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Abstract

This paper undertakes a detailed productivity and competitiveness comparison for the cotton and jute textile industries in Britain and India for the period 1860-1940 to examine why India was only able to beat Britain decisively in jute but not cotton. I collect data on factor costs over the period, and examine differences in capital productivity rates. I assess the extent to which manning ratios differed between the two countries for the two industries and whether they changed over time. I then construct implied unit cost ratios, with and without allowing for capital-labour substitution, and use these to infer productivity differences. As the UK had far higher wages but only marginally lower capital costs for the vast majority of the period, India should have had an absolute cost advantage in both industries, even at British factor proportions, that could only have been increased by capital-labour substitution. This implies some missing (labour) productivity residual in the UK's favour. I examine an old and hotly debated hypothesis that differences in labour intensity per worker (assuming manning ratios reflected this) explain this productivity gap, while explicitly allowing capital-labour substitution. Observed differences in manning ratios quantitatively explain the majority of the required productivity gap for cotton, but not jute, throughout the period, and my implied potential increases in profits for Indian firms that reduced manning rates are large and persistent enough to rule out managerial failures (the alternative hypothesis in the literature) as their cause. Such labour intensity differences per worker between the UK and India, relative to the wage ratio, were smaller for jute than for cotton, which explains why India was relatively successful in that industry, and Britain in the other.

1 Introduction

Imagine a poor, densely populated, agrarian society with secure private property rights, low marginal tax rates, and few regulations and barriers to entry into business. Suppose also that it was completely open to foreign capital investment during a period of globalisation and had no (or low) tariffs on intermediate inputs and capital goods. If you would predict rapid economic growth thanks to capital accumulation and the adoption of modern technology in labour intensive and export orientated manufacturing to ease population pressures by importing land-intensive goods from abroad, you would be wrong - at least in the case of Colonial India, one of the subjects of this paper, which fits the description above. Or perhaps not entirely wrong - there was both a substantial volume of foreign investment and a major growth of modern, factory, manufacturing industry that, in absolute terms, would have been considered successful industrialisation except for India's high population level. So we are left with a puzzle: Why did industrialisation only get so far?

Traditional accounts of India's failure to fully industrialise under colonial rule usually take the political economy angle. There is little credible evidence, however, that the state blocked industrialisation at all, and so that dead end will not be explored here.[1] While it is certainly true that political processes were different between India and Britain, the actual legal environment for manufacturing firms was fundamentally the same. In this sense this is as controlled an experiment as we are likely to get from history to examine the role of factors in industrial performance other than institutional. By 1900 two very large (in absolute terms) modern factory textile industries had sprung up thanks to the efforts of both local and foreign investors and managers. These used raw cotton and raw jute, both Indian produced crops, as their inputs, and their centers were located close to the areas that cultivated them: Bombay had the larger cotton industry, and Calcutta had the larger jute one. Britain, producing neither raw cotton nor raw jute, had large manufacturing industries in both:

[1] There is a much more plausible story about the colonial state suppressing economic performance in the tribal areas and parts of Central India since it rolled back its pro-land market reforms in those areas following outbreaks of violence against moneylenders and merchants. But the equally poor performance of the rest of the country with functioning land markets suggests that these were unimportant for the great question of Indo-European income differences.

cotton in Lancashire, and jute in Dundee.[2] As time passed, Calcutta beat Dundee freely and fairly, but Bombay was unable to dominate Manchester in the home market (with the important exception of coarse yarns for hand loom weavers) until Indian firms got tariff protection. These facts are illustrated by Figure 1, which plots employment in the industries in the two countries over time, and Figure 2, which plots cotton consumption for spinning and cotton yarn consumption by power looms in the two countries over time.[3] Here I set out to find the reason why India failed in the more famous case, and succeeded in the less well known one. This is one important aspect of the puzzle mentioned above. Restricting my analysis to UK-India comparisons, ignoring the international context, is valid because the other large cotton textile industries were reliant on protectionism (in the Americas, France, and Russia, for example) with the late exception of Japan, and for jute India and Britain were by far the main two manufacturers and exporters.

