Government Ownership and Productivity: A Historical Perspective from Indian Railways

Dan Bogart
Assistant Professor
Department of Economics
UCI
dbogart@uci.edu

Latika Chaudhary
Assistant Professor
Department of Economics
Scripps College
latika.chaudhary@scrippscollege.edu

Draft: April 2010

Abstract

Using a new dataset on Indian railways, we study the effects of state ownership on productivity between 1874 and 1912. Despite the move to greater state ownership, Indian railways experienced rapid TFP growth of 1.7 percent per year in this period. Moreover, we find no evidence of a decline in TFP relative to trend following state takeovers of private companies. Our estimation relies on a key feature of the institutional background whereby the former private railway companies were taken over by the Government of India at predetermined dates set by contracts negotiated in the 1850s and 1860s. We compare the same railway system before and after it changed ownership to identify the effects on productivity. The neural effect of state ownership cannot be explained by the guarantee system where private companies received a 5 percent dividend guarantee. Instead we find that the Government of India undertook actions similar to private companies. Our findings have broad implications for understanding the effects of state ownership under colonial regimes.

Keywords: Nationalization, State Owned Enterprises, India, Railways, Institutions
JEL codes: D2, D23, H54, L33, N75, O2

We thank Kris Mitchner, Bill Sundstrom, Alex Field and seminar participants at Santa Clara University for valuable comments. We also thank the Center for Global Peace and Conflict Studies for providing valuable grant money. Garrett Neiman, Shivani Pundir, Jennifer Ringoen, Nilopa Shah, Henry Oh, Shayona Dhanak, and Sanjana Tandon provided able research assistance.

1. Introduction

Does state ownership undermine productivity? Do the effects of state ownership differ if the state is democratic, authoritarian, or controlled by foreign interests? Questions of this nature have long engaged economists generating a large theoretical and empirical literature. But, much of what is known about the effects of state ownership is based on case studies and econometric analyses of recent data. Relatively few studies consider evidence before 1980.

Our paper takes a historical perspective and studies a dramatic transition from private to state ownership in one of the most economically important sectors of the Indian economy. The first railways were constructed in India in the mid- nineteenth century and had transformative effects on the expansion of markets, price and wage convergence, and famine amelioration (Kumar, ed. 1982, Kerr 2007, Donaldson 2008, Studer 2008, Burgess and Donaldson 2010). The initial rail network was built and owned by private British companies operating under a favorable regulatory regime because the Government of India guaranteed a 5 percent dividend on capital. A clause in the original concession contract, however, allowed the Government to purchase a private railway company only at specified future dates. Beginning in 1880, the Government of India exercised the takeover option in every case and by 1910 the Government owned over 90 percent of railway miles compared to less than 10 percent in 1875.

Although the Indian experience mirrors the global wave of railway nationalizations that began in the 1870s, the state takeover of Indian railways was unique in two ways. First, the magnitude of the ownership change in India was very large compared to other parts of the world. Between 1870 and 1910 the fraction of world railway miles owned by private companies decreased from 90 to 70 percent and about 10 percent occurred through state takeovers of private railways (Bogart 2009). Second, the state takeover in India was implemented by a colonial

regime. Large-scale nationalizations also occurred in Switzerland and Japan but they were initiated or approved by democratically elected officials. In Germany, Austria, and Russia nationalizations were the brainchild of domestic, authoritarian governments. Colonial state takeovers were rare.

Our paper studies whether this shift from private to state ownership lowered total factor productivity in Indian railways. A reading of the recent literature on privatization would suggest government takeovers should lower productivity because a majority of the studies find significant increases in total factor productivity following privatizations (Megginson and Netter 2001, Djankov and Murrell 2002, and Estrin et al. 2009). In settings as diverse as Mexico, Romania, Canada, and Argentina privatization of firms has a positive effect on productivity in many different sectors including railways (La Porta and Lopez-de-Silanes 1999, Brown, Earle and Telegdy 2006, Ramamurti 1997, Laurin and Bozec 2001). Nonetheless, it is unclear whether nationalizations should necessarily produce the opposite effect and unlike the privatization literature, there are few rigorous empirical studies of nationalizations.[1]

To test the effects of government takeovers, we constructed a new data set of the 15 major railway systems operating in India. These systems jointly account for 90 percent of the total rail mileage in this period. Using *Annual Reports on the Administration of Indian Railways* and *Reports to the Secretary of State for India in Council on Railways in India*, we collected detailed information on mileage, passenger and goods traffic, fuel consumption, labor, locomotives and vehicles from 1874 to 1912. We also used the *Reports* to precisely identify the ownership and operation status of each railway system including when the state took ownership

[1] Some examples include Hart (1953) examining British trucking. There are some historical works examining the rise of state ownership and its effects on efficiency. See Hausman and Neufeld (1991), Toninelli (2000), and Bogart (2010).

of private lines. To our knowledge our study is among the first to use such detailed firm-level data to study state takeovers of private firms.

We begin our analysis by estimating aggregate total factor productivity (TFP) using average yearly residuals from a Translog production function. We include railway fixed effects and weight our observations by railway mileage to address railway specific heterogeneity and differences in size. Despite the increasing Government stake in the railways sector, our estimates show that Indian railways experienced relatively rapid TFP growth from 1874 to 1912. The average annual rate of 1.7 percent is comparable to TFP growth in US railways in the same period and greater than the TFP growth on British railways.

In the next part of our analysis, we test the effect of government takeovers by comparing railway systems before and after they changed ownership. We add a dummy for state ownership to our production function estimation and also control for railway fixed effects, year fixed effects, and railway specific trends. Surprisingly, we find no significant evidence of a decline in TFP relative to trend after state takeovers. The coefficient on state ownership is negative, but statistically insignificant. Moreover, the finding is robust to different specifications and robustness checks.

A major concern in such types of studies is the potential endogeneity of the timing of state takeovers. However, in our context the timing of government takeovers was predetermined and the state could not manipulate takeovers to coincide with periods of increasing or decreasing productivity. The Government of India could only takeover a railway company either 25 or 50 years after its original concession contract. Five railway companies were taken over on their 25th anniversary and due to an intervention by the British Secretary of State in 1869 the last three private companies were purchased on the 50th year of their contract. Although the takeover year

was exogenous, the firms may have anticipated the takeovers and these anticipation effects could bias the results on state ownership. To test this hypothesis, we include a dummy for the 5-year window before takeover and compare TFP after takeovers to TFP 5 years before takeovers. The main conclusion is unchanged: the switch to state ownership did not have a negative effect on productivity.

What can account for our findings on state ownership? One explanation is that the regulatory system of guaranteeing privately-owned railways a 5 percent return lowered their productivity and thus made privately-owned railways perform relatively worse than they would in other contexts. Another explanation is that the Government of India was a unique state, and thus made state-owned railways perform relatively better than in other contexts. To distinguish between the two explanations, we compare companies receiving guarantees to those that were not receiving guarantees at the time of state takeovers. If guarantees were the main factor, we would expect some difference in productivity because railways receiving no guarantees would presumably have had stronger private incentives and the transition to state ownership should be relatively worse for productivity. However, we find no evidence of a differential effect of state ownership on productivity depending on whether the private railway was receiving guarantees or not at the time of takeover.

We believe that unique features of the colonial government may partly explain the neutral effect of state ownership on Indian railways. The Government of India had a strong incentive to maintain productivity because railways contributed to a substantial portion of total government revenues—35 percent by 1913. Efficient administration of railways was also of great strategic interest to the British colonial authority. Last but not least, the Government of India was not a democracy. It was unencumbered by the usual pressures faced by elected officials. There was

little influence from labor unions demanding higher employment or locals demanding a train station and frequent services irrespective of need.

Our findings have important implications for understanding the effects of state ownership. In our context, state owned railways were just as productive as privately owned railways. Although one may question the generality of our case because private railways in India were regulated and subsidized, our private firms are not a complete anomaly. History and the present day offer numerous examples. In Latin America and continental Europe, private firms receiving government subsidies also constructed railways. Germany, France and Italy have subsidized their private car industries at some point or another during the past century. Today the US government insures banks deposits in private banks and provides implicit guarantees. In many real world contexts, the alternative to state ownership is rarely pure private and unregulated firms (Megginson and Netter 2001, p. 331).

We also think our findings do not imply that state ownership would have a neutral effect on productivity in other political contexts. Unlike railway nationalizations in Switzerland, Japan and France that decreased operating efficiency, state ownership in India was implemented by an authoritarian colonial regime. The Government of India, at least in the railways sector, was perhaps more concerned with costs and productivity relative to other state owned enterprises. In this respect, our paper relates to the growing literature on colonial institutions that emphasize both positive and negative effects of colonialism. Our finding suggest that while undesirable in many respects, colonial institutions may positively influence the effects of state ownership in sectors such as railways.

2. Background on Indian Railways

The first Indian passenger line totaling 20 miles was opened in 1853 and by the early

1900s India had the fourth largest national rail network in the world at 34,656 miles in 1913 (Government of India 1955). Throughout India's early railway development, private companies often conflicted with the state, but even in the public sphere different groups clashed with each other. The Secretary of State, housed in London, was a British Cabinet member and had formal control over administration in India. The Viceroy was instructed by the Secretary and served as the administrative head for the Government of India. British officials working for the Government were more in tune with Indian interests and at times advocated for greater efficiency and accountability. The Secretary of State, in contrast, was more influenced by the demands of private British companies.

Ten private companies incorporated in Britain constructed and managed the early lines under the 'guarantee system' up to 1868. Figure 1 shows a map of the rail network and the major private companies operating in 1870. The private railways were organized as joint stock companies through concession contracts entered into with the Secretary of State. The contracts had the following general terms. Capital was raised in Britain primarily through shares. The Government provided a 5 percent guarantee on the share capital at a fixed exchange rate of 1s. 10d to the rupee. The net receipts were paid into the Government treasury and rebated to the company. If the net receipts yielded less than the guaranteed return to shareholders, the Government compensated the company. If they exceeded the guaranteed return, the Government was entitled to receive half of all surplus profits and company shareholders received the other half. After the interest payments were paid off, the company would receive all the profits.

The Government provided further assistance by giving land free of charge. The companies thus avoided the expense and delay of negotiating directly with landowners. In return for assistance, the Government retained substantial control. It had a veto over the placement and

gauge of the lines. It could also influence operations through a government director who sat on the company board. The Government also retained the right to purchase private railways after 25 or 50 years. The contracts stipulated that the Government had to announce the repurchase within six months after the 25th year or the 50th year of the original contract. This institutional detail is critical for our empirical analysis. The purchase price was to be based on the mean market value of the company's stock in the preceding three years (Bell 1894, p. 66-72).

Guarantees were a key feature of the first phase of Indian railway development. British railway promoters in the 1840s emphasized the difficulty of raising British capital for a potentially risky Indian infrastructure project without an explicit guarantee and subsequent attempts to finance private railways without guarantees failed (Bell 1894, p. 73). Similar to India, railway investors in France, Argentina, Russia, Brazil, and elsewhere also insisted on guarantees (Eichengreen 1995). In India, the experience with guarantees was mixed. The early lines were unprofitable for several years (i.e. earned less than 5 percent) and the Government was forced to honor profit guarantees to shareholders. Guarantee payments continued after the 1860s but a few companies such as the East Indian began earning in excess of 5 percent.

