railroads. Profits provide one way of revealing whether Britain's informal empire translated into anything tangible. Moreover, by extending the measures of profit to include external benefits—the gains to shippers from cheap transport—it is possible to roughly gauge the degree to which the motor force "informal empire" generated benefits for Argentines.

This section poses and answers two questions. First, how profitable were the investments in British-owned railroads? Second, did these specific lines create any benefits, in the form of cheap transport, for the regions they served? Answering these questions proceeds in three steps. First, the profits of the railroad sector as a whole are computed, in order to provide a benchmark rate of return. Second, the profits of two main British-owned lines—the Central Argentine, and the Buenos Aires Great Southern--are estimated. Third, the measure of private profits is expanded to include a conservative estimate of the benefits each railroad created by reducing transport costs in the region it served.

The study of railroad profitability and the social rate of return from railroad investments has long captured the interest of economic historians. Extant research on the returns to railroad capital focuses largely on the United States and Canada.[27] There is comparatively little work of this kind in relatively backward economies, and, with the exception of Brazil, none measuring the consequences of public transport subsidies elsewhere in the Americas.[28] To begin with, two measures of profit are computed for the Argentine railroad sector as a whole. The first is an annual rate of return:

$$\pi_t = \frac{R_t - C_t - \delta K_t}{K_t} \qquad (1)$$

[27] Fogel, *The Union Pacific Railroad*; Fleisig, 'The Union Pacific Railroad' pp. 155-172; *idem*, 'The Central Pacific Railroad', pp. 552-566; Mercer, 'Building Ahead of Demand', pp. 492-500; idem, *Railroads and Land Grant Policy*; Ransom, 'Social Returns', pp. 1041-1060; George, *Government Subsidies*; Carlos and Lewis, 'The Profitability of Early Canadian Railroads', pp. 401-426.

[28] An exception is Feeny, *The Political Economy of Productivity*.

Where R is the annual operating revenue, C the annual operating cost, K the capital employed in the railroad, d the rate of depreciation. This simply expresses the railroad's net revenues, adjusted for depreciation, as a ratio. The results are shown in Figure 2. The accounting rates of return presented in the figure do not include depreciation; in effect, delta is zero. Three features are notable about the results in Figure 2. First, volatility for the sector as a whole is low. There are relatively few wild swings. Second, these profits are not high in any absolute sense. The maximum rate of return at no point exceeded 8 percent. Third, the behavior of the profit series is generally consistent with the main macroeconomic indicators of the Argentine economy, although there are some curious leads and lags. Railroad profits fell with the depression of 1873, dropping from the six percent or better that characterized the three years before the depression, to under five percent. Interestingly, profits fell well before the financial and economic crisis of 1890. Having recovered to their pre-depression levels in the period 1882-1884, they fell again, this time lower still, in 1889, staying relatively low through the 1890s. Figure 3 puts the railroad sector's annual profits in context, by comparing them to the yields on the Argentine internal debt, and the yields on consoles in London (after 1881). The return on railroads was well under the internal debt yield, typically just above the console yield, throughout the period.

Three factors militate against relying solely on the annual measure of profit. The first is the peculiarities of nineteenth-century railroad accounting in Argentina. Railroad capital was rarely depreciated in contemporary reporting, leading to an overstatement of the capital stock. Operating costs often included both replacement expenditures and new capital outlays, which should have appeared in the capital account. That they did not leads both to an understatement of net revenues, and to further distortions in the measures of capital. The second factor is the very nature of the cost

and earnings profiles of railroads. Railroads embodied investments that were long in maturing. The impulse to new production in the regions served by the railroad, and the associated increase in the volume of traffic over time, meant that profits in early years could be consistently low or even negative, yet quite high in later years. While such "construction ahead of demand" aids in revealing of the developmental impact of the railroad, widely varying annual rates of return across the years make it difficult to assess correctly the "average" return to the line for the period under consideration. Finally, in addition to the practical difficulties in accounting for profits on Argentine railroads, it turns out that the very measure of the annual accounting rate of return is inherently biased in an indeterminate direction.[29]

Since the annual profit series does not permit ready computation of the “average” rate of return for the sector as a whole over the entire period, I use a second measure to remedy this, computing the rate of return for which the present value of the railroad sector goes to zero:

$$PV = \sum_{T=0}^{T} \frac{(R_t - C_t - I_t - \delta K_t)}{(1+r_i)^t} + \frac{V_T}{(1+r)^T} \qquad (2)$$

where PV is the present value of the railroad, R is the railroad’s annual revenues, C are the annual costs, I is the annual investment outlay, K is the end-of-year capital stock, delta is a depreciation

[29]Accounting rates of return equal the true economic rate of return only if the depreciation schedule is the time-rate-of-change of the present value of the cash flow stream. To the extent that the stream is not constant then the accounting return can depart dramatically from the true return. See Thomas R. Stauffer, "The Measurement of Corporate Rates of Return: a Generalized Formulation," *The Bell Journal of Economics and Management Science* 2, no. 2 (1971): pp. 466-467.

rate, V is the value of the railroad at the end of the period (1913), and r is the internal rate of return for which PV equals zero. [30]

Internal rates of return for the sector, presented in Table 4, confirm the view of modest profits presented by the annual series. As a sensitivity test, different depreciation schedules are applied to the sector's capital stock.[31] The higher the depreciation rate, the higher the rate of return. Nonetheless, even assuming that the railroad burned 2.5 percent of its equipment each year, the profits on railroads were not high, barely rising above 5 percent. Although the experiences of individual railroads might vary considerably, for the railroad sector as a whole profitability appears quite modest. Spot observations of government bond yields near the end of the period suggest that railroad profits were effectively the same as the social rate of discount.

