Labor Productivity in the Railways, 1890-1920

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1 Introduction

Why do nations fail? Wolcott and Clark [2009] offer a perspective on economic growth through a comparison of the cotton textile industries in India and Japan in the late nineteenth and early twentieth centuries. Textile mills in the two nations had comparable outputs as of 1890. In the ensuing fifty years, output per worker hour quintupled in Japan but did not increase much in India. These trends fit well with the bigger picture of rapid Japanese growth and the sluggish Indian performance from 1890-1938. Why did India fail?

It wasn't the technology. It wasn't the management. It was the labor. Such is the argument put forth by Wolcott and Clark [2009]. Compared to their Japanese counterparts, Indian mills were simply overstaffed. Indian workers were idle for significant portions of the day. The central problem of the Indian textile industry from 1890-1938 was "the failure to improve labor productivity." Wolcott and Clark [2009] hypothesize that this stems either from high leisure preferences of Indian workers or the failure of the market bargaining power to incentivize workers to increase labor inputs. Indian workers may have resisted a "rationalization" of the work force by holding out for higher wages. While Wolcott and Clark do not state an explicit preference for either theory, they seem to lean towards the former in their arguments and

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conclusions.

Wolcott and Clark [2009] find that Indian firms that tried to rationalize and reduce their labor force did not make larger profits. The paper defends managerial efficacy – Indian managers demonstrated competence in many other aspects of the business, such as capitalizing on profit-making opportunities when they were presented. The Indian underperformance also cannot be directly linked to animosity towards the colonial rule — foreign and Indian owned firms showed similar performance. There was no systemic difference to profits based on whether a foreign or local manager was employed at a firm. In essence, the paper suggests that India failed to grow because of the preferences of its people.

Can we draw conclusions about the economic growth of Japan and India based on their textile industries? Regardless of whether the conclusions of Wolcott and Clark [2009] reflect reality, they certainly warrant further exploration. With this in mind, a natural question arises: are the differences in labor productivity pervasive? This paper explores the question through a comparison of railway construction and operations in India and Japan.

Railroads in India and Japan have been generously documented making the industry a good candidate for this study. In India, railways were conceived, financed, constructed, and administered primarily by the British. However, most of the labor and staff building and running the railways were Indian (e.g. over 95% of staff involved in railway operations from 1895-1920) [Kerr, 2006]. Construction was started in 1850 and in 1853 the first train officially ran on the 21 miles of track between Bombay and Thane [Satow and Desmond, 1980].

Japan's story is quite different. Japanese rulers resisted foreign support for a railroad for many years before the *Meiji* government was able to (or chose to, or was persuaded to) initiate railroad construction with financial and technical backing from the British [Aoki et al., 2000, Free, 2008]. Construction on the first line between Tokyo and Yokohoma was started in 1870 and was completed by 1872 [Aoki et al., 2000].

Building on this background, the paper proceeds as follows. Section 2 considers the historical context for railway construction and issues that may confound the analysis. Section

3 discusses railway operation and two models for labor productivity. Section 4 describes the data on railroad operations. We focus on the period between 1895-1920, since this was the period for which data was available. Section 5 gives the basic results.

2 Building the Railways

Descriptions of railway planning and construction help to understand the context in which railways were received. Some of the relevant similarities and differences between India and Japan can be aptly highlighted. Unfortunately, almost no quantitative documentation of the railway construction in both India and Japan exists. Had this data been available, miles of track constructed per worker or per worker-hour would have been a natural measure of labor productivity.

Railway construction in both countries was by no means easy. It took over two years to build each of the 21-mile track from Bombay to Thane or the 18-mile track from Tokyo to Yokohoma — incredibly long by contemporary Western standards [Kerr, 1995, Free, 2008]. Eyewitness accounts (mostly by British observers) lend some perspective:

> "Apparently, all along the new line there were scenes of more than average confusion, as English engineers and surveyors, Japanese labourers, and Japanese bureaucrats, all of who could be stubborn when it suited, learned how to make a go of it together *as a team*. ... But ... things were apparently chaotic and disorganized to the point of considerable waste [Free, 2008, p. 71]."