As the pioneering sector of the industrial revolution, and the first to spread internationally, the cotton textile industry has taken a prominent place in the economic history literature.[4] Anglo-Indian comparisons have been made for the early mechanisation period in Britain by Broadberry and Gupta, and, methodologically speaking, I am merely following in their footsteps here by applying their method to the post 1850 period when India started to adopt modern technology (Broadberry and Gupta, 2009). Why Britain was able to beat India at cotton has, of course, been discussed before. The relevant debate for us started with a 1987 paper by Gregory Clark finding major labour productivity differences in the cotton textile industry between different nations at a snap-shot around 1900 (Clark, 1987). Capital productivity differences, according to Clark, were very small in comparison to differences in labour productivity - the major difference was in manning ratios (workers per machine). These differences just so happened to almost perfectly align with international wage differences; wages per unit of effective labour had been almost equalised

[2] While Britain did have the notable acquired advantage of the cotton market of Liverpool, enabling British firms to economise on circulating capital, Bombay had the largest cotton market in Asia.

[3] The raw jute consumption series are not presented as they look very much like the employment figures, there being no real trade in yarn.

[4] Jute, by contrast, has been essentially neglected except by historians of Dundee and Bengal, and little of this work has been quantitative, e.g. Lenman et al. (1969), and Basu (2004).

internationally. By claiming to rule out managerial failure, capital and/or raw materials - labour substitution, worker experience, and so on, Clark argues that these differences in labour efficiency - one hour of labour in different countries contained different amounts of actual work - reflected "local effects" since they did not follow immigrants from their place of origin. This was essentially a cultural argument where preferences regarding work effort and consumption bundles differed internationally and, when in the proverbial Rome, people did as the Romans did. India was one of the lowest wage and productivity countries, while the UK had relatively high wages and rather high productivity levels. Clark's article has been controversial and sparked a long series of papers: others have persistently claimed, Clark's arguments notwithstanding, that low labour productivity was instead due to capital-labour substitution and/or managerial failures.[5] None of these opinions were new: Vera Anstey's classic account of the Indian economy from the 1930s, for example, equivocated between "although wages are low, labour is dear", and the managerial failure and K-L substitution views (Anstey, 1952, pp. 228-31).

I will test the Clark story against the classic alternatives in the second half of this article, but rather than wading right into controversy, it is time to turn to what the long run data itself says. My method is essentially that of Broadberry and Gupta: collect data on input and factor costs and combine these using the implied unit cost functions from certain types of production functions. The inverse of the ratio of the cost functions is an implied, residual, productivity ratio. In Broadberry and Gupta's paper, covering 1680-1820, that was very clearly the new technology associated with the industrial revolution in Britain that had not yet spread to India. Here, however, I am examining the factory industries in both countries and so the source of any residual cannot be differences in technology.[6]

To compare the two industries in the two countries, I first construct and present relative hourly

[5] The main citations, in chronological order here are (Clark, 1987), (Wilkins, 1987), (Clark, 1988), (Hanson, 1988), (Clark, 1989), (Wolcott, 1994), (Wolcott and Clark, 1999), (Wolcott, 2008), (Clark, 2007), (Allen, 2008), (Gupta, 2011), (Bessen, 2012).

[6] India had a very large hand loom sector, which is not dealt with at all here. There were around 2 million hand loom weavers in the interwar period, who took around a third of the Indian cloth market by yardage, and probably a majority by value added.

factor cost estimates. Second, since my factor costs are on a per hour basis, I then examine capital productivity in terms of output per machine hour. I attempt to control for differences in the quality of production. I estimate comparative manning rates (men per machine). These allow me to construct implied unit cost ratios. I then calculate such implied costs for a Cobb-Douglas production function, which permits a good deal of capital-labour substitution, and Leontief production functions, which do not, to see if these can fit the data. I then quantitatively examine the role of capital-labour substitution, management failures, and labour intensity/efficiency in explaining the facts from the above exercise.

Before all this, however, the first step is data collection. I need data on: (1) Employment, (2) Spindle and loom counts, (3) Output/consumption of inputs, (4) Wages, (5) Interest rates (and a depreciation figure), (6) Capital per spindle and loom, (7) Hours worked per machine and per worker per week. And such data I have managed to assemble. Data for the first three and the last items are taken from a wide range of sources and further comment on these is relegated to Appendix A. I focus on manufacturing costs in the main text, but a description of sources and data for input and output prices is presented in Appendix B.