How did the two main British lines stack up against the sector as a whole? Evaluating in retrospect the efficacy of railroad investments is much like evaluating the need for subsidies. Here two evaluative criteria are relevant.[32] If informal empire was meaningful, then the market rate of return (for the market as a whole) should be less than the private return to the railroad. The second criterion for evaluation is the social rate of return. If the British-owned railroads actually created any benefits to Argentine shippers, then the social return from the railroad will exceed the market rate of return. Projects that met only the first criterion were undesirable, because they extracted super-

[30] Depreciation of Argentine railroads used in constructing the empirical estimates below, and for the net capital stock as a whole in the productivity estimates, is 1.5 percent per annum. By way of comparison, Davis and Gallman adopted a 1.7 percent rate for Argentine railroads; Davis and Gallman, "Savings, Investment, and Argentine Economic Growth before World War I. Rates of 1.5 percent and 1.97 percent have been applied to US railroads in this period; Neal, "Investment Behavior by American Railroads, 1897-1914," 132.

[31] Additional issues about the reliability of the capital stock measure are discussed below in the section on productivity.

[32]Engerman, 'Some Economic Issues Relating to Railroad Subsidies', pp. 443-463.

normal profits from Argentina. However, projects that met the second criterion, even if they did meet the first one, were desirable, because they created benefits for local shippers.

. The profits of the Central Argentine and the Buenos Aires Great Southern are computed as internal rates of return, as was done for the sector as a whole:

$$PV = \sum_{t=0}^{T} \frac{(R_t - C_t - I_t)}{(1+r_i)^t} + \frac{V}{(1+r_i)^T} \qquad (3)$$

where PV is the present value of the railroad, R is operating revenues in each year, C is operating costs, I is net capital expenditures, t is a time subscript indicating the year of operation, T is the time period corresponding to the final year considered (1913), V is the value of the railroad in the terminal period, and r_i is the internal rate of return.[33] For all railroads, both operating expenditures (C) and investment expenditures (I) in these reports contain part of the capital outlays. Replacements and new investment often appeared, in varying degrees, under operating costs. However, since both categories of expenditures appear in the numerator, the total capital expenditures, irrespective of accounting category, enter into the identity in the proper manner.

Table 5 presents the resulting estimates. The private internal rates of return for both lines were six percent per year. Clearly, the Central Argentine and the Buenos Aires Great Southern outperformed the sector as a whole (compare Table 4). Strictly speaking, these results support the

[33]Since there is no closed-form solution for r, it is calculated in expression (1) using numeric techniques. Because the expression is a polynomial it has multiple positive real roots, or more than one real positive r for which PV is zero. In practice the minimum positive real value for r is obtained here by finding the value of r for which slightly increasing and decreasing r causes PV to change sign.

notion that informal empire might have translated into superior returns. But were these truly "high" profits? Dividend data from a wide range of companies for the last years of the period suggest that even these lines were very modest performers.[34] In fact, double-digit returns from Argentine firms were the norm around 1910. In short, if the informal imperialists were successful in extracting a piece of the surplus, they weren't especially successful at doing so.

While the internal rate of return in the previous section provides a measure of the "average" profitability for the firm over the period under consideration, it misses the larger set of benefits created by the railroad through the reduction in transport costs. Since the assets most privileged by cheap transport—land and fixed capital—were owned largely by Argentines, any such benefits accrued to them and not the British owners of the railroad. The social return on the investment in each railroad of the two railroads is estimated. It adds to the profits of the railroad a measure of the external benefits arising from the savings on transport costs. High social rates of return reveal a railroad that is desirable because of it contribution to raising the level of income and output in the region it serves. The average social rate of return on the investment in the railroad is given by:

$$PV = \sum_{T=0}^{T} \frac{(R_t - C_t - I_t + B_t)}{(1+r_i)^t} + \frac{V}{(1+r)^T} \qquad (4)$$

[34] Drawn from dividend tables in the *Argentine Yearbook*, and from the dissertation in progress at UCLA by Yovanna Pineda.

where B_t is a measure of the external benefits, r_S is the social rate of return, and all other variables are the same as in (2) above. No attempt is made here to render a social valuation of V.[35]