Government control was another notable feature of the early concession contracts, but in practice the authority and reach of Government officials was limited. The Government appointed engineers "were not experienced enough in railway construction and the fear of causing delay to the progress of work often led them to overlook the negligence of companies (Sanyal 1930, p. 63)." The Government also exercised weak control over many aspects of operations because railway companies could appeal to the Secretary when they opposed a policy change. In the 1860s, for example, the government pressed for a merger among the private railways in southern India. The Madras railway company refused and was successful in defeating the merger.

The Government option to repurchase private railways remained in the background until the late 1860s. Several companies were indebted to the Government on account of past guarantee payments. The Government, under the authority of Lord Lawrence, viceroy from 1864 to 1869, began pressing for state ownership and the end of the guarantee system (Bell 1894, p. 75-76). In 1869, the Secretary of State, however, offered to clear company debts and void the Government's right to repurchase at the 25th year of the contract. In return companies had to share half of all surplus net profits with the Government from that point forward. The Great Indian Peninsula, Madras, and Bombay, Baroda and Central India railways accepted the offer, while the East Indian refused.[2] The 1869 episode had a number of lasting effects (Bell 1894, p. 26-27). The most significant for our purposes is that three major private railways were assured of their right to own and operate railways through the 1900s.

State owned and state operated railways marked a second phase in Indian railway policy under Lord Lawrence and his viceroy successor Lord Mayo. Beginning in 1869 no new contracts were signed with private companies and the Government constructed several new lines. Many of the new lines broke from the standard gauge to a smaller meter gauge (3 feet 3 3/8 inches). The era of state railway construction, however, was short-lived. The 1870s economic depression coupled with the war in Afghanistan increased the Government's borrowing costs. And, famines in 1877 highlighted the need for a rapid extension of the network, which the Government was unable to achieve. Advocates of private provision capitalized on the Government's failures and argued for a reintroduction of the private sector.

The Government purchase of the East Indian railway in 1879 marked the beginning of the

[2] The Government opposed the renegotiation because it forgave interest debts just as private companies were beginning to earn profits above 5 percent, but they had no authority to veto the agreement because it came from the Secretary.

third phase in Indian railway policy. As late as 1877 it was unclear whether the Government would exercise its option to take over the East Indian. In the same year, the Secretary sent a letter to company directors indicating the Government's intention to purchase the line. The Secretary also suggested the possibility of a new arrangement in which the company could operate the railway in exchange for a portion of the profits and a reduced guarantee (Huddleston, 1906 p. 101). The new 'arrangement' was enacted in 1879 wherein investors were given government annuities equivalent to the market value of their shares over the previous three years. The line was subsequently worked by the newly formed East Indian Company, which retained one-fifth of the capital, now guaranteed at 4 percent, and also received one fifth of surplus profits for working the lines.[3]

Over the 1880s, 1890s, and 1900s, the Government purchased all of the original private railway companies. Several were bought when the 25th year of the original contract arrived.[4] The Government exercised the purchase option when the 50th year arrived for Great Indian Peninsula in 1900, Bombay, Baroda and Central India in 1906, and Madras in 1908 on account of their 1869 renegotiated contracts. After takeover the Government chose to operate the railway in a few cases such as the Eastern Bengal, the Sind, Punjab and Delhi, and the Oudh and Rohilkhand railways. The public works department managed these lines in a similar manner as the state owned lines constructed in the 1870s. In most other cases, the Government entered into agreements with directors of the former railway companies. The newly formed companies generally held less than 20 percent of the capital. The profits were guaranteed, at lower rates of 3 to 4 percent and at smaller capital values. Surplus profits were shared with the Government in

[3] It was believed that greater profits were the Government's objective in purchasing the East Indian and leaving its management in the hands of the company (Huddleston 1906, p. 106). The East Indian did not receive any guarantee payments in the 1870's and was the most profitable of all Indian railways at the time.
[4] This includes Eastern Bengal in 1884, Sind, Punjab and Delhi in 1886, Oudh and Rohilkhand in 1889 and South Indian in 1891.

proportion to their respective capital shares. Government control and supervision also substantially increased following the shift to state ownership (Huddleston 1906).

The public-private partnership model became increasingly common after the 1880s as many state owned and operated railways were transferred to private operation, and new companies were set up on similar terms. However, public opinion turned against private operation and beginning in the 1920s the Government gradually took over all railway operations. The move to state ownership between 1874 and 1912 was the key first step in India's move to complete nationalization of its railways. Our study exploits this transition to identify the effects of state ownership on productivity.

3. Theoretical Framework

A vast theoretical literature in economics has studied the relationship between private or public ownership and performance (Shleifer 1998, Djankov and Murrell 2000, and Shirley and Walsh 2000 among others offer recent reviews of this literature) and researchers have made arguments both for and against state ownership. A classic argument for state provision is made in the event of market failures such as natural monopolies, externalities and public goods, (Sappington and Stiglitz 1987). More recent studies have extended the argument to incomplete contract settings with significant public goods benefits (Besley and Ghatak 2001).

But, many scholars have argued for private provision on account of 'government failures.' A general criticism is that state owned firms do not maximize profits. Instead they pursue objectives that may be politically desirable, like greater employment or universal coverage of service, but are not necessarily efficient. A different criticism focuses on incomplete contracts. In this view, mangers in private firms have stronger incentives to cut costs and improve efficiency because they can appropriate the resulting gains. Government bureaucrats in

comparison do not face the same incentives because they are often paid fixed salaries (Hart, Shleifer, and Vishny 1997, Shleifer 1998). State owned enterprises are also believed to be less efficient because they face soft budget constraints. Firm budgets are subsumed within larger government budgets and the discipline of the capital market is absent (Kornai 2000, Kornia, Maskin, and Roland 2003).

This literature has mixed predictions for the Indian experience. First, private railway companies in our context do not fit the traditional mould of private ownership discussed in the theoretical literature. While these companies stood to benefit from higher profits, they were subsidized on the downside by Government guarantees. The 5 percent dividend guarantee dulled company incentives to manage costs judiciously and encouraged extravagance in construction as argued by British government officials of that period. Thus, subsidized private ownership in our case did not always create the right incentives to reduce costs and improve productivity.

Second, the unique nature of our 'state' also makes it difficult to draw predictions from the theoretical literature. While railways conferred significant public goods benefits, the colonial state was not beholden to the native population to invest in infrastructure projects with large social benefits. The provision of public services was not an important objective of the Government and public investments on average were low in India (Roy 2000, Chaudhary 2009). On the other hand railways were an important modern sector for the Government of India. The Government had numerous economic and strategic reasons to run the sector like a profit maximizing firm. The authoritarian nature of colonial rule also gave the state flexibility to make unpopular but perhaps necessary economic decisions to improve productivity. It also lessened the incentive to use state-owned railways as an employment program, which is often the problem in countries with democratic institutions.

Given our context, it is difficult to draw clear predictions from the theoretical literature. Moreover, theorists such as Laffont and Tirole (1993) have made the case that "theory alone is thus unlikely to be conclusive in this respect" (quoted in Megginson and Netter 2001, p. 328) in distinguishing between the effects of public and private ownership on productivity. Hence, we believe the question of whether state ownership hindered or improved the productivity of Indian railways is an empirical question. And, we use detailed data from this period to answer the question.

4. Data

We created a new data set of Indian railway systems from 1874 to 1912 for the econometric analysis using *Administration Reports on the Railways in India* (Director General of Indian Railways), *The Statistical Abstracts of British India* (Board of Trade), and *History of Indian Railways* (Government of India 1947). We used data from the *Administration Reports* published annually from 1882 in conjunction with the *Report to the Secretary of State for India in Council on Railways in India* for the pre-1882 years. The latter report is less detailed compared to the *Administration Reports*, but we were able to obtain information on unit mileage, locomotives, fuel, labor, and vehicles like wagons and carriages. These variables are essential for estimating a production function. Since fuel is unreported in the years before 1874, we begin the analysis in 1874 and end in 1912, just before the beginning of World War 1—a thirty-eight year period covering the peak of colonial authority in India when the state gradually took over all the former private companies.

Our data are extracted primarily from the tables titled "General Results of Working of the Principal Indian Railways" reported annually before 1900 and for each half year after 1900. For the post-1900 variables, we either aggregate or average the variables over the two half

years to construct an annual observation. The tables include passenger and goods earnings, train miles, passenger miles and ton miles (i.e. the number of tons carried one mile). Passenger miles are unreported for state owned railways from 1874 to 1879. We construct this variable by multiplying the number of passengers transported and the average trip length in 1880 for each state owned railway. We construct annual series for fuel, labor, locomotives and vehicles from other reported tables.

Our measure of output in the production function, Y_{it}, is the weighted average of passenger and ton miles described in equation 1. The weights are the respective shares of passenger and goods earnings to total earnings.

$$Y_{it} = \text{ton miles}_{it} \times (\text{revenue share goods}_{it}) + \text{passenger miles}_{it} \times (\text{revenue share passengers}_{it}) \quad (1)$$

Caves, Christensen, and Swanson (1980) advocate the use of cost elasticities as alternative weights for the measurement of output in railways, but in practice these are very close to the revenue shares.[5]

On the inputs, fuel represents total fuel consumed in tons including coal, wood and coke. Coal accounts for more than 80 percent of total fuel consumed in this period. Our measures of capital capture total number of track miles, locomotives and vehicles. Given the change in locomotive technology over this period, we also constructed a value-adjusted measure of locomotives and it did not affect our results. Labor includes both the Indian and European workers hired by each system. Europeans comprised less than 5 percent of total employment. Our main specification uses total workers as a measure of the labor input, but in some specification checks we differentiated between European and non-European workers.

[5] We estimated a variable cost function and found the cost elasticity for ton miles to be 0.28 and the cost elasticity for passenger miles to be 0.21. Using this estimate the relative cost elasticity of ton miles and passenger miles is 0.57 and 0.43 respectively. The average revenue share for ton miles and passenger miles is 0.59 and 0.41 respectively, so our revenue share weights are very close to relative cost elasticity.

We would ideally like to follow an individual railway line for the entire time period. Reporting changes and mergers, however, complicate the analysis in two ways. First, if there is a merger between two lines, we only have data on the new merged system. Second, there is a significant reporting change in 1900: the pre-1900 reports provide data on the "principal standard and metre gauge lines" but after 1900 they report data on the "principal railway system" aggregating the main company or state line with any other secondary lines worked by the same company or state. Although the pre-1900 reports occasionally include secondary lines with primary lines, data on secondary lines are reported separately in many cases.

To illustrate the problem, consider the case of the East Indian Railways, a private company and the first to be taken over by the state in 1879. For the 1880s and 1890s, the East Indian includes the main East Indian line and three small state-owned lines worked by the East Indian (Patna-Gaya, Sindia and Dildarnagar-Ghazipur). In the same period, East Indian also manages the operations (i.e. working) of three private assisted company lines (Tarakessur from 1885, Delhi-Umballa-Kalka from 1891 and South Behar from 1899). Data on the latter are reported separately before 1900, but beginning in 1900 East Indian is reported as one system including state lines and assisted company lines.