2 Comparisons of Factor Costs

Methods and sources for wage and capital costs require explanation in a bit more detail. I have collected a substantial volume of wage observations (for the Indian industries in particular) and I extract trends in each case by means of a 'hedonic' regression:[7]

$$Ln(\text{Daily Wage}_i) = \sum_{t}^{Years} \beta_t \, D_t^{Year} + \sum_{c}^{Controls} \gamma_c \, D_c^{Control} + \epsilon_i \qquad (1)$$

I.e. with dummies for each year and a set of control dummies (female workers, children, skilled

[7] The number of wage observations is 1,945 for the cotton industry in India, 1,864 for the jute industry in India and 307 for Scotland.

roles etc).[8] There are, of course, missing years and so I linearly interpolate to fill these gaps. For Scotland I run a similar regression, with the caveat that for jute there were few observations, and so I also included some Scottish cotton wages in the sample combined with a dummy for cotton workers. As most jute workers there were women, my baseline category is a female worker who is not in a skilled role. My English cotton wage series is Bowley's general cotton wage figure up to 1906, and then the 1906 value adjusted by the Oldham spinner's list index values for the years up to 1939 (Fowler et al., 1987). Hourly wages can then be calculated (with i now indexing country-industry combinations) as:

$$\text{Hourly Wages}_{i,t} = \frac{\text{Daily Wage}_{i,t}}{\text{Working Hours}_{i,t}} \tag{2}$$

Data on the working hours of labour are taken from a variety of sources described in Appendix A. It is important to note that these figures may not always be representative of marginal labour costs for each industry. In the UK, workers and employers in the cotton sector had agreed upon wage lists that essentially applied to all firms in the town.[9] As jute was a one town industry, and since the Lancashire lists for different towns tracked one another closely, they probably do form a good guide to marginal labour costs. For India, however, things may be different. There were no standardised lists. Each mill had its own list and these apparently, to the amazement of commentators, substantively differed even between mills in the same town.[10] As much of the early Indian wage data comes from single firms, substantial nominal rigidity in these series does not imply the same for the industry as a whole, especially as expansion overwhelmingly took the form of new

[8] The roles counted as skilled are described in Appendix A. The implied skilled worker premia in India from these regressions are 105 % for cotton and 77 % for jute above unskilled worker incomes. While skill premia were presumably higher in India than in England, skilled workers in India were still far cheaper than unskilled ones were in England for we will see that the unskilled wage ratio between the two countries was around 4.5 or so for cotton. Thus Indian industrial failure, it seems, cannot have been due to an absolute lack of skilled labour - which would imply that it was more expensive in absolute terms, not just relative to unskilled labour than in the UK - unless we capitulate to the Clarksian view and allow one hour of labour hire in England to buy much more actual labour than in India.

[9] Adherence to these was basically enforced by custom, and only by formal law in the 1930s, e.g. Huberman (1996).

[10] As discussed by Morris (1965, pp. 154-158), and see the contemporary reports from European trade unionists compiled by Ahuja and others (Ahuja et al., 2020).

mills rather than the growth of existing ones.[11] Money wages also do not capture other aspects of job compensation - even when adjusting for hours - as there may have been in kind benefits, and the quality of working conditions also mattered. In kind payments appear to have been unimportant in both countries, but working conditions presumably were superior in Britain (excluding, if Clark is to be believed, effort levels). How so, and the cost of bringing these conditions about to employers, I cannot say.

My capital cost measure is based upon the user cost of capital:

$$\text{Hourly Capital Cost}_{i,t} = \frac{(i_t + \delta)P_{K,t}}{\text{Machine Hours}_{i,t}} \tag{3}$$

Where i is the nominal interest rate, δ is the depreciation rate, and $P_{K,t}$ is the price of capital goods interpreted broadly, i.e. the whole cost of a mill per spindle or loom. Note that I do not account for expected capital gains. I use the nominal rather than real interest rate as I assume that long run inflation expectations were next to zero under commodity standards. Interest rates, of course, can be hard to measure at an industry level as financial frictions ensure that not everyone faces the same interest rate. Nevertheless, cotton and jute mills were large enterprises, especially by Indian standards, and were financed by capitalist groups who had access to the formal banking system. For India, I use the Bank of Bengal's (later the Imperial Bank of India's) published interest rate. For Britain, I use the Bank of England's discount rate with a slight upward adjustment to make it comparable (conceptually) to the Indian interest rate.[12] I assume an annual depreciation rate of 3.5 per cent.