The social benefits of the railroad project in each period (B_t) are the resource savings created by the railroad and received by the consumers of transport services.[36] Thus, the social rate of return encompasses the streams of producers' and consumers' surplus created by the railroad. No single measure of social benefits prevails in the literature. Although the actual levels of freight service each year derive from rail reports and government surveys, the counterfactual levels of freight service that would have prevailed in the absence of those railroads is unobservable. However, it can be reasonably inferred from the actual levels.[37] For both the Central and the Buenos Aires Great Southern, the estimates incorporate two assumptions: first, the demand schedule for freight services in the market served by each line was linear, and, second, at the prevailing pre-rail freight charge absolutely no freight was shipped. The social benefits in any year are taken as:

$$B_t = \frac{1}{2} Q_t \left(P_M - P_{Rt} \right) \qquad (5)$$

[35]Computing the social rate of return here is done with numeric techniques in the same manner as for the internal rate of return.

[36]In this case what is being redistributed would be income from the pre-rail transport sector, to the consumers of transport services in the economy once it had railroads.

[37]Studies of transport projects that calculated social benefits using freight shipments (as opposed to changes in land values) handled the issue in various ways. See Mercer, *Railroads and Land Grant Policy*, pp. 237; Davidson, 'A Benefit Cost Analysis', pp. 131; Carlos and Lewis, 'The Profitability of Early Canadian Railroads', pp. 415-416; Coatsworth, 'The Impact of Railroads', pp. 140; Ransom, 'Social Returns', pp. 1046.

where Q_t is ton kilometers produced by rail in year t, P_{rt} the rail charge per ton kilometer in year t, and P_m the ton-kilometer charge for pre-rail shipment. This implies that all of the freight carried by rail resulted from the reduced cost of shipment. While this is obviously "wrong"--substantial freight was shipped at pre-rail rates in Argentina, and that is precisely why those rates are available--it ensures that the resulting social benefits stream is not overstated. Such a strong assumption potentially does serious damage to magnitude of the estimated benefits. That they will prove to be large under such restrictive conditions inspires confidence in the argument that these lines unambiguously created gains to the regions they served. In practice, then, the average social rate of return is computed using a lower-bound measure of the freight social savings, just like that employed in the previous section of this paper. The average social rate of return indicates whether the benefits conferred by the railroad exceeded returns to investments in other projects available at the time.[38]

The bottom row of Table 5 shows that the lower-bound estimates of the social rates of return on the Central Argentine and Buenos Aires Great Southern were 14 percent and 12.4 percent respectively. Although one can certainly find Argentine firms that paid dividends higher than these average social rates of return at various points in time, it is worth bearing in mind that the railroad's social returns are likely very understated. In short, if informal imperialism did lead to earning high profits, the extraction of surplus value, or other sorts of commercial advantage, it did not prevent Argentines from enjoying appreciable benefits from the capital formed by British-owned railroads.

[38]The usefulness of the approach is underscored by a voluminous historical literature using it to offer new insights on the consequences of specific transport projects; Carlos and Lewis, 'The Profitability of Early Canadian Railroads', pp. 401-426; Coatsworth, 'The Impact of Railroads', pp. 140-142; Davidson, 'A Benefit Cost Analysis', pp. 127-150; Fishlow, *American Railroads*; Fogel, *The Union Pacific Railroad*; Mercer, *Railroads and Land Grant Policy*; Ransom, 'Social Returns', pp. 1041-1060.

IV. Productivity Change on Railroads, 1892-1913

How did the Argentine railroad sector perform in terms of productivity? If Argentina enjoyed falling transport costs as a result of rising productivity within the railroad sector, then total factor productivity growth within the industry contributed to the social savings, and hence productivity growth in the aggregate. To measure total factor productivity change, I pursue two independent measures. The first, limited to the period from 1892 to 1913, is based on the cost dual, and employs indices of input costs and output prices to provide an index of TFP:

$$A = \frac{c}{p} = \frac{r^k w^L f^M}{p}$$

where

$$p = \frac{R}{Q_p MC_p + Q_F MC_F}$$

The cost index in the numerators is a weighted geometric index of the railroad's main inputs: labor, capital, and fuel. The weights are the shares of wages, profits, and material costs in total costs for the sector as a whole in 1913. The input cost indices are also for the sector as a whole, using average coal costs, wages, and capital earnings. The denominator of the TFP expression confronted the problem of aggregating two distinct forms of output, namely freight and passenger services, into a single composite output measure that could be used to create a composite output "price." The levels of freight ton kilometers and passenger kilometers were aggregated using the

marginal cost of each (derived from a linear cost function) for 1913 to give a composite physical output series. Dividing this into total revenues provided a composite price used in the productivity index.

Figure 4 presents the resulting index of railroad TFP for 1892-1913. Efficiency at the end of the period was some 70 percent greater than at the beginning. Indeed, TFP increased at an average rate of three percent per year.