We address the pre and post 1900 difference by creating a consistent series of the "principal railway system" from 1874 to 1912. Since data on such assisted lines is reported separately in other tables of the pre-1900 reports, we merge their information to the primary system managing their operation. A detailed appendix is available upon request, which describes the principal railway systems and the included assisted lines. For a few systems such as Bengal Nagpur railways, our labor measure is not reported for the same system level as the

other inputs and outputs.[6] This introduces some measurement error and should attenuate the estimates on labor.

To address the issue of mergers, we follow the railway system and also include information on any secondary lines to each system before they merge together.[7] While this creates an artificial joint system before mergers, we believe the method is more accurate at disentangling the effects of state ownership from mergers. In many cases, the Government of India used takeovers to merge neighboring regional lines into one system such as the merger of the Sind, Punjab and Delhi railways to Indus and Kandahar state railways in 1886. By following a consistent joint system of 15 railway systems, mergers are less likely to confound our results. As an additional robustness check, we also constructed a 'solo' railway system where we dropped any secondary lines in the years before they merge. In the results section, we focus on both the join and solo panels.[8]

Our analysis focuses on the main standard and metre gauge railway systems of British India that accounted for almost 90 percent of the network. We do not study the smaller narrow and special gauge lines where consistent information is unavailable. We also exclude the Native State owned lines from the analysis because of the complicated relationship between Native States, the Government of India and private companies, and the resulting ambiguity in their organizational form.[9]

---

[6] Bengal Nagpur is an unusual system because it manages standard, meter and narrow gauge lines. Other than labor, all the other variables do not include information on the narrow gauge lines. Since these narrow lines accounted for a small percentage of the total mileage, we believe the resulting measurement error is probably small.

[7] The only exception is the break up of East Coast State Railways in 1900 and the re-organization of Madras, Southern Mahratta and South Indian Railways in 1908. East Coast Railway began operations in 1895. In 1900, part of the railway was merged with Madras and another section was merged with Bengal Nagpur making it difficult to accurately assign the pre-merge information.

[8] As a final check, we also created a panel with the merged secondary lines included as separate systems in the years before they merge. Our results were also robust to this panel.

[9] This refers to the Nizam's Guaranteed State Railway, Jodhpore-Bikaner, Udaipur-Chittoor, Bhavnagar-Gondal-Junagarh-Porbander. The only exception is Mysore state railways, which begins the period as a Native State railway but is merged with the Southern Mahratta Railway Company in 1887.

We constructed two variables to capture ownership. First, we use the organization of the main railway line within a system to code the entire system. The primary lines on average represent the majority of the total mileage. Second, we also coded the fraction of miles of each type within the system such as the fraction of state-owned miles. Figure 2 graphs the main organizational changes in the railway sector from 1874 to 1912. In the early 1870s, privately owned railway lines comprised over 90 percent of the system but by 1912 they accounted for less than 10 percent. As private mileage decreased, there was a parallel increase in state owned miles that were either operated by the state (25 percent) or operated by private companies (65 percent by 1912). Our data include both the switching private railways and the non-switching state railways constructed in the 1870s.

Table 1 displays the summary statistics of the main variables used to estimate the production function. Output almost quadrupled between 1880 and 1910, while the proportion of passenger earning to total revenues remained roughly constant at 39%. Labor and capital also doubled over this period, while the total amount of fuel tripled from 1880 to 1910. A crude comparison of the changes in inputs to outputs indicates some evidence of total factor productivity (TFP) in the railway sector. This is matched with an increase in net earnings as a proportion of capital outlay, which increased from 4.3 percent in 1880 to 5.4 percent in 1910. While these summary statistics are informative, the next section describes a production function approach to estimating TFP and the effects of state ownership on TFP.

5. Empirical Strategy

Output for a railway system is modeled as a function of its inputs namely capital, labor, fuel, and the residual, which captures output unexplained by inputs. Specifically, we set up the following equation, $Y = f(K,L,F,E)$ where Y is output, K is a vector of capital inputs, L is labor

input, F is fuel input and E is the residual.

Our first goal is to estimate changes in the residual *E* due to aggregate TFP growth. We begin with a general TFP analysis because there are no estimates in the literature and it serves as a basis for evaluating overall railway policy.[10] Following the approach developed by Caves, Christensen, and Swanson (1981), we use year fixed effects to measure the average TFP in each year (relative to a base year). We do this by estimating the Translog production function:

$$y_{it} = \sum_{k=1}^{K} \beta_k q_{ii}^k + 0.5 \sum_{k=1}^{K} \beta_{kk} q_{ii}^k q_{ii}^k + \sum_{k=1}^{K} \sum_{j=1, j \neq k}^{J} \beta_{kj} q_{ii}^k q_{ii}^j + \delta_t + \alpha_i + \varepsilon_{it} \qquad (2)$$

where y_{it} is the natural log of output for railway system *i* in year *t*, q_{it}^k is the natural log of rail miles, locomotives, vehicles, labor and fuel for system *i* in year *t*, $q_{it}^k q_{it}^j$ is the product of the natural log of input k and j, δ_t are year fixed effects, α_i are railway-system fixed effects, and ε_{it} is the error term.[11] The Translog functional form nests the Cobb-Douglas production function with $\beta_{kk} = 0$ for all k and $\beta_{kj} = 0$ for all k and j combinations. The Cobb Douglas is more restrictive because it does not allow for a general substitution pattern between outputs and inputs. On the other hand, the Cobb Douglas is more parsimonious than the Translog and so we also provide estimates assuming the Cobb Douglas form.

The railway system fixed effects α_i control for any time-invariant unobserved heterogeneity at the railway-system level. Geography and railway gauges are two important sources of heterogeneity. For example, constructing and operating railway lines in mountainous terrain prone to land slides may perhaps reduce the output produced or require more inputs to

[10] Christensen (1981) estimates labor productivity for Indian railways using indices of output and labor but does not estimate TFP.

[11] The Translog is widely used in the estimation of TFP, especially in railways, because it imposes fewer assumptions on the elasticity of substitution. See Caves and Christensen (1981) for an application of the Translog.

produce the same output. Railway gauges are also relevant because meter gauge railways (3 feet 3/8 inches) in India had lower output potential than standard gauge railways (5 feet 6 inches).

The year fixed effects δ_t measure the natural log of the aggregate TFP relative to the omitted year 1874. The percentage change in TFP from 1874 to each year is given by the formula 100*(exp(δ_t)-1). Naturally there will be shocks like depreciation in the value of the rupee that affect TFP for all railways in a particular year. Although the shocks are interesting, we emphasize the long-run trends.

Our initial specifications assume there are no systematic differences in TFP growth across railways due to change in ownership. To measure this effect, we follow the approach used by Brown, Earle, and Telegdy (2006) who include a dummy variable for private ownership in a production function specification. In our case, we add the variable $dstateown_{it}$: a dummy taking the value 1 in years when the railway system is state owned and 0 when it is privately owned. As the specification includes railway system and year fixed effects, we identify the effects of ownership from changes within the same railway system over time. If ownership lowered residual output and hence lowered TFP then the coefficient on $dstateown_{it}$ would be negative and statistically significant.

Our approach is analogous to the general reduced form approach adopted by the privatization studies to measure the effects of ownership (Megginson and Netter 2001). Moreover, on account of our institutional background the timing of state takeovers should be exogenous to unobservable variables correlated with productivity. But, there may be concerns about the endogeneity of the other inputs such as labor, fuel and capital. In theory there are solution to this problem (for example, Olley and Pakes 1996), but we prefer a reduced form approach, which exploits the temporal variation in ownership changes within railway systems.

This also ensures our findings are comparable to the privatization studies.

In addition to state ownership, we also test whether state operations have a differential effect on productivity. Unlike ownership changes, we are less confident regarding the potential endogeneity of operational changes because the Government of India had the option to decide between state and private operations. We also observe bi-directional changes in state operations making the interpretation more complicated. In some cases privately operated railways switched to state operations, but in other cases state operated railways switched to private operation. We use the variable $dstateoperate_{it}$: a dummy taking the value 1 in years when the railway system is state operated and 0 when it is privately owned to test for the effect of state operations. But, we are cautious about drawing strong conclusions based on these results.

Railway system and year fixed effects address a variety of identification problems, but there could still be railway specific time varying heterogeneity correlated with production and a switch to state ownership. If the Government of India happened to purchase private lines when output was trending upwards or downwards, the coefficient on state ownership would be biased. We therefore include includes a set of interaction terms between a time trend and a dummy for each railway in the regressions, which control for unobservable trends at the railway system level. By including railway specific trends, we identify the effects of state ownership by comparing deviations in TFP from the railway trend before and after the change to state ownership within a railway system.

Finally, we examine specifications that control for anticipation effects. If firms or the Government of India anticipated a government takeover then the previous specification may yield biased estimates of the effect of state ownership because TFP could deviate from the trend prior to the government takeover. We control for anticipation effects by adding a dummy

variable for any of the five years preceding a switch from private to state ownership. In these specifications the variable $dstateown_{it}$ captures the deviation from the railway trend conditioning on the deviation in trend in the five years prior to government takeovers.

6. Results

6.1 The Productivity of Indian Railways 1874-1912

We begin our analysis by evaluating the overall productivity of Indian railways between 1874 and 1912 using information on our 15 individual railway systems. We present results for the joint and solo panels. Specifications 1 to 3 in table 2 focus on the Cobb Douglas production function and specifications 4 to 6 focus on the Translog. A likelihood ratio test comparing the two models rejects the Cobb Douglas in favor of the Translog, but we still report the Cobb Douglas to help interpret the estimates. We augment the specification with year fixed effects and railway fixed effects, and to account for serial correlation we report robust standard errors clustered at the railway system level. On account of differences in total mileage across systems, we report both weighted and unweighted regressions.

Table 2 shows the estimates of our inputs for the joint panel, which combines observations for railway systems that eventually merge. The coefficients for the Cobb Douglas function are statistically significant with roughly the expected sign (see columns 1-2). An increase in mileage, vehicles, and fuel increases output, as does an increase in labor although the latter finding is not robust in the weighted regression. The coefficient on locomotives is insignificant, perhaps because of measurement error or the correlation with vehicles. Although the sum of the individual input coefficients is slightly less than one, we cannot statistically reject the null hypothesis of constant returns to scale.

The coefficients in the Translog model are different on account of the interaction terms.

The output elasticity for inputs is non-constant and varies with other inputs, including labor and locomotives, labor and vehicles, labor and fuel, locomotives and vehicles, and vehicles and fuel. Weighting the observations does seem to affect the magnitude of the coefficients, but generally the signs and significance are the same. The coefficients are broadly similar when using the solo panel (see columns 5-6). Their concurrence is reassuring and suggests that mergers do not substantially affect our estimates, which would be the case if the composition of outputs and inputs changed significantly for railway systems.