Capital costs are harder to come by. I have taken capital per spindle or loom (which includes more

[11] Thus, in periods of price inflation, new firms may have had to pay higher nominal wages at the margin - which is relevant for 1880-1913 - and following deflation new, marginal, firms may have been able to pay lower nominal wages - which is relevant for 1929-1939. For example, nominal Indian cotton wages apparently did not drop by much during and after the price level collapse of the Great Depression. Yet by 1935 employment was 17.6 per cent higher than it had been in 1929. Even ignoring churn for existing workers, this fifth or so of the industry had no historically set wage level.

[12] By 0.5 percentage points, as suggested by G. Findlay Shirras (1920, p. 159). Note that Shirras also suggests, on the same page, that often loans could be taken out at rates below the Presidency bank rate when it was relatively high.

than just the price of one unit of such machinery) at a baseline year and then adjusted that by Feinstein's capital goods price index. Clark notes that machinery cost more in India than in the UK since it had to be imported from that country, but construction and land costs were lower resulting in similar capital costs overall. His figures for jute show that these cancelled one another out, but for cotton I increase the price of capital per machine by 25 per cent throughout the period for India based upon his figures (Clark, 1989, Tab. 1), (Clark, 1987, Tab. 2).[13] As with wages, capital costs have to be adjusted for working hours. The Indian hours I use for machinery when comparing marginal costs for both cotton and jute are the observed cotton industry ones, since those for jute were frequently lower than one may expect for many firms due to a cartel agreement.[14] As there was free entry into the jute industry, independent mills could run whatever hours they liked (subject to law), and so the cotton hours are a better guide to marginal capital costs per loom hour, although many Indian cotton mills ran for fewer hours per year than was possible as double shifts were not adopted on any scale until the 1930s.[15] I do not account for taxation here. In both countries direct income and corporate taxes were extremely low by modern standards until the interwar years.[16]

And what about my results from this exercise? Wage comparisons in this context require conversion at the existing nominal exchange rate. As nominal wages were sluggish and investment based upon long run conditions, I have smoothed the exchange rate series to remove noisy temporary shocks and this series and will be used in the rest of the text.[17] The ratio between British and Indian factory wages in Pounds at the current exchange rate, adjusting for differences in daily work hours, and the

[13]R. Robson suggests that the cost of a ring frame in the 1950s was 30.4 percent higher in Lahore than in Manchester (Robson, 1957, p. 325). This was far inland, and, according to his figures, for the coastal regions of India the price would be only 15 per cent higher.

[14]The cartel was apparently not successful (Gupta, 2005). But this was to be expected given the lack of barriers to entry.

[15]Double shifts were an obvious way to substitute labour for capital that the Indian cotton industry did not bother with until very late in the day - a point in favour of the view that labour was not cheap in India.

[16]In Britain the indirect tax burden, the economic incidence of which that could have potentially fallen on capital or labour at the margin, was far higher than in India; the colonial fiscal system was based around lump sum land taxes (the economic incidence of which fell upon landowners), while the metropolitan one raised most revenue through customs and excise taxes on consumer goods. The economic incidence of the latter is a complicated question that I will not go into.

[17]The number of Rupees per Pound Sterling is plotted over time in Figure D.1, with the smoothed series. This is a loess trend with a span of 0.25.

ratio of hourly capital costs, for the cotton industry are presented in Figure 3, and those for jute are presented in Figure 4. Some things are notable. First, the ratio of wages was far, far, higher than the ratio of capital costs. Second, the Indian wage advantage was smaller in the case of jute than cotton, and yet this was the sector it dominated. Third, similar capital costs implies that capital was not particularly scarce in India (for the modern sector at least) and low investment, it seems, was the result of a low demand for it, not a lack of supply. The first should not be surprising, the second is somewhat so, but the third goes entirely against received wisdom.