At the outset, it is certainly not clear that either Japan or India was more technically advanced or better suited to the introduction of railroads or western technologies. Take for instance, a story from Japan:

> "Excavation had to be done by hand, and the Japanese 'coolies' initially refused to use wheelbarrows to haul away the spoil, insisting instead on using two baskets slung

> on each end of a bamboo shoulder pole in the time honored Japanese way of doing the job. ... Japanese surveyors... from the samurai class... refused to remove the two swords always carried by a samurai as a badge of class distinction, despite the fact that the steel of the swords ... caused faulty readings [Free, 2008, p. 74]."

Curiously enough, a railway engineer in India reported a similar story in 1870:

> " 'It has been often attempted to introduce the wheelbarrow mode of work, but with little success. The basket of antiquity — probably antediluvian — still holds it's own. I have heard of an enthusiast in wheelbarrows who, having exhausted his morning energy in the fond endeavor to restrain a gang of coolies from using the objectionable basket, had the mortification on making his evening tour of inspection, to find them carrying the wheelbarrows on their heads, in the belief that it was only a convenient modification of the principle [Kerr, 2006]. ' "

We can see from these stories that implementing or adopting foreign technologies is by no means easy. Both India and Japan faced many hurdles — cultural and otherwise. The aforementioned anecdotes suggest that labor productivity in foreign and local industries might well be very different. Local attitudes may also influence the productivity of the railways. The Japanese embraced their railways and locals used them enthusiastically. Indeed, the railways were inaugurated in 1870 with an address by the Emperor:

> " 'We open the railway service between Tokyo and Yokohama with our personal presence and express a desire that hereafter all of you will avail yourselves of the facilities offered through this railway whereby commerce will prosper and millions of people will obtain wealth and prosperity [Free, 2008, p.80] ' "

The Japanese aggressively pursued independence in engineering and railway development. The first graduates from Tokyo Engineering College graduated in 1879. By 1880 the Japanese set out to build their first line sans foreign field assistance. The *yatoi* (foreign workers) were in fact seen as potential hinderances to development [Free, 2008, p.102]. Though these attitudes cannot be quantified, they must have had an enormous impact on Japanese growth, and might well be the answer to the question 'Why did Japan succeed?'

Indians did not demonstrate the same patriotic support or enthusiasm for the railways. Indeed, the *swadeshi* ("our country") and nationalism movements in India led to boycotts and bombings of various railways at times. The railways were built to serve British political and economic interests. Early railways in India connected centers important for British exports, and a large number of passengers on the Indian trains belonged to the British military force. However, it seems that the railroads were largely embraced by Indians as a mode of transportation, as evinced by the numbers of passengers [Kerr, 2006].

There were clearly many similarities in the railroad industries in India and Japan. However, it is certainly not surprising that there were vast differences in the evolution of railways in India and Japan, which hinder easy comparisons between the nations. We consider these in the next section.

2.1 Comparison challenges

Comparison between labor productivities in the railroad industry in India and Japan is confounded by historical and other factors such as:

- **Indian head-start:** Japan started construction on their first railway project in 1870. By 1871, India had already built 5,074 miles of tracks with major lines between Bombay-Calcutta, Bombay-Madras and Calcutta-Delhi [Kerr, 2006]. While Indians were more experienced by 1890, the Japanese benefited from newer technologies. British engineers were also able to use their experience constructing railways in India during Japanese construction [Free, 2008].

- **Geographical differences:** British India was more than eight times larger than Japan, and thus, the railway network of India was orders of magnitude longer than that of Japan. Even growth in mileage within a constant time window differed significantly between the two countries. For instance, in thirty years of railway construction (1850-1881), India had 9,723 miles of track [Kerr, 1995, p. 63], while from 1870-1900, Japan had 3,856 miles of track [Aoki et al., 2000, p. 206]. In fifty years of construction, by 1901, India had 24,185 miles of track, whereas Japan by 1920 had 8,666 miles of track [Kerr, 1995, Aoki et al., 2000].