The fixed effects for each railway system are reported at the bottom of table 2. The Great Indian Peninsula railway (GIPR) is omitted and serves as the reference railway. The fixed effects coefficients for the original private railways are reported first beginning with the East Indian and ending with the Oudh & Rohilkhand. The large and positive fixed effect for the East Indian confirms the conventional wisdom of historians that this railway was the most productive of all. The large and negative coefficient on the Madras is also consistent with conventional accounts that it was a poor performer and continued to receive guarantee payments up to the year it was taken over by the state in 1908. The remaining railways beginning with Rajputana Malwa were state owned throughout our period. The fixed effect for most of these railways is negative, but the difference is significant only for Southern Mahratta and Assam Bengal. In general, the coefficients on the railroad fixed effects highlight the differences across Indian railways and the importance of comparing within railway systems as compared to across systems.

Figure 3 plots the coefficients on the year fixed effects from 1875 to 1912, which we interpret as the log of TFP (the reference year is 1874). The coefficients are from regression 3 on the joint panel but the TFP graphs are similar for all the specifications reported in table 2. TFP steadily increased at an average annual growth rate of 1.7 percent. By comparison, Fishlow

(1966) estimates average annual TFP growth on US railroads to be 2.1 percent from 1870 to 1910. Herranz-Locan's (2006) finds that TFP on Spanish railways grew at an average annual rate around 1.5 percent from 1870 to 1913. Thus TFP on Indian railways grew at a slightly higher annual rate than Spain and close to the rate for the US. Interestingly Indian TFP growth well outpaced the British railway sector. Crafts, Mills, and Mulatu (2007) estimate that British TFP grew at an average annual rate of 0.9 percent from 1870 to 1912.

Broadly, table 2 and the related TFP graph supports a positive view of Indian railway performance and the policy of state ownership. But, to get at the role of the state ownership more precisely we need to examine the effects at the railway system level. Perhaps by looking more closely we might find that Government of India takeovers lowered productivity growth.

6.2 State Ownership and Performance

Between 1874 and 1912, all the former privately owned companies were taken over by the Government of India. We exploit this change in ownership and test whether state ownership increased or decreased productivity. This is largely an empirical question as we discussed in section 3 and our particular context offers some nice empirical features. First, selection problems are not a concern because the Government took over all the private companies. Second, the timing of the takeover was predetermined. Companies were taken over on the 25th anniversary of their original contract or on the 50th anniversary if they were part of the 1869 deal with the Secretary of State. Thus, the Government could not time their take over for example during periods of success or failure. We also test whether there were any initial differences in residual output for railways with earlier original contracts or those participating in the 1869 deal by estimating the following two regressions for the years 1874 to 1879 (the last year before the first private railway was taken over by the Government).

$$y_{it} = \sum_{k=1}^{K} \beta_1^{\,k} q_{ii}^{k} + \delta_t + original\_contract\_year_i + \varepsilon_{it} \qquad (3)$$

$$y_{it} = \sum_{k=1}^{K} \beta_1^{\,k} q_{ii}^{k} + \delta_t + 1869\_deal\_dummy_i + \varepsilon_{it} \qquad (4)$$

If the productivity of railways that had an earlier original contract was initially different then we should find the original contract year variable to be significant. If railways that participated in the 1869 deal were initially different then the dummy for the 1869 deal should be significant. Neither of these variables is significantly different from zero. The coefficient for the original contract year is -0.012 with a standard error of 0.027. The coefficient for the 1869 deal dummy is -0.252 with a standard error of 0.187. Thus we do not find any evidence of initial differences in productivity between companies based on the original contract dates or the intervention by the Secretary of State in 1869.

To measure the effects of state ownership, we introduce an ownership dummy in our production function specification augmented by year fixed effects, railway fixed effects, and railway trends. The ownership dummy captures the average deviation in TFP of state owned lines relative to their trend.[12] Table 3a presents the results for the joint (specification 1-4) and solo panels (specification 5-6). A change to Government ownership does not significantly influence TFP for better or worse. The coefficient on state ownership is negative but statistically insignificant in all the specifications. Regardless of weighting, panel or the type of production function we estimate, TFP does not significantly change under state ownership.

Our dummy for state ownership captures the organization of the primary line within a

[12] Given the many observable and unobservable differences across railroads, we prefer to compare railroads before and after they changed ownership. Moreover, there could be important trends in productivity, which may be correlated with the increase in the Government of India's ownership stake in the railway sector from 1874 to 1912. To address such concerns, we also include railroad specific trends to control for any unobservable factors trending up or down that may influence productivity and the switch to public ownership.

system. But, the railroad systems also include smaller lines owned by different entities (public or private) and managed by the primary railroad within the system. Hence, an ownership dummy could bias our coefficients. To address such concerns, table 3b replicates the regressions from table 3a including the fraction of state owned miles within a system instead of the ownership dummy. The findings are unchanged: the coefficients are negative but statistically insignificant. Indian railways enjoyed high TFP growth over this period and a switch to state ownership did not change the trend for former private railroads.

6.3 Anticipation Effects

The recent empirical literature on privatization emphasizes that firms may anticipate ownership changes and change behavior accordingly (Brown, Earle and Telegdy 2006). In our context, we are reasonably confident the Government of India could not time takeovers but private companies could anticipate the takeover and respond in the preceding years. This is especially true of companies participating in the 1869 deal (Great Indian Peninsula, Madras, and Bombay, Baroda and Central India) because the state took ownership of these lines on the 50^{th} year of their original contract. The rest were taken over on the 25^{th} year of their contract. Uncertainty surrounding takeovers was thus larger for companies taken over in the early 1880s compared to those after 1900. Hence, we expect any anticipation effects to be larger for the latter companies because they knew a takeover was likely far in advance.

Anticipation effects complicate the interpretation of public ownership. If firms begin responding to a potential takeover 3 to 4 years prior to the actual takeover, then we may want to compare the average TFP under state ownership to average TFP 5 years before the takeover. Alternatively if firms begin responding 8 to 9 years prior, then we may want to compare the average TFP under state ownership to average TFP 10 years before the takeover. To test for

anticipation effects, table 4 includes dummies for 5-year intervals before takeovers. We only present results for the solo panel because in many cases lines were merged at the same time or shortly after the state took over a railroad. Thus, anticipation effects by private companies could be mis-measured in the joint panel that artificially joins lines before they actually merge.

In specifications 1 and 2, we include a dummy for the 5-year window just before private companies were taken over and the non-switching railways are coded as 0. Since companies were taken over in different years, the precise years of each window vary by system. As in the earlier tables, we show both weighted and unweighted regressions. Including this 'anticipation' dummy does not change the result on state ownership; the coefficient is still negative and insignificant. But, firms may have anticipated takeovers even earlier and perhaps our test is too restrictive. In specifications 3 and 4, we address this issue and test whether anticipation effects began as early as 6 to 10 years before takeover. Clearly, it is ambiguous whether the relevant comparison should be 4 years, 5 years or 8 years before takeover. But, we hope by including separate dummies for both 5 years before and 6 to 10 years before, we are allowing for more flexibility. The coefficient on the dummy for 6 to 10 years before takeover is negative and significant in the unweighted regression but the finding is not robust to weighting.

Based on the institutional history, we believe only certain firms would have anticipated takeovers in the window, 5 to 10 years before takeover. The East Indian was the first company acquired by the Government of India in 1879 and there was uncertainty around their takeover (Huddleston 1905). Firms such as Eastern Bengal and Sind, Punjab and Delhi were in the next set of takeovers in 1884 and 1886 respectively. They were more likely to anticipate a takeover only after 1880 shortening their anticipation window to 5 years. After the takeovers in the 1880s, the three firms associated with the 1869 deal (GIPR, Madras and BB&CI) were less uncertain

about what would follow when their contracts came due in the 1900s. Anticipation effects with long lags are probably most relevant for them.

To test whether anticipation effects were indeed larger for GIPR, Madras and BB&CI, we interact a dummy for these three systems with state ownership and with dummies for 1 to 5 years before and 6 to 10 years before takeover (specifications 5 and 6). The coefficients on the interactions for the years before takeover are negative and statistically significant in both regressions. TFP for these three firms began to decline relative to trend as early as 10 years before takeover and continued to decline relative to trend in the years immediately preceding the takeover. But, there is no differential effect of state ownership on these firms. The coefficients on state ownership and the interaction term are negative but statistically insignificant.

This exercise suggests anticipation effects were relevant for firms that participated in the 1869 deal, which effectively delayed their switch to state ownership by another 25 years. Moreover, the negative sign on the pre-takeover dummies suggests that these firms responded by reducing effort and TFP declined relative to trend. Anticipation effects by these three firms could generate an upward bias on state ownership. If firms deteriorated their performance in anticipation of a takeover, then this could explain why we find no significant negative effects of state ownership on TFP. We exploit the heterogeneity in anticipation effects across systems to assess this hypothesis. In specifications 7 and 8 we drop firms that participated in the 1869 deal. Anticipation effects are most serious and significant for this group, and dropping them should reduce any associated bias. The coefficients on state ownership are still insignificant and cannot be statistically differentiated from zero. Although important for the later takeovers, anticipation effects are not driving our results on state ownership.

6.4 State Operation and Performance

Broadly, our findings support a neutral or perhaps a mildly positive view of state ownership in colonial India. On the positive note, overall TFP increased in the railway sector between 1874 and 1912 despite an increase in public ownership. Moreover, state takeovers of private companies did not lead to any significant declines in performance. We have focused on ownership changes, but operations offer another assessment category. Section 2 describes how many railway companies retained private operations, albeit under lower guarantees, when they were taken over. But, in the case of Eastern Bengal, Sind, Punjab and Delhi, and Oudh and Rohilkhand both ownership and operation was jointly taken over by the state. Moreover, state owned lines such as Rajputana Malwa, Bengal Nagpur and Burma switched from state operation to private operation.

The Government of India took over operations for different reasons. In the case of Sind, Punjab and Delhi, the Government valued the location of the line because it was close to the northwest frontier and Afghanistan. The Government of India was keen to control the line for military and strategic reasons. It is unclear whether the relative unprofitability of the company was a factor. On the other hand, the Government of India was disappointed with the performance of Oudh and Rohilkhand and the inefficiency did influence the operation decision. Finally, Eastern Bengal was a relatively profitable line before takeover. And, it was near other state owned and privately operated lines such as the East Indian. Based on these three cases, no uniform rule or reason appears to have motivated the state decision.

Nonetheless, we are less confident about the results on operations because the switch to state operations may be endogenous. With this caveat in mind, table 5 presents the results including a dummy variable for state operation in specifications 1-2 in addition to the dummy variable for state ownership. The coefficient on operation is negative but statistically

insignificant. In specifications 3-4, we conduct an additional test including a dummy variable for state owned and privately operated systems to assess whether these unique organizational forms are associated with differential performance gains. The coefficients on the state owned and privately operated dummy are positive but statistically indistinguishable from zero. Neither state ownership nor state operation reduced TFP relative to trend in the Indian railways sector.