The second estimate of TFP change pushes the estimates back to 1875, and avoids a potential pitfall of the index in Figure 4. Because the first estimate uses the dual, and railroads were a regulated activity, it may systematically distort the numerator. If freight and passenger fares were set too low by regulators, the capital earnings in the cost index would not reflect actual capital costs. Referring to Figure 3, it is clear that capital earnings were at a level that suggests the risk of such a distortion is quite limited. Nonetheless, turning to physical measures avoids this problem. The second index divides outputs by inputs to derive TFP:

$$A = \frac{\alpha Q_F + \beta Q_P}{\phi L + \gamma F + \rho K}$$

where the Q's are indices of output of passenger kilometers and freight ton kilometers, L is an index of the number of railroad workers, F is an index of locomotive coal consumption; and K is an index of the net capital stock. Inputs were weighted by their respective cost shares, while outputs where weighted by their revenue shares.

Detailed discussion of the derivation of the underpinning components is suppressed here, but it is important to note that reliability of the input and output series is greater after 1891 than

before. From 1892 to 1913 components are taken directly from railroad operating and financial figures. From 1875 to 1891 several different estimations were required. Neither passenger nor freight output was directly available, since no data on the average passenger trip and freight haul was reported. These were estimated, by regressing them on revenues and other likely correlates from 1892 to 1913, then extrapolating backward to 1875. Direct information for selected lines in 1869 and 1886, and the sector as a whole in 1888, provided a check on the output estimates. The capital input posed no difficulty.[39] Railroad employment was derived indirectly, in two steps. First, the railroad wages in 1892 were extended backward to 1881 using an index of real wages for unskilled workers in Buenos Aires.[40] The average share of wages in total operating costs in the 1890s was applied to total operating costs from 1875 to 1891 to establish an estimated labor share of costs. Dividing the wage into total labor costs yielded an estimate of employment. From 1875 to 1880 the same procedure was applied, using the 1881 railway wage. For coal usage, consumption is derived using some basic ratios. The average share of railroad coal consumption in total Argentine coal imports from 1892 to 1913 was 25 percent. This figure was applied to coal import quantities from 1875 to 1891 to derive railroad coal consumption, with the exception of 1881-1886. For those years, the coal estimate comes from linear interpolation.

[39] Given the large amount of "water" in the accounts of US railroads in this period, such a claim warrants a brief elaboration. Both contemporaries and historians have found that the Argentine government was very diligent in preventing over-statement of railroad capital stock. A leading contemporary railroad specialist noted that water might account for only a few percent of the recognized book value of the railroads in Argentina, in explicit contrast to the watering-run-amok problem in the nineteenth-century US; see Bunge, *Ferrocarriles Argentinos*, 101-112. By way of example, attempts by the newly fused Central Argentine Railway and the Buenos Aires and Rosario line to write-up dramatically the book value of their merger were refused by the Argentine government; see Lewis, *British Railways in Argentina*, 160-161. The figures accepted by the Argentine government accurately summed the capital accounts of the two merging firms; *Estadistica de los Ferrocarriles en Explotacion*, 1907.

[40] Taken from Cortes Conde, *El Progresso Argentino*.

Figure 5 presents the resulting index. The levels from 1892 to 1913 support the results in Figure 4. From 1875 to 1892 productivity in railroads rose as well, though it dipped a bit in the 1880s. Overall, the trend rate of growth was 2.6 percent a year, less than the trend rate of growth of real GDP per capita over the same interval. In light of precarious nature of the TFP estimates for the 1870s, less can be made of those than of the 1880s, and especially 1890s onward. The sources of this productivity growth were several, though quantitatively, it is difficult to separate out their relative contributions. Qualitatively, it is easier to identify likely contributors. Locomotive horsepower increased in the late nineteenth century, and the application of new braking systems allowed trains to run at higher speeds between stations, and begin to stop later, thus raising average speed. One source of productivity gain that can be crudely quantified is the impact of increasing utilization. Because railroad investments could be long in maturing, the physical capacity may be in place before there is sufficient demand for railroad services to fully utilize the track and rolling stock available. This would make productivity appear low, especially if later on utilization rises (thus making later productivity look high). To see what impact this had in Argentina, Figure 5 presents a second line based on a counterfactual TFP growth. The growth of the capital stock is constrained to equal the growth of output, thus imposing a fixed capital-output ratio. While there is little difference between the two lines early on, the divergence later is clear. The gap between the two is the amount of TFP growth accounted for by rising capacity utilization.

Argentine railroad productivity may be placed in context by comparison to similar estimates for the U.S., U.K., and Canada. Table 5 presents relative partial and total factor productivities for

Argentina and those cases.[41] In comparison with both the UK and US, Argentine total factor productivity was relatively high in 1875, did not grow as quickly through 1890, then began to catch up through 1910. In comparison with Canada, Argentine railroad productivity started much higher, but did not grow as fast.[42] Given that railroad technology was largely of US and UK origin, it is perhaps unsurprising that Argentina's productivity performance was so similar to that in the two most advanced and industrial nations.