- **The 'colonial' factor:** The Indian railways were managed and controlled primarily by the British. Indians had very little planning input. While the initial Japanese railways were built with considerable British input, the local government was involved in the decision process, and the railways were built to create and connect Japanese economic centers. The different local attitudes in India and Japan discussed in the previous section (e.g. the Japanese enthusiasm and push for self-sufficiency) were probably related to this factor.

Unfortunately, history is not a controlled randomized experiment. Any comparison between two nations is subject to challenges of this nature. All the above factors are difficult to eliminate in our analysis. In this paper, the primary comparisons between the countries start in 1895, by which point even Japan had 25 years of experience with railways. We assume that any head-start effects had largely washed out by 1895. We consider geographical differences through two models discussed in the next section. Differences in planning and management are an important factor affecting worker motivation. Our analysis does not tease this final variable apart from labor productivity.

3 Labor productivity in railway operations

Although the data on construction employment in both Japan and India is particularly sparse, both countries have records for the staff members employed to operate the railways. Starting 1895, the British documented various aspects of the railway operations in India, and Japanese documentation goes back to 1886. The latter sections of this paper focus on railroad operations from 1895 onwards.

Labor productivity measures the output produced by unit labor input. In this case, passenger-miles per employee and tonnage-miles per employee are two metrics that have been previously used to measure labor productivity in railroad operations [Mizutani and Nakamura, 1996]. Passengers transported per employee and total-tonnage transported per employee is another potential metric. Since most employees are not exclusively dedicated to passenger transport or goods transport, and the data under consideration only provides us with total employment numbers, an ideal metric would use a weighted-sum of the passengers and goods transport achieved such as:

- (α·passenger-miles + β·tonnage-miles) per employee, or
- (α·passengers + β·tons of goods) per employee

However, the appropriate multipliers α and β that accurately represent the relative effort expended in transporting passengers versus goods are difficult to calculate. Hence, we do not combine the passenger and goods data.

In the particular case of India and Japan, it is unclear whether we should take track mileage into account to calculate output. With this in mind, we consider two possible models to work with and evaluate their utility for our purpose. Both of these models ignore the number of stations on a line and directly deal with the relationship between track length and line staffing. As setup we introduce some notation:

- C: total commodity (i.e. tons of goods or total passengers)
- S: total staff
- m: miles of track

3.1 Density model

The density model compares the number of staff members it takes to transport one unit of commodity for one mile in India and Japan respectively. The relative sizes of the two countries no longer confound the measurement, since we normalize by track length. Total staff members are assumed to increase in proportion with track length.

- ρ: density of employees (per miles of track)
- c: density of a commodity (goods or passengers, per mile of track)
- Labor productivity: $LP = \frac{\text{total output}}{\text{total input}} = \frac{C}{S} = \frac{c \cdot m}{\rho \cdot m} = \frac{c}{\rho}$

Under this model, the labor productivity in transporting P passengers with S staff for m miles, as well as the the labor productivity in transporting P passengers with S staff for $2m$ miles is given by $\frac{P}{S}$, which is clearly problematic for comparison. The model fails to capture the idea that transporting one passenger from Delhi to Bombay (1400 km) produces "more output" than transporting the same passenger from Kobe to Osaka (30 km).

3.2 Unit-work model

The work model defines one unit of output as the work done by transporting one unit commodity for one mile. This definition has been used previously to measure railway labor productivity by Mizutani and Nakamura [1996]. In this case as well, we also assume that the staff employed increases with track length, but do not specify an explicit relationship. Then,

- $LP = \frac{\text{total output}}{\text{total input}} = \frac{C \cdot m}{S}$

The unit-work model does not run into the issues of the density model, but has other problems of its own. The gigantic Indian landmass implies that Indian statistics on passenger-miles or goods-miles might easily dominate Japanese ones, due to the large track lengths as opposed to being a true measure of work output.