6.5. Discussion of State Ownership in India

To some readers our findings on the effects of state ownership may appear surprising. Why did a change to state ownership not produce any significant negative effects on subsequent productivity? One view is that the Government of India avoided some of the failings of traditional state owned enterprises. It behaved differently because it was an authoritarian or colonial state. An alternate view is that private ownership in our context is a qualified private because companies enjoyed 5 percent dividend guarantees, which subsidized their losses. Incentives to adopt technologies and promote efficient management were perhaps not as strong as among traditional private firms. A combination of the two explanations could also account for our findings.

We begin by studying the effects of the guarantees. Contemporaries generally regarded the guarantee system as ineffectual in restraining construction and operational costs. Officials often criticized the system because "shareholders had their 5 percent whatever happened (Bell 1894, p. 66)." The Secretary of State in 1868 advocated the use of guarantees, but admitted, "the system tends to weaken the ordinary motives to efficient management and superintendence (Bell 1894, p. 19)." Ornate railway stations and luxury cabins testify to some private extravagance on a public purse.

The negative rhetoric and large guarantee payouts notwithstanding, some private

companies such as the East Indian received guarantees in the 1850s and early 1860s but enjoyed high returns—above the guaranteed dividend—before being taken over. Other companies such as Madras, Oudh and Rohilkhand, and South Indian, however, consistently earned returns below 5 percent and received guarantees. In the five years before takeover, three railways earned a return in excess of 5 percent in all of the five preceding years and the rest either never earned a return above 5 percent or did so infrequently.

To assess the importance of guarantees on productivity, we interact state ownership with a dummy for the companies receiving any guarantees in the five years before takeover. We also include a dummy for all state-owned railways to capture the general effect of switching from private to state ownership. If guarantees are driving the observed findings, we might expect positive effects of state ownership on companies receiving guarantees at takeovers. Economic theory would suggest railways receiving guarantees had worse incentives and therefore state ownership should be better for productivity. The estimated coefficient on the interaction between state ownership and railway companies receiving guarantees is positive but statistically insignificant across all the specifications in table 6. While this test does not rule out that guarantees may have generated some inefficiency among private railways, it does suggest that guarantees alone cannot account for the neutral effect of state ownership on productivity.

Another explanation for our findings is related to particular actions taken by the Government of India. A typical criticism is that state owned enterprises are less productive because they do not maximize profits. While we cannot entirely rule out this argument, there is anecdotal evidence indicating the Government of India took an active interest in the management of railways, especially once they were state owned. The Government often used takeovers to reorganize existing networks with a stated purpose of improving efficiency. For example, repairs

to locomotives and carriages were centralized in the Lahore workshop following the merger and reorganization of the Sind, Punjab, and Delhi railway with the Indus Valley and Punjab Northern lines in 1886. Concentrating the repair process in a single location contributed to the use of more sophisticated technology and avoided the redundancy of having three individual workshops in the region (Kerr 2007, p. 85).

The Government also organized 'railway conferences,' to create exchanges between state railway officials and companies. The first railway conference in 1880 introduced a code of general rules for the working of all lines, including agreements for the interchange of rolling stock, a uniform classification of goods, and accounting standards. Subsequent conferences in the 1880s and 1890s tried to assimilate the construction of rolling stock. A special committee met regularly to adopt standards, arrange experiments, and publish research (Bell 1894, p. 114). The Lahore workshop and railway conference examples suggest that the Government desired the productive operation of railways.

The Government of India was also distinctive in motivating its employees. In 1880 the Government introduced a profit sharing agreement with state railway employees known as the Railway Provident fund. The Government contributed one-half of one percent of the net earnings of state railway earnings, disbursing them to employees in proportion to their salary and position (Bell 1894, pp. 109-110). The Railway Provident fund contradicts the theory that Government of India railway employees faced weak incentives.

While undesirable in many ways, the authoritarian nature of the Government of India is perhaps another reason why state ownership had a neutral effect in India. A number of observers in the early 1900s associated authoritarian governments with greater efficiency in railways. For example, there was a saying that 'under a Democratic constitution State railways corrupt politics

and politics corrupt state railways (quoted in Ghose 1927 p. 26).' The analogue to this view is that under authoritarian constitutions politics do not corrupt state railways because governments are less beholden to social pressures at odds with profit maximization. As a supporting example, there were requests from farmers and merchants to extend the network of the East Indian railway into less populated regions and to expand its wagon stock to handle exceptional periods of freight. The Government of India refused these requests on the grounds they were uneconomical (Huddleston 1906). It could safely make such choices because there were few political consequences from ignoring constituent demands.

A final and potentially important factor was the Government of India's fiscal reliance on railways. By 1913 almost 35 percent of its total tax revenues came from state owned railways (Statistical Abstract relating to India 1915). Thus the Government had a strong incentive to maintain productivity following takeovers. The Government's fiscal reliance on railways was partly the result of its weak tax system. Although the land tax was an important source of revenue in the 19th century, it declined in importance in the early 20th century. Excise and custom taxes were also small by comparison. The weakness in India's tax system may be a consequence of colonialism and probably constrained economic development (Roy 2000). In the case of railways, however, it may have provided a mitigating factor for productivity. If the Government of India allowed productivity to decrease on state-owned railways then it risked losing an important source of government revenues.

7. Conclusion

In this paper, we use a new data set on individual Indian railway systems to estimate TFP in the railway sector and measure the effects of state ownership. We find evidence of significant and rapid TFP growth from 1874 to 1912, a period in which the Government of India became a

majority owner in Indian railways. Moreover, we find no evidence of a statistically significant decline in TFP following state takeovers of private railway companies. The results are not due to anticipation effects or weak incentives rooted in the guarantee system. Unlike traditional state owned enterprises, we argue that the Government of India was cognizant of costs and adopted measures to improve productivity.

Our findings may be surprising in light of the theoretical literature arguing against state ownership and the recent privatization experiences in some countries. We believe the colonial environment is key to understanding the neutral effects of state ownership in our context. The Government of India had strong incentives to operate railways cheaply and on account of their colonial status they were not encumbered by constituent demands for high employment and redundant services.

References

Adams, John, and Roberts Craig West. "Money, Prices, and Economic Development in India 1861-1895." *Journal of Economic History* 39, no. 1 (1979): 55-68.

Bell, Horace. *Railway Policy of India: With Map of Indian Railway System.* Rivington, Percival 1894.

Besley, Timothy and Maitreesh Ghatak. "Government versus Private Ownership of Public Goods." *Quarterly Journal of Economics* 116, no. 4 (2001): 1343-1372.

Bogart, Dan. "A Global Perspective on Railway Inefficiency and the Rise of State Ownership, 1880-1912." Forthcoming, *Explorations in Economic History*, 2009.

British Board of Trade. *The Statistical Abstract of British India*. Years 1880-1912.

Brown, J. David, John S. Earle, and Almos Telegdy. "The Productivity Effects of Privatization: Longitudinal Estimates from Hungary, Romania, Russia, and Ukraine." *Journal of Political Economy* 114, no. 1, (2006): 61-99.

Burgess, Robin and Dave Donaldson. "Can Openness Mitigate the Effects of Weather Fluctuations? Evidence from India's Famine Era." *American Economic Review Papers and Proceedings*, May 2010 forthcoming.

Caves, W., Laurits Christensen, and Joseph Swanson. "Productivity in U.S. Railroads, 1951-1974." *The Bell Journal of Economics* 11, no. 1, (1980): 166-181.

Caves, W., Laurits Christensen, and Joseph Swanson. "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955-1974." *The American Economic Review* 71, no. 5, (1981): 994-1002.

Chaudhary, Latika. "Determinants of Primary Schooling in British India." *Journal of Economic History* 69, no. 1 (2009): 269-302.

Claessens, Stijn and Simeon Djankov. "Privatization Benefits in Eastern Europe." *Journal of Public Economics* 83, no. 3, (2002): 307-324.

Crafts, Nicholas, Terence C. Mills, Abay Mulatu. "Total factor productivity growth on Britain's railways, 1852–1912: A reappraisal of the evidence" *Explorations in Economic History* 44 (2007): 608-634.

Datta, K.L. *Report on the Enquiry into the Rise of Prices in India*. Superintendent Government Printing, Calcutta,1915.

Djankov, Simeon and Peter Murrell. "Enterprise Restructuring in Transition: A Quantitative Survey." *Journal of Economic Literature* 40, no. 3, (2002): 739-92.

Donaldson, Dave. “Railways and the Raj: The Economic Impact of Transportation Infrastructure.” Working Paper, 2008.

Eichengreen, Barry. “Financing Infrastructure in Developing Countries: Lessons from the Railway Age.” The World Bank Research Observer, 10, no. 1 (1995): 75-91.

Estrin, Saul, Jan Hanousek, Evzen Kocenda, and Jan Svejnar. “The Effects of Privatization and Ownership in Transition Economies.” *Journal of Economic Literature* 47, no. 3, (2009): 699-728.

Fishlow, Albert. “Productivity and Technological Change in the Railroad Sector, 1840-1910” in *Output, Employment, and Productivity in the United States after 1800*. Eds. Brady, Dorothy S. Cambridge: NBER, 1966.

Fiszbein, Ariel, and Pamela Lowden. *Working Together for a Change: Government, Civic and Business Partnerships for Poverty Reduction in Latin America and the Caribbean*. Washington, DC: Economic Development Institute of the World Bank, 1999.

Ghose, S.C. *Lectures on Indian Railway Economics-Part I*. Calcutta, Calcutta University Press, 1927.

Government of India. *Prices and Wages in India*. Department of Statistics, India: Calcutta, Superintendent Government Printing, 1896 and 1922.

Government of India. *Statistical abstract relating to British India from 1903-04 to 1912-13*. London: His Majesty's Stationary Office.

Government of India. *History of Indian Railways, Constructed and in Progress Corrected up to 31 March 1955*. Ministry of Railways, 1955.

Government of India. *History of Indian Railways*, 1947.

Hart, P.E. “The Efficiency of the Road Haulage Industry Under Nationalization.” *The Journal of Industrial Economics* 2, no. 1 (1953): 51-57.

Hart, Oliver, Andrei Shleifer, Robert Vishny. “The Proper Scope of Government: Theory and an Application to Prisons.” *Quarterly Journal of Economics* 112, no. 4 (1997): 1126-1161.

Herranz-Locan, Alfonso. “Railroad Impact in Backward Economies: Spain, 1850-1913.” *The Journal of Economic History* 66, no. 4, (2006): 853-881.

House of Commons. “Administration Report on the Railways in India” for 1882-1912. *Parliamentary Papers.*

Huddleston, George. *History of the East Indian Railway, Volume 1*. Calcutta: Thacker, Spink, and Co., 1906.

Hurd, John II. “Railways and the Expansion of Markets in India 1861-1921.” *Explorations in Economic History* 12 (1975): 263-288.

_____.“Railways” in ch. 8 of the Cambridge Economic History of India, vol. 2:1757-1970. Eds. D. Kumar and M. Desai. London: Cambridge University Press, 1983.

Iyer, Lakshmi. “Direct versus Indirect Colonial Rule in India: Long-term Consequences.” Forthcoming, *The Review of Economics and Statistics,* 2009.