Productivity increases within the sector redounded to the economy as a whole, since they permitted railroads to produce ever increasing levels of service at lower cost. Had Argentina's railroads not enjoyed any productivity increase after 1890, it would certainly have reduced the freight social savings, by as much as one third to one half (although they would have remained significantly large irrespective). Productivity improvements within the railroad sector were a key contributor to the overall benefits arising from the railroad development in Argentina.

IV. Conclusions

Argentina, more than any other Latin American nation, relied on British capital to fuel its economic growth. More British capital went into railroads than any other sector of activity before 1914. These investments, like British investments in Brazil, were attracted to areas of recent or

[41] U.S. railroad productivity taken from Fishlow, "Productivity and Technological Change in the Railroad Sector, 1840-1910" (with the 1875 values interpolated from Fishlow's 1870 and 1880 estimates); UK railroad productivity is actually for England and Wales, derived from Hawke, *Railways and Economic Growth* (from 1875 to 1890), and Foreman-Peck, "Railways and late Victorian Economic Growth," (from 1890 to 1910); Canadian railroad productivity from Alan Green, "Growth and Productivity Change in the Canadian Railway Sector, 1871-1926," chap. in Engerman and Gallman, *Long-Term Factors in American Economic Growth*.

[42]Indeed, TFP growth is so rapid on Canadian railroads when compared with the other countries that one cannot help but wonder about the robustness of the estimates with respect to their assumptions; see Green, "Growth and Productivity," and Fishlow's comments therein.

hoped-for future settlement. In practice, however, they did not garner over the long term the bulk of the benefits they created. Rather, they earned only modest rates of profit. The rest of the gains they generated went to Argentine producers and consumers, who found in the railroad an affordable replacement for archaic modes of shipment. Moreover, in an economy undergoing rapid accumulation of new stocks of inputs, these railroads were an important contributor to aggregate productivity gains, first by replacing a less efficient mode of shipment, and second by registering their own intra-sectoral productivity increases. There can be little doubt that railroads were essential for economic growth, and no doubt played a major role in transforming the Argentine pampa.

TABLE 1 RAILROAD FREIGHT SERVICES IN ARGENTINA, 1913

RAILROAD	TONS	TON KILOMETERS	REVENUES
Central Norte	2,054,698	443,114,994	3,938,442
Argentino del Norte	493,038	88,420,125	1,220,865
Provincia de Santa Fe	2,062,650	481,846,619	4,764,336
Cia. General en la Provincia de Bs. As.	1,294,712	274,233,229	2,497,954
Central Cordoba	3,183,087	866,708,093	7,954,572
Pacifico	17,261	1,971,071	105,002
Central del Chubut	32,854	2,299,308	96,713
Tranvia a Vapor de Rafaela	55,017	1,925,595	51,686
Nor Este Argentino	374,148	98,526,997	1,218,004
Entre Rios	961,006	164,073,855	2,125,840
Central de Buenos Aires	581,043	105,089,863	998,257
Sud de Buenos Aires	9,610,775	1,594,695,007	16,834,518
Oeste de Buenos Aires	3,747,462	882,478,389	8,793,509
Central Argentino	10,033,984	2,029,615,655	20,760,430
Buenos Aires al Pacifico	3,686,933	1,328,780,378	11,800,325
Pacifico (Bahia Blanca y N. O.)	1,705,685	276,952,046	2,431,767
Pacifico (Gran Oeste Arg.)	1,688,203	271,533,308	4,213,538
Rosario a Puerto Belgrano	450,694	73,117,158	830,260
TOTAL	42,033,250	8,985,381,690	90,636,018

NOTE: Revenues are in gold pesos of 1913.

TABLE 2—Direct Social Savings on Freight Services, 1913, Unadjusted for Water Substitutes

UPPER BOUND

Freight Output	9 Billion Ton-Kilometers
Cost of Service in absence of Railroad	0.74 Billion Gold Pesos
Cost of Service by Rail	0.091 Billion Gold Pesos
Direct Savings	0.65 Billion Gold Pesos

LOWER BOUND

$$LBDSS = \int_{Pr}^{Pn} DP^{a}\,dp = D\left[\frac{P^{a+1}}{a+1}\right]_{Pr}^{Pn} =$$ 0.34 Billion Gold Pesos

TABLE 2—Direct Social Savings on Freight Services, 1892-1913 (unadjusted for water substitutes)

Year	DSS	DSS/GDP	LBSSA	LBSSA/GDP
1892	60,153,541	0.10	35,418,327	0.06
1893	73,623,802	0.11	42,305,751	0.06
1894	88,075,019	0.11	48,984,808	0.06
1895	96,848,452	0.12	55,127,636	0.07
1896	121,998,075	0.12	67,814,057	0.07
1897	107,286,470	0.14	59,866,608	0.08
1898	115,782,225	0.13	66,431,851	0.07
1899	143,867,997	0.14	83,057,178	0.08
1900	149,798,795	0.15	85,475,370	0.09
1901	188,108,651	0.18	102,223,829	0.10
1902	191,957,678	0.18	103,343,585	0.10
1903	208,580,074	0.17	117,279,577	0.09
1904	254,492,756	0.17	140,992,453	0.10
1905	298,673,364	0.18	163,783,484	0.10
1906	356,252,520	0.21	191,640,843	0.11
1907	373,671,881	0.23	201,505,119	0.12
1908	434,042,811	0.23	235,368,845	0.12
1909	434,083,281	0.21	235,224,554	0.11
1910	463,110,495	0.22	248,557,367	0.12
1911	502,479,590	0.23	266,905,433	0.12
1912	584,796,246	0.24	307,880,497	0.13
1913	655,150,662	0.26	338,709,252	0.14

NOTE: DSS is the upper bound measure of the direct social savings from railroads. LBSS is the lower bound estimate, derived by applying the price elasticity of demand for freight services.