4 Data

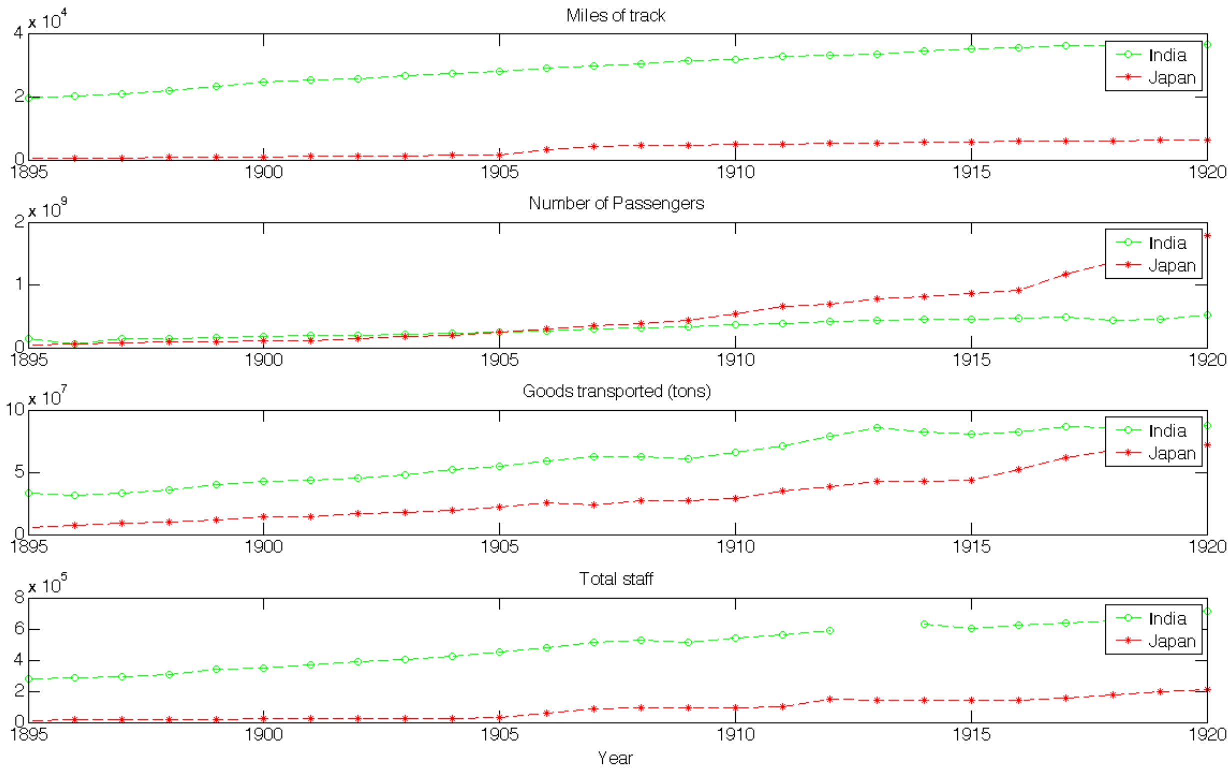

Figure 1: Basic mileage, passenger, goods and staff trends for India and Japan

Statistics for Indian operations are from *Her Majesty's Stationary Office* via The Digital South Asia Library[1]. Japanese data is from the Statistics Bureau of the Ministry of Internal Affairs and Communications[2]. Figure 1 compares basic statistics for the period 1895-1920. Track length in Japan is dwarfed by that in India. From 1905-1920, Japanese railways gradually started transporting thousands more passengers than Indian railways. More goods were transported by the railway in India for the entire period.

We do not have data for the total staff employed in India in 1913, and thus, we leave this data point out of the analysis. Data on passenger-miles or tonnage-miles transported were not

[1]http://dsal.uchicago.edu/statistics/
[2]http://www.stat.go.jp/english/data/chouki/12.htm

directly available for India for this period. We estimated these data using detailed reports of the numbers of passengers and tons of goods transported on each of the many large and small railway networks in the country. The total passenger-miles for a given year was calculated as the sum $\sum(P \cdot m)$ over about eighty networks, where P is the number of passengers on the network, and m is the number of miles in the network. Most of the networks were between 10 to 100 miles in length. Six were over a 1000 miles. Tonnage-miles were calculated similarly. This is a very rough estimate (order of magnitude). Passenger and tonnage data were not available for every small network, and so all these smaller networks were excluded (i.e. their passengers/tonnage was set to zero). These data were directly available for Japan.