Kerr, Ian. *Engines of Change: The Railroads that Made India*. Westport: Praeger, 2007.

Kerr, Ian (ed.). *Railways in Modern India*. New Delhi: Oxford University Press, 2001.

Kornai, Jano, Eric Maskin, and Gerard Roland. “Understanding the Soft Budget Constraint.” *Journal of Economic Liteature* 41, no. 4 (2003): 1095-1136.

La Porta, Rafael and Florencio Lopez-de-Silanes. “The Benefits of Privatization: Evidence from Mexico.” *Quarterly Journal of Economics* 114, no. 4, (1999): 1193-1242.

Lauren, Claude and Yves Bozec. “Privatization and Productivity Improvement: the Case of Canadian National.” *Transportation Research* Part E 37 (2001): 355-374.

McAlpin, Michelle Burge. “Railroads, Prices and Peasant Rationality: India, 1860-1900.” *Journal of Economic History* 34, no. 3 (1974): 662-84.

Megginson, William and Jeffrey M. Netter. “From State to Market: A Survey of Empirical Studies on Privatization.” *Journal of Economic Literature* 39, no. 2, (2001): 321-89.

Olley Steven and Ariel Pakes. “The Dynamics of Productivity in the Telecommunications Equipment Industry.” *Econometrica* 64, no. 6 (1996);1263-97.

Ramamurti, Ravi. “Testing the Limits of Privatization: Argentine Railroads.” *World Development* 25 (1997): 1973-93.

Roy, Tirthankar. *The Economic History of India 1857-1947*. New Delhi: Oxford University Press, 2000.

Sanyal, Nalinksha. *Development of Indian Railways*. Calcutta: University of Calcutta, 1930.

Sappington, David and Joseph Stiglitz. “Privatization, Information, and Incentives.” *Journal of Policy Analysis and Managemen*t 6, (1987): 567-82.

Shleifer, Andrei. “State versus Private Ownership.” *Journal of Economic Perspectives* 12, no. 4 (1998):133-150.

Shirley, Mary, and Patrick Walsh. “Public vs. Private Ownership: The Current State of the

Debate." World Bank Policy Research Working Paper no. 2420, 2001.

Studer, Roman. "India and the Great Divergence: Assessing the Efficiency of Grain Markets in Eighteenth- and Nineteenth-Century India." *The Journal of Economic History* 68, no. 2 (2008):393-437.

Thorner, Daniel. "The Pattern of Railway Development in India." *Far Eastern Quarterl*y, XIV (1955): 201-6.

_____. *Investment in Empire: British Railways and Steam Shipping Enterprise in India 1825-1949*. Philadelphia: University of Pennsylvania Press, 1977.

Toninell, Pierangelo Maria (ed.). *The Rise and Fall of State-owned enterprise in the Western World*. Cambridge: Cambridge University Press, 2000.