Table 3—Internal Rate of Return to Argentine Railroads, 1857-1913, under different depreciation scenarios

Rate of Depreciation	Internal Rate of Return
0	4.02
1	4.45
2	4.82
2.5	5.01

NOTE: Depreciation rates are constant, applied to gross annual investment, and employ a perpetual inventory concept to derive the net capital stock each year. The first difference of the resulting series is net annual investment, and is used in the calculations of profitability discussed in the text.

Table 4—Average Annual Private and social internal rates of return on the two main British Railways in Argentina up through 1913

	BUENOS AIRES GREAT SOUTHERN	CENTRAL ARGENTINE RAILWAY
PRIVATE RETURN	6.0	6.05
SOCIAL RETURN	14.0	12.4

NOTE: see text for discussion of data and method.

Table 5—Comparative Railroad Productivity Growth: Argentina, U.S., U.K, and Canada, 1875-1913

Argentine Partial and Total Factor Productivity Growth

Year	ARG O/L	ARG O/K	ARG O/M	ARG TFP
1875	47.9	58.9	145.2	61.0
1880	39.2	41.3	200.2	49.3
1890	36.5	40.4	114.6	45.0
1900	81.1	65.3	129.1	82.3
1910	100.0	100.0	100.0	100.0

Comparative Partial and TFP Growth, Argentina and UK

Year	ARG/UK O/L	ARG/UK O/K	ARG/UK O/M	ARG/UK TFP
1875	0.7	1.0	1.6	1.1
1880	0.5	0.7	1.9	0.8
1890	0.4	0.5	1.3	0.6
1900	1.0	0.8	1.5	1.0
1910	1.0	1.0	1.0	1.0

Comparative Partial and TFP Growth, Argentina and US

Year	ARG/US O/L	ARG/US O/K	ARG/US O/M	ARG/US TFP
1875	1.0	1.5	1.3	1.3
1880	0.7	0.9	1.7	0.9
1890	0.5	0.8	1.0	0.7
1900	0.9	0.9	1.1	0.9
1910	1.0	1.0	1.0	1.0

Comparative Partial and TFP Growth, Argentina and Canada

Year	ARG/CAN O/L	ARG/CAN O/K	ARG/CAN O/M	ARG/CAN TFP
1875	2.3	2.0	3.2	2.4
1880	1.9	1.3	3.8	1.9
1890	1.3	1.0	1.8	1.3
1900	1.5	0.8	1.4	1.3

1910	1.0	1.0	1.0	1.0

FIGURE 1.