5 Results

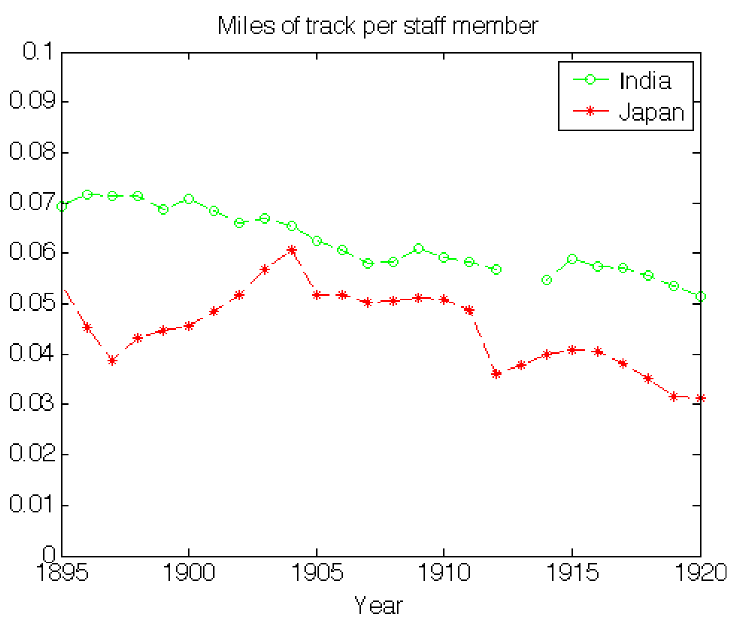

Figure 2: Miles of track per staff member

Figure 2 shows that the staff members in both countries per mile of track were in fact quite similar. This supports our assumption that railways stations and staff members had comparable and uniform densities in India and Japan.

The results from both the density and the unit-work models are considered in figures 3 and 4 respectively. By 1895 railroads in both countries had moved out of infancy, and we assume that the data are directly comparable. In this analysis, we ignore and do not control for any effects of a potential head-start for India, the 'colonial' factor or management differences. Hence, the labor productivity we observe is a measure of worker abilities or work ethic *while taking into account these factors*, and not just dependent on the individual worker.

Figure 3: **Density Model.** Top: Tons of goods transported per staff member in India and Japan. Bottom: Passengers transported per staff member in India and Japan

Figure 3 does not show any clear trends in Japanese performance over time. However, Japan clearly outperforms India under the density model. Japan transports up to seven times more tons of goods and fifteen times more passengers per staff member than India during the peaks near 1905. 1905 is interesting in particular since Japan and India were transporting almost exactly the same number of passengers. However, India had about twenty times more track miles and twenty times more staff members.

Under the unit-work model, India appears to have much higher labor productivity than

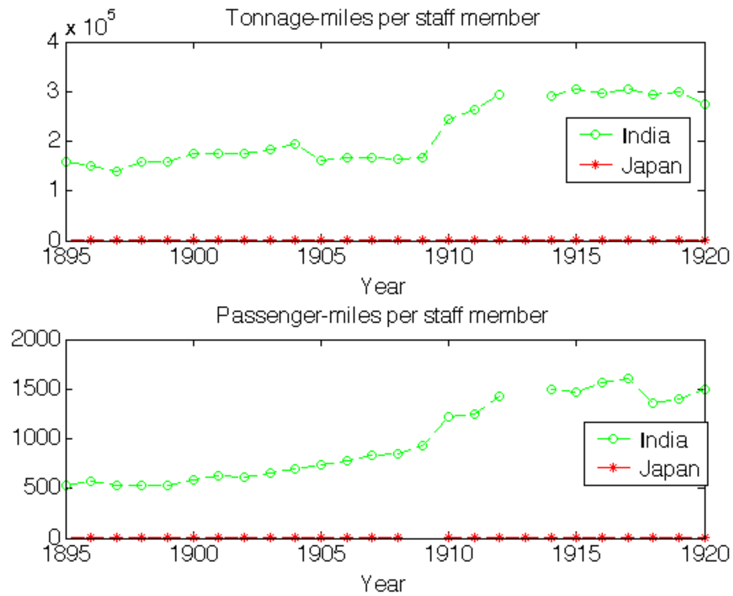

Figure 4: **Unit-work model.** Top: Tonnage-miles of goods transported per staff member in India and Japan. Bottom: Passenger-miles transported per staff member in India and Japan