Figure 1: Map of Indian Railways in 1870

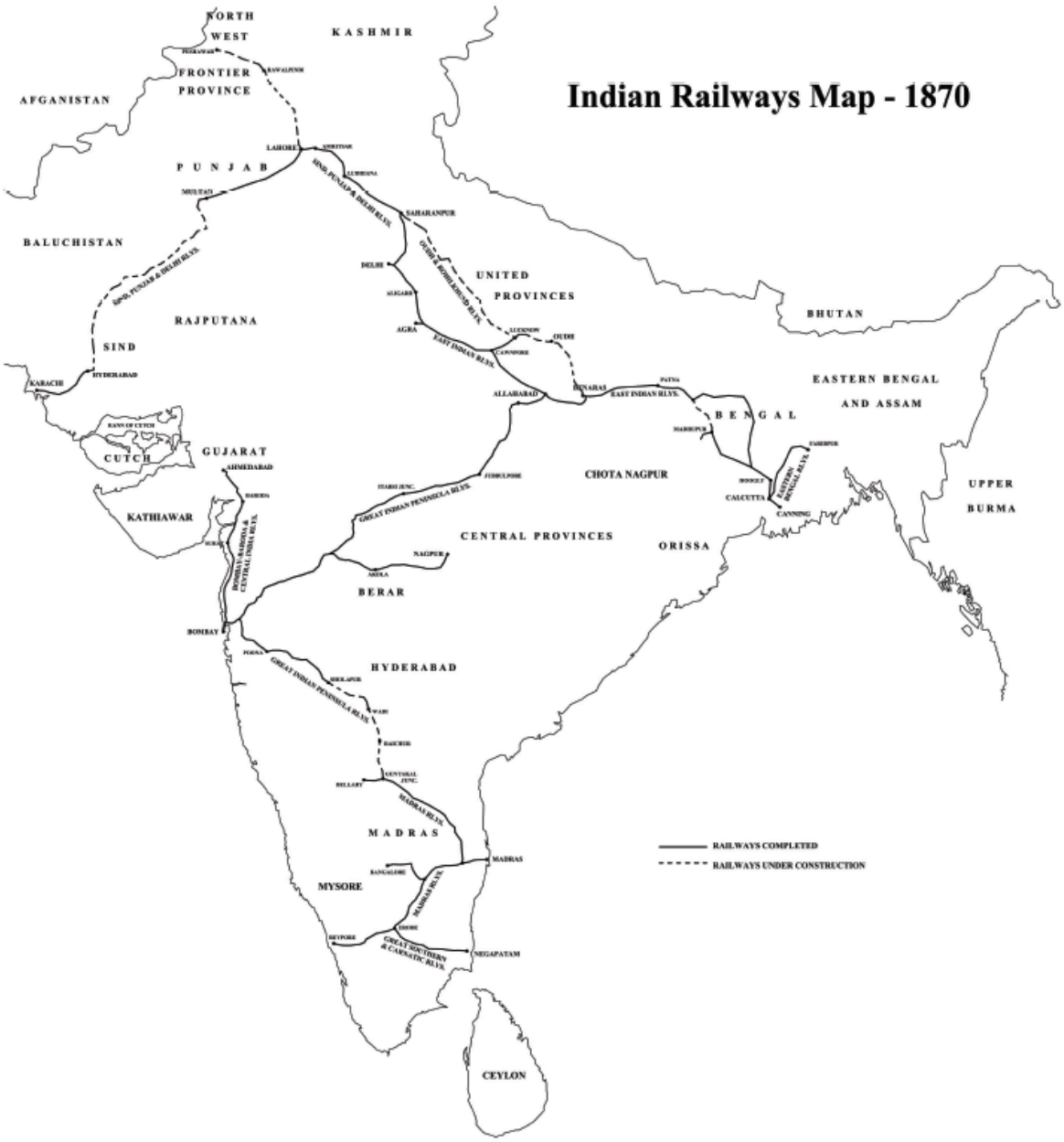

Figure 2: Indian Railways by Organization

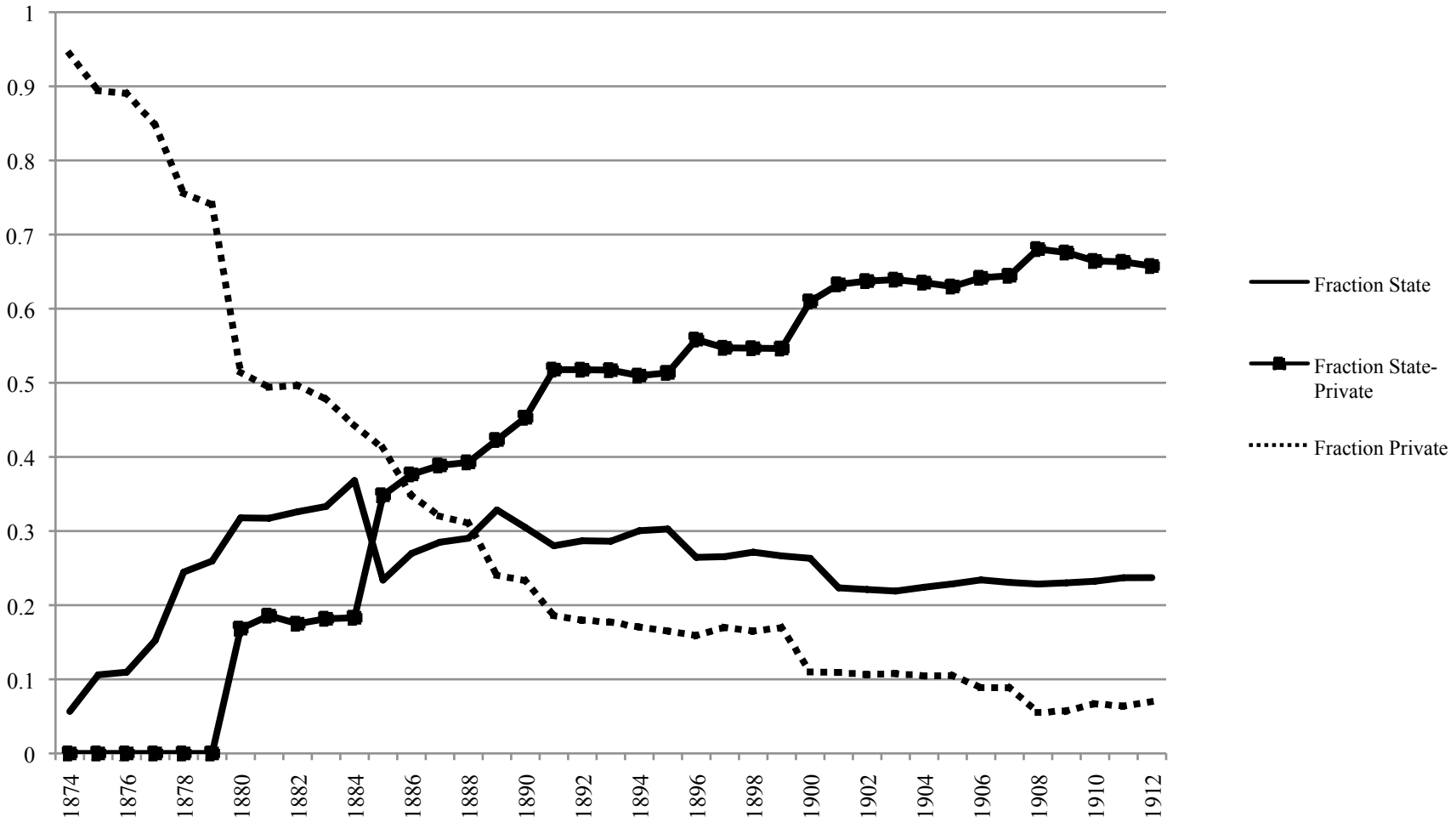

Figure 3: TFP, Indian Railways from 1875-1912

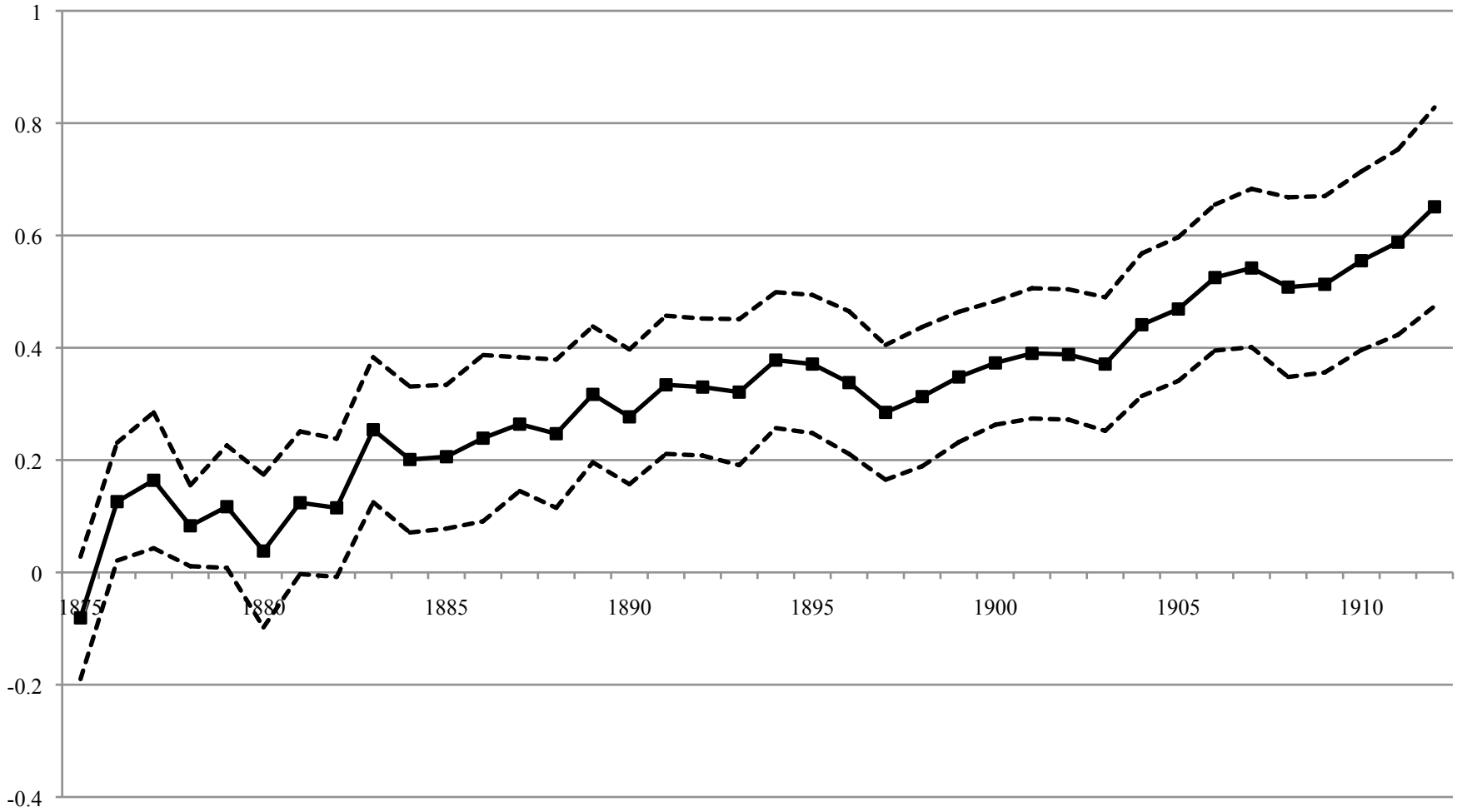

Table 1: Summary Statistics

	1874-1912	1880	1890	1900	1910	*% Change*
Railway Output	428,000,000	180,000,000	282,000,000	437,000,000	895,000,000	*397%*
Passenger-Miles	441,000,000	221,000,000	327,000,000	428,000,000	908,000,000	*311%*
Ton-Miles	398,000,000	149,000,000	244,000,000	419,000,000	839,000,000	*463%*
Fraction of Passenger Earnings	38%	38%	39%	37%	41%	*6%*
Fraction of Goods Earnings	57%	59%	56%	59%	55%	*-6%*
Total miles	1,238	751	1,058	1,408	1,971	*163%*
Locomotives	283	182	252	285	484	*165%*
Vehicles	6,311	3,845	5,478	6,313	11,334	*195%*
Labor	21,351	12,868	18,112	22,108	36,930	*187%*
Fuel	128,247	55,699	79,165	141,484	270,379	*385%*

Source: See text for details.

Table 2: Performance of Indian Railways 1874-1912?

	Ln(Output = Weighted Average of Pass-Miles and Ton-Miles)					
	Cobb-Douglas Production Function		Translog Production Function			
	(1)	(2)	(3)	(4)	(5)	(6)
(in logs)						
Total Mileage	0.339***	0.226**	0.082	-0.230	-1.308	-1.278
	[0.109]	[0.085]	[1.460]	[1.965]	[1.958]	[1.769]
Locomotives	-0.004	0.087	-3.350	-6.672**	-2.112	-3.792
	[0.133]	[0.196]	[3.210]	[3.106]	[3.376]	[3.048]
Vehicles	0.372**	0.295*	2.170	5.532*	-0.372	1.576
	[0.144]	[0.141]	[3.175]	[2.582]	[2.760]	[2.220]
Fuel	0.221*	0.290***	-0.129	-1.255	0.627	-0.346
	[0.117]	[0.082]	[0.889]	[0.932]	[1.160]	[0.826]
Labor	0.185**	0.111	2.409	3.832	3.664*	4.151*
	[0.062]	[0.111]	[1.804]	[2.215]	[1.761]	[1.950]
Labor*Labor*0.5			-0.617**	-0.541*	-0.548*	-0.563*
			[0.237]	[0.288]	[0.280]	[0.316]
Loco*Loco*0.5			-1.177	-2.107***	-1.021	-1.525**
			[0.849]	[0.699]	[0.874]	[0.705]
Vehicles*Vehicles*0.5			0.571	0.349	1.213**	1.013
			[0.741]	[0.644]	[0.557]	[0.578]
Miles*Miles*0.5			-0.031	-0.286	1.097**	0.711*
			[0.435]	[0.468]	[0.442]	[0.347]
Fuel*Fuel*0.5			0.052	0.115	-0.041	0.051
			[0.132]	[0.164]	[0.107]	[0.174]
Labor*Locomotives			0.441	0.994**	0.853**	1.077***
			[0.346]	[0.382]	[0.378]	[0.316]
Labor*Vehicles			-0.256	-0.826*	-0.346	-0.598
			[0.385]	[0.409]	[0.436]	[0.412]
Labor*Miles			0.085	0.013	-0.213	-0.179
			[0.239]	[0.193]	[0.270]	[0.285]
Labor*Fuel			0.265**	0.290*	0.151	0.19
			[0.121]	[0.146]	[0.135]	[0.149]
Locomotives*Vehicles			0.517	1.231*	-0.132	0.317
			[0.724]	[0.575]	[0.636]	[0.506]
Locomotives*Miles			-0.105	0.045	-0.364	-0.09
			[0.366]	[0.507]	[0.395]	[0.405]
Locomotives*Fule			0.148	-0.216	0.258	-0.043
			[0.154]	[0.129]	[0.218]	[0.105]
Vehicles*Miles			-0.164	-0.234	-0.255	-0.340*
			[0.302]	[0.300]	[0.268]	[0.169]
Vehicles*Fuel			-0.524***	-0.459	-0.344	-0.311
			[0.171]	[0.269]	[0.265]	[0.293]
Miles*Fuel			0.136	0.359	0.024	0.153
			[0.153]	[0.221]	[0.181]	[0.198]

Table 2: Continued

	(1)	(2)	(3)	(4)	(5)	(6)
East Indian	0.513***	0.522***	0.536***	0.548***	0.495***	0.477***
	[0.024]	[0.028]	[0.042]	[0.052]	[0.038]	[0.034]
Madras	-0.244**	-0.297**	-0.414***	-0.372***	-0.418***	-0.320***
	[0.109]	[0.102]	[0.119]	[0.079]	[0.122]	[0.092]
BB&CI	0.289	0.194	0.168	0.195	0.080	0.175
	[0.181]	[0.144]	[0.168]	[0.133]	[0.165]	[0.111]
SPD	-0.085	-0.019	-0.055	-0.032	-0.180***	-0.168***
	[0.048]	[0.030]	[0.055]	[0.033]	[0.060]	[0.042]
South Indian	0.199	0.162	0.148	0.21	0.044	0.162
	[0.193]	[0.140]	[0.184]	[0.141]	[0.187]	[0.144]
Eastern Bengal	-0.139	-0.216	-0.247*	-0.230**	-0.290*	-0.258**
	[0.156]	[0.131]	[0.136]	[0.102]	[0.157]	[0.093]
Oudh & Rohilkhand	-0.052	-0.089	-0.163	-0.105	-0.235	-0.118
	[0.195]	[0.168]	[0.161]	[0.119]	[0.165]	[0.124]
Rajputana Malwa	-0.059	-0.018	-0.017	0.023	-0.079	-0.004
	[0.128]	[0.086]	[0.125]	[0.109]	[0.129]	[0.103]
Bengal & Northwestern	-0.155	-0.187	-0.233	-0.158	-0.396*	-0.224
	[0.270]	[0.178]	[0.213]	[0.157]	[0.212]	[0.155]
Burma	-0.076	-0.235	-0.219	-0.264*	-0.292	-0.255
	[0.235]	[0.149]	[0.200]	[0.147]	[0.211]	[0.153]
Bengal Nagpur	-0.353	-0.195	-0.322	-0.123	-0.423*	-0.157
	[0.245]	[0.158]	[0.205]	[0.126]	[0.215]	[0.133]
Southern Mahratta	-0.692***	-0.701***	-0.734***	-0.652***	-0.917***	-0.744***
	[0.180]	[0.122]	[0.192]	[0.150]	[0.221]	[0.169]
Assam Bengal	-0.568	-0.631**	-0.691**	-0.557**	-0.795**	-0.543*
	[0.344]	[0.267]	[0.308]	[0.228]	[0.305]	[0.256]
Rohilkhand and Kumaor	-0.569	-0.635*	-0.549	-0.463	-0.559	-0.367
	[0.382]	[0.306]	[0.321]	[0.280]	[0.326]	[0.314]
Weights	No	Yes	No	Yes	No	Yes
Panel	Joint	Joint	Joint	Joint	Solo	Solo
Observations	515	515	515	515	509	509

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors clustered at the railway system level in brackets
All regressions include year FE and railroad FE.

Table 3b: Did State Ownership Reduce Productivity?