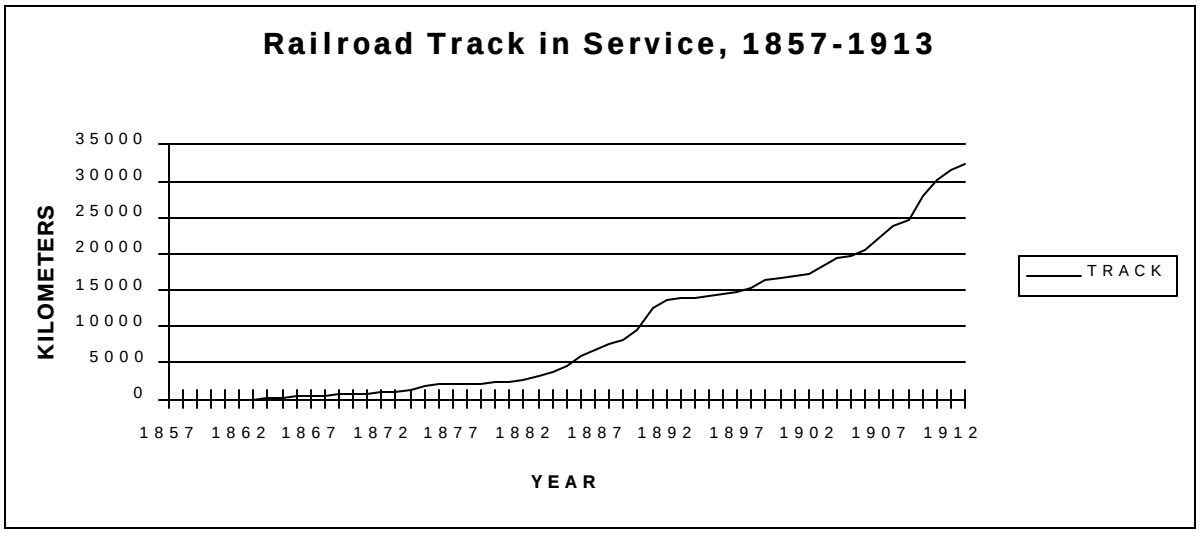
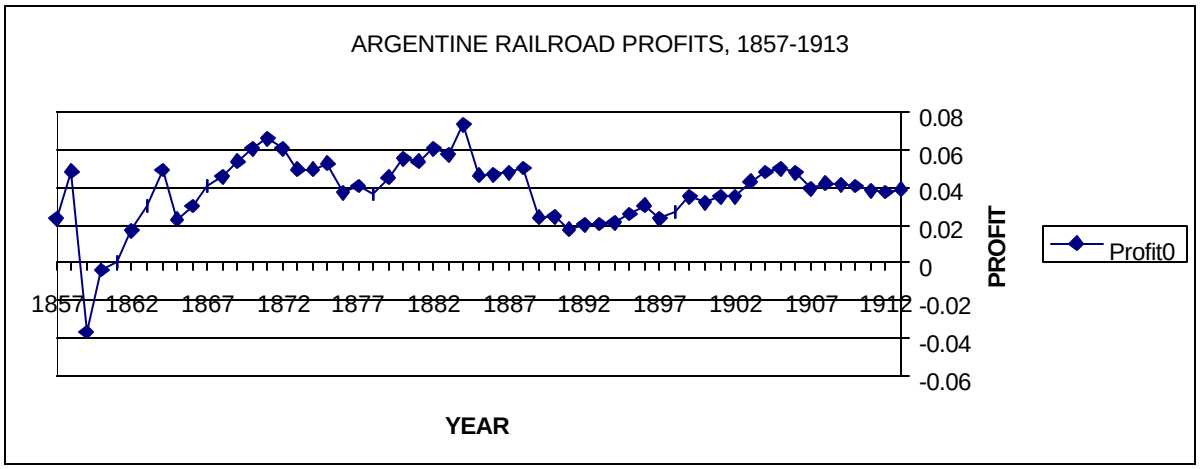
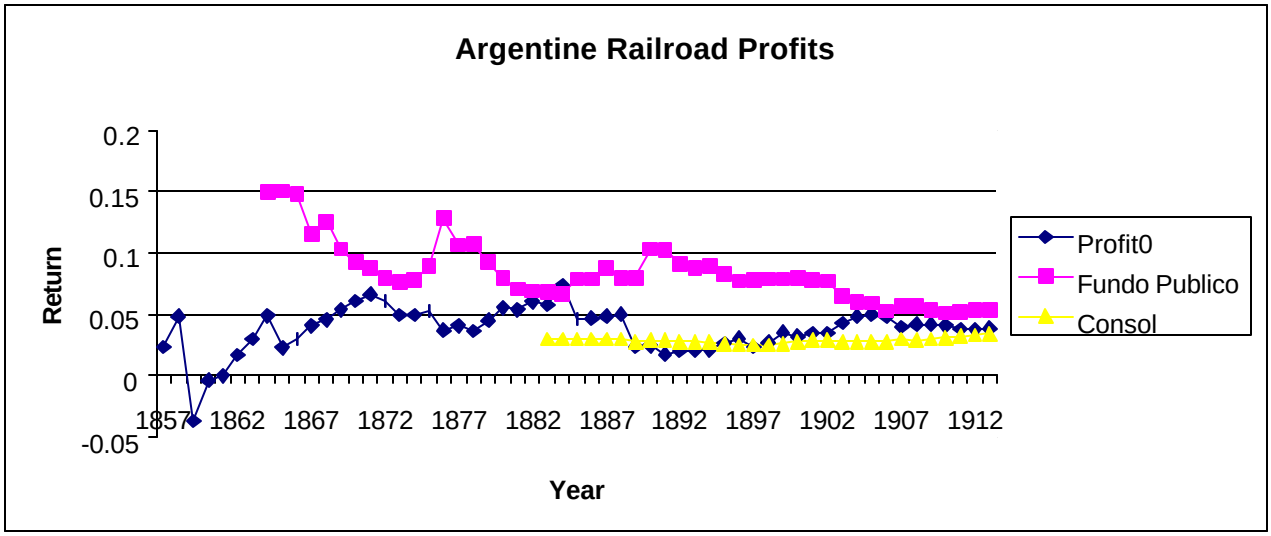