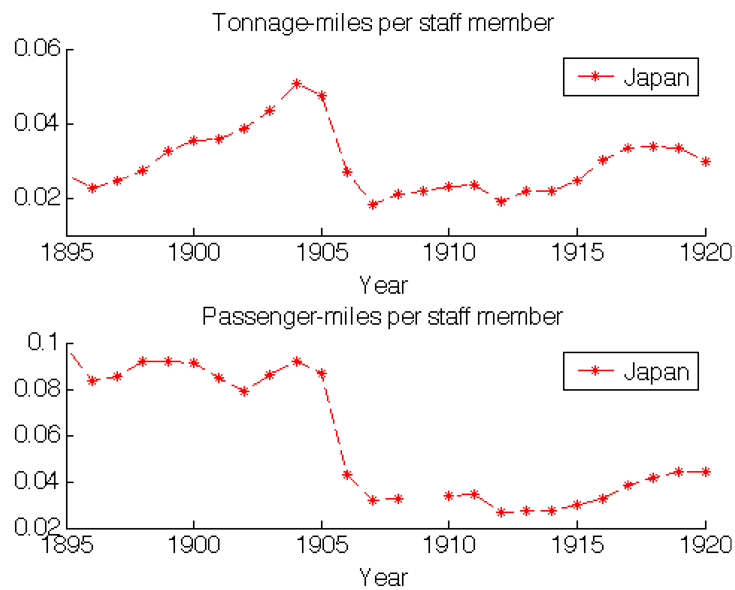

Figure 5: **Unit-work model.** Detailed view of Japan's commodity-miles per staff member

Japan (figure 4). This might due to the much larger track lengths in India. However, even this conclusion is problematic since figure 2 shows that the number of staff members per mile of track were not that different in India versus Japan, and hence the staff numbers should have been normalized the track length. Since the scale prevents close observation of Japan's labor productivity measure under the unit-work model, figure 5 zooms in on this.

The density model and the unit-work model provide conflicting results. The results from the unit-work model rely on estimated data for India, as described in section 4. We are unable to test the accuracy of the estimation — and an inaccurate estimate may be the reason behind the contradictory predictions of the models. Hence, we are forced to accept the results from the density model as more reliable.

6 Conclusions

This paper compares the labor productivity in railway operations in India and Japan from the period 1895-1920 using two different models. Under the *density* model Japan's labor productivity was higher than India's throughout the period. Under the *unit-work* model, Indian productivity was higher than that of Japan. Conclusions from the density model alone support the hypothesis that labor productivity throughout Indian society was lower than Japanese labor productivity from 1895-1920. It seems low productivity is pervasive, subject to the limitations of our framework.

Unlike Wolcott and Clark [2009], we do not have additional information regarding railroad management that allows us to distinguish between the effects of management and labor preferences. Anecdotal evidence brings to light the different attitudes of the Japanese and the Indians. The enthusiasm of the Japanese to develop their own railway system likely contributed to their success. These stories lend support to the conclusions suggested by the data.

A study of this nature is only a small step towards understanding labor productivity and the bigger question of 'Why did India fail?'. A detailed study of the industry could also provide the necessary information to compare the technological and managerial expertise in India and Japan. Modeling assumptions could be refined to provide more accurate estimates of the labor productivity in both countries — how realistic are the assumptions of uniform density? Weighting the number of passengers and goods transported appropriately to give a better estimate of the output of the railroad industry is another immediate next step.

Finally, we believe that an attempt to quantify the impact of colonization would get at the heart of one aspect of the issue. Is labor productivity in communities with local governance higher than productivity in communities that are colonized? A comparative study of the railroads in India and South Africa might be a good place to start.

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