	Ln(Output = Revenue Weighted Avg. of Pass-Miles and Ton-Miles)					
	Cobb-Douglas		Translog Production Function			
	(1)	(2)	(3)	(4)	(5)	(6)
Fraction State Owned	-0.058	-0.036	-0.039	-0.062	-0.015	-0.043
	[0.048]	[0.042]	[0.047]	[0.044]	[0.097]	[0.091]
(in logs)						
Total Mileage	0.402***	0.298***	2.072	2.005*	1.047	1.981
	[0.094]	[0.097]	[1.206]	[0.971]	[2.171]	[1.715]
Locomotives	-0.099	-0.047	-1.511	-3.084	-4.786*	-4.096*
	[0.103]	[0.123]	[1.831]	[1.985]	[2.547]	[2.205]
Vehicles	0.267**	0.209	1.374	3.799**	2.028	2.553*
	[0.099]	[0.122]	[2.312]	[1.678]	[1.694]	[1.315]
Fuel	0.248**	0.300***	-0.581	-2.000*	1.035	-0.496
	[0.094]	[0.078]	[0.716]	[0.949]	[0.994]	[0.847]
Labor	0.130***	0.138	-0.154	0.662	2.263	1.706
	[0.043]	[0.085]	[0.908]	[1.276]	[1.567]	[1.684]
Labor*Labor*0.5			-0.348***	-0.338*	-0.32	-0.318
			[0.106]	[0.165]	[0.202]	[0.237]
Loco*Loco*0.5			-0.392	-0.814	-1.027	-0.705
			[0.560]	[0.599]	[0.673]	[0.543]
Vehicles*Vehicles*0.5			-0.382	0.017	0.19	0.391
			[0.596]	[0.487]	[0.350]	[0.316]
Miles*Miles*0.5			0.200	-0.097	0.587	0.458
			[0.348]	[0.364]	[0.415]	[0.302]
Fuel*Fuel*0.5			0.035	0.157	0.002	0.117
			[0.110]	[0.181]	[0.096]	[0.150]
Labor*Locomotives			-0.066	0.351	0.47	0.490*
			[0.166]	[0.202]	[0.360]	[0.266]
Labor*Vehicles			0.231	-0.301	-0.061	-0.173
			[0.235]	[0.300]	[0.347]	[0.330]
Labor*Miles			-0.070	-0.097	-0.096	-0.192
			[0.165]	[0.113]	[0.233]	[0.179]
Labor*Fuel			0.228*	0.375**	-0.031	0.163
			[0.113]	[0.151]	[0.136]	[0.145]
Locomotives*Vehicles			0.402	0.712	0.275	0.192
			[0.528]	[0.475]	[0.328]	[0.272]
Locomotives*Miles			0.004	0.108	0.05	0.319
			[0.242]	[0.228]	[0.455]	[0.372]
Locomotives*Fule			0.066	-0.247	0.279	-0.059
			[0.151]	[0.151]	[0.206]	[0.144]
Vehicles*Miles			-0.121	-0.210	-0.371	-0.472*
			[0.209]	[0.174]	[0.280]	[0.235]
Vehicles*Fuel			-0.132	-0.288	-0.165	-0.171
			[0.203]	[0.249]	[0.248]	[0.271]
Miles*Fuel			-0.133	0.099	-0.085	-0.051
			[0.139]	[0.222]	[0.153]	[0.192]
Weights	No	Yes	No	Yes	No	Yes
Panel	Joint	Joint	Joint	Joint	Solo	Solo
Observations	515	515	515	515	509	509

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors clustered at the railway system level in brackets
All regressions include year FE, railroad FE and railroad trends.

Table 4: Anticipation Effects

	Ln(Output = Revenue Weighted Avg. of Pass-Miles and Ton-Miles) Translog Production Function							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State Ownership	-0.117	-0.0671	-0.1731*	-0.0907	-0.1138	-0.0841	-0.0936	-0.0545
	[0.0776]	[0.0700]	[0.0831]	[0.0781]	[0.1247]	[0.1111]	[0.1560]	[0.1453]
State Ownership, -5 to -1 years before takeover	-0.036	-0.0242	-0.0715	-0.0388	0.006	0.0103		
	[0.0370]	[0.0296]	[0.0429]	[0.0376]	[0.0299]	[0.0262]		
State Ownership, -10 to -6 years before takeover			-0.0817***	-0.036	-0.036	0.011		
			[0.0244]	[0.0278]	[0.0305]	[0.0473]		
State Ownership*1869 Deal Firms					-0.234	-0.080		
					[0.1614]	[0.1555]		
State Ownership, -5 to -1 years before takeover*1869 Deal Firms					-0.3180***	-0.1997**		
					[0.0979]	[0.0689]		
State Ownership, -10 to -6 years before takeover*1869 Deal Firms					-0.1695***	-0.1358***		
					[0.0378]	[0.0356]		
Weights	No	Yes	No	Yes	No	Yes	No	Yes
Panel	Solo	Solo	Solo	Solo	Solo	Solo	Solo	Solo
Observations	509	509	509	509	509	509	392	392

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors clustered at the railway system level in brackets

All regressions include year FE, railroad FE and railroad trends.

Table 5: Did State Operation Reduce Productivity?

Ln(Output = Revenue Weighted Avg. of Pass-Miles and Ton-Miles)				
	Translog Production Function			
	(1)	(2)	(3)	(4)
State Ownership	-0.052	0.000	-0.124	-0.157
	[0.080]	[0.081]	[0.143]	[0.110]
State Operation	-0.099	-0.165		
	[0.129]	[0.104]		
State Ownership*Private Operation			0.061	0.159
			[0.127]	[0.101]
(in logs)				
Total Mileage	1.725	2.411	1.504	2.319
	[2.134]	[1.611]	[2.137]	[1.635]
Locomotives	-5.352**	-3.842*	-5.323*	-3.487
	[2.388]	[1.950]	[2.524]	[1.999]
Vehicles	1.81	1.939	1.883	1.555
	[1.557]	[1.221]	[1.609]	[1.408]
Fuel	1.241	-0.413	1.287	-0.413
	[1.014]	[0.923]	[1.020]	[0.910]
Labor	2.262	1.628	2.244	1.618
	[1.622]	[1.804]	[1.602]	[1.801]
Labor*Labor*0.5	-0.351*	-0.372	-0.333	-0.382
	[0.194]	[0.245]	[0.190]	[0.247]
Loco*Loco*0.5	-1.116*	-0.534	-1.131*	-0.466
	[0.590]	[0.527]	[0.612]	[0.555]
Vehicles*Vehicles*0.5	0.398	0.706	0.357	0.771
	[0.443]	[0.485]	[0.463]	[0.536]
Miles*Miles*0.5	0.422	0.333	0.452	0.312
	[0.415]	[0.301]	[0.443]	[0.306]
Fuel*Fuel*0.5	-0.012	0.094	-0.007	0.093
	[0.091]	[0.152]	[0.093]	[0.149]
Labor*Locomotives	0.479	0.542	0.464	0.528
	[0.400]	[0.325]	[0.391]	[0.316]
Labor*Vehicles	-0.058	-0.171	-0.054	-0.158
	[0.363]	[0.370]	[0.357]	[0.363]
Labor*Miles	-0.049	-0.137	-0.06	-0.136
	[0.194]	[0.157]	[0.192]	[0.155]
Labor*Fuel	-0.04	0.158	-0.044	0.165
	[0.140]	[0.173]	[0.140]	[0.167]
Locomotives*Vehicles	0.203	-0.069	0.253	-0.118
	[0.270]	[0.342]	[0.273]	[0.373]
Locomotives*Miles	0.247	0.411	0.195	0.388
	[0.452]	[0.336]	[0.453]	[0.342]
Locomotives*Fule	0.301	-0.06	0.31	-0.061
	[0.214]	[0.158]	[0.217]	[0.155]
Vehicles*Miles	-0.508	-0.581**	-0.476	-0.558**
	[0.289]	[0.250]	[0.281]	[0.248]
Vehicles*Fuel	-0.187	-0.169	-0.209	-0.187
	[0.263]	[0.281]	[0.274]	[0.285]
Miles*Fuel	-0.072	-0.023	-0.06	-0.01
	[0.159]	[0.212]	[0.170]	[0.220]
Weights	No	Yes	No	Yes
Panel	Solo	Solo	Solo	Solo
Observations	509	509	509	509

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors clustered at the railway system level in brackets
All regressions include year FE, railroad FE and railroad trends.

Table 6: Heterogeneous Effects of Guarantees?

Ln(Output = Revenue Weighted Avg. of Pass-Miles and Ton-Miles)				
	Translog Production Function			
	(1)	(2)	(3)	(4)
State Ownership	-0.141	-0.026	-0.07	-0.027
	[0.094]	[0.065]	[0.052]	[0.042]
State Ownership*Receiving Guarantee	0.118	-0.035	0.083	0.041
	[0.163]	[0.170]	[0.111]	[0.109]
(in logs)				
Total Mileage	1.027	1.994	1.871	1.602*
	[2.185]	[1.914]	[1.142]	[0.889]
Locomotives	-4.819*	-4.199*	-1.241	-2.249
	[2.573]	[2.244]	[1.769]	[1.985]
Vehicles	2.087	2.497	1.343	3.268*
	[1.691]	[1.448]	[2.328]	[1.734]
Fuel	1.168	-0.42	-0.584	-2.049*
	[0.975]	[0.926]	[0.740]	[0.988]
Labor	2.131	1.712	-0.192	0.685
	[1.499]	[1.666]	[0.869]	[1.161]
Labor*Labor*0.5	-0.314	-0.319	-0.348***	-0.342*
	[0.201]	[0.233]	[0.101]	[0.170]
Loco*Loco*0.5	-1.028	-0.742	-0.316	-0.608
	[0.657]	[0.580]	[0.505]	[0.554]
Vehicles*Vehicles*0.5	0.176	0.42	-0.419	0.015
	[0.362]	[0.388]	[0.599]	[0.518]
Miles*Miles*0.5	0.482	0.481	0.224	0.023
	[0.362]	[0.299]	[0.341]	[0.327]
Fuel*Fuel*0.5	0.008	0.124	0.042	0.167
	[0.095]	[0.155]	[0.106]	[0.185]
Labor*Locomotives	0.416	0.488*	-0.092	0.315*
	[0.354]	[0.262]	[0.160]	[0.155]
Labor*Vehicles	-0.03	-0.162	0.247	-0.246
	[0.344]	[0.346]	[0.230]	[0.262]
Labor*Miles	-0.042	-0.186	-0.048	-0.103
	[0.213]	[0.184]	[0.161]	[0.107]
Labor*Fuel	-0.057	0.151	0.217*	0.354**
	[0.144]	[0.154]	[0.114]	[0.155]
Locomotives*Vehicles	0.292	0.185	0.375	0.586
	[0.313]	[0.263]	[0.520]	[0.481]
Locomotives*Miles	0.074	0.353	-0.036	0.019
	[0.490]	[0.479]	[0.232]	[0.246]
Locomotives*Fule	0.3	-0.046	0.074	-0.238
	[0.207]	[0.153]	[0.151]	[0.137]
Vehicles*Miles	-0.382	-0.503	-0.096	-0.166
	[0.318]	[0.311]	[0.218]	[0.230]
Vehicles*Fuel	-0.187	-0.175	-0.12	-0.256
	[0.244]	[0.271]	[0.209]	[0.260]
Miles*Fuel	-0.065	-0.062	-0.148	0.076
	[0.153]	[0.200]	[0.132]	[0.209]
Weights	No	Yes	No	Yes
Panel	Solo	Solo	Joint	Joint
Observations	509	509	515	515

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors clustered at the railway system level in brackets
All regressions include year FE, railroad FE and railroad trends.