FIGURE 2



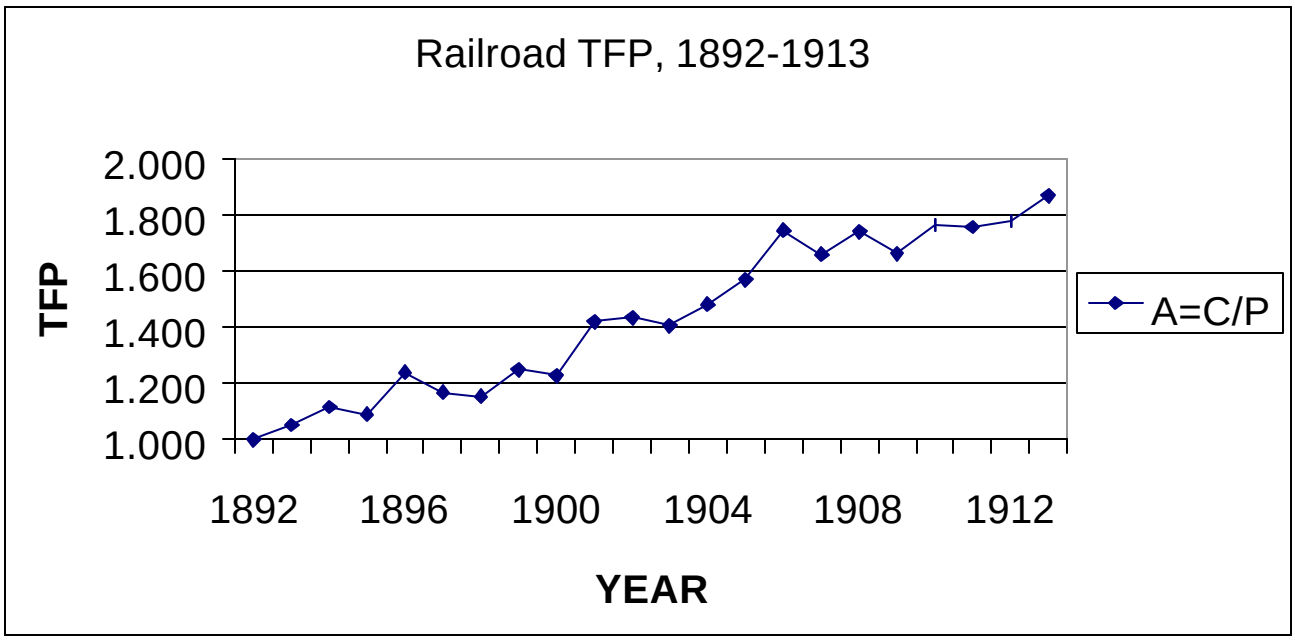
NOTE: “Profit 0” is net operating earnings divided by undepreciated capital stock of railroad sector.

FIGURE 3.



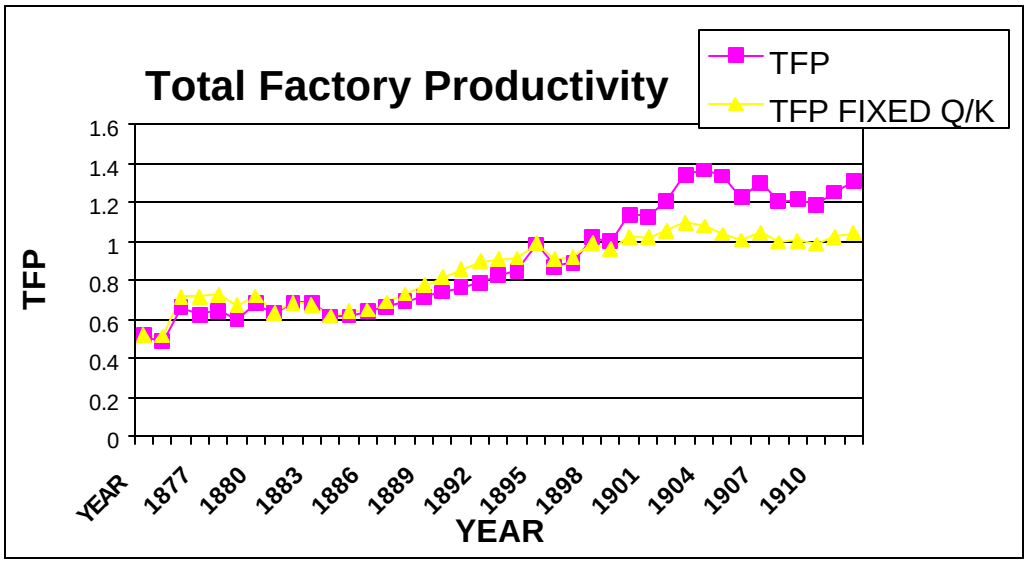
NOTE: "Profit 0" is net operating earnings divided by undepreciated capital stock. "Fundo Publico" is the current yield on Argentine internal debt. "Consol" is the yield on English consols.

FIGURE 4.



NOTE: TFP Computed using the dual, applying a geometric index of input prices and a hybrid output price. 1892 = 1.0.

FIGURE 5. Total Factor Productivity Growth, 1875-1913



NOTE: TFP computed using indices of physical outputs and inputs, with weights and components discussed in text. Index is set so that 1900 = 1.0. The Fixed Q/K index constrains the capital stock to grow at the same pace as output, controlling in part for increasing capacity utilization.