3 Comparisons of Capital Productivity

Did productivity per machine hour differ between Britain and India? If you support the factor substitution story, then you would expect it to be higher in India, but if you buy the Clarksian story you would not. The quality of production and machinery differences have to be accounted for here. Let us start with cotton. Britain primarily used American and Egyptian cotton while India primarily used its own (plus a small amount of imported) cotton. These inputs differed by their fibre lengths (staple lengths) - Indian cotton had notoriously short fibres. Different fibre lengths were best suited to different qualities of yarn. The standard measure is the count of yarn - how many hanks of 840 yards weigh 1 lb, denoted by a number followed by ”s”. Most Indian cottons were only economically suitable for spinning (by machine) yarns up to 40s, while American and especially Egyptian ones could go much higher. Of course, if the Indians wanted to they could have imported Egyptian (and American) cotton. The average count spun in the Indian industry per spindle hour in this period was approximately 20s, while that for Lancashire was around 40s.[18] Yarn count matters for our productivity comparison. When measured by output by weight per spindle hour, the count of the yarn has a dramatic negative impact on productivity (Leunig, 2003). Machinery also mattered. Lancashire stuck to the spinning mule on the whole, while the Indian

[18]The average count per lb of yarn was less than 40s, but the relevant metric here is per spindle hour, and Robson reports the averaged ”balanced” count for English mules in the 1950s (most of which were installed in the early 20th century) at around 40s (Robson, 1957, p.65).

industry had largely shifted to ring spinning machines by 1910. Ring spindles produced more yarn of the same count per hour largely because they operated continuously, while the mule was an intermittent spinner.

Controlling for count and the type of machinery, however, there is no evidence that spindle productivity systematically differed in India's favour in comparison to Britain. We can compare Leunig's figures for British rings from around 1910 with figures from the 1920s for India from Arno Pearse, and from around 1935-40 from an Indian guidebook for cotton mill managers by B. S. Benjamin (1942). Pearse examined around 30 Indian cotton mills and reported their output in oz per 10 hours for different yarn counts (Pearse, 1930). He noted that most of these tended to "be considered better-class mills". Benjamin lists "Spinning Particulars" from actual Indian mills. Figure 5 plots the productivity estimates by count from the three sources. I run the regression:

$$Ln(\text{Oz per Hour}_i) = \beta_0 + \beta_1 \text{Count}_i + \beta_2 \text{D}_i^{England} + \epsilon_i \tag{4}$$

Results are presented in Table 1. Raising the count of yarn spun by one appears to lower the output by weight per hour by 3.8 per cent or so. The coefficient of the England dummy implies an English productivity advantage of around 12.5 per cent (compared with Indian data from decades later), but it is statistically insignificant. Using the same machines for similar counts, physical productivity per capital hour was the same or somewhat higher in England, even if the English figures are one to two decades older.

Thus differences in productivity per spindle hour between India and England for cotton were to some extent due to differences in counts and machinery. Figure 6 plots output per spindle hour over time between the two nations for the cotton industry with three English series: an unadjusted one, one adjusting for count (unadjusted times 2.18, from Leunig's data), and another also adjusting for mules vs rings by increasing the English figure by a factor of 1.23.[19] With the exception of the

[19]This may overstate things before 1912. R. Robson gives the share of rings in English spindles at 0.2 in 1912 and 0.3 in 1939 (Robson, 1957, p.339). Wolcott and Clark give the Bombay ratio as 0.7 in 1912 and 0.94 in 1938 (Wolcott and Clark, 1999, Table 4). Assuming that one ring spindle was equivalent to 1.5 mules in terms of output per hour,

mid 1870s and the period after 1920, capital productivity follows the same trend in both countries, and has the same level when adjusting for differences in yarn quality and machinery.[20] Even in the 1920s India had at most a small advantage in spindle productivity (the gap is larger around 1931-3, but the depression years are obviously not representative), and this is plausibly due to a decline in English capacity utilisation over that period since it substantially narrows after 1935 as spindles were scrapped in Lancashire.

What about weaving? The 1942 Fact Finding Commission estimated Indian power loom yarn consumption after 1900, which can easily be adjusted to consumption per loom hour (FFC, 1942, p. 285). I can calculate English consumption per loom hour by deducting yarn exports from yarn production.[21] Figure 7 plots capital productivity between 1900 and 1940 for cotton weaving as measured by the lb of yarn woven per loom hour. Here India does rather well - it overtakes Britain and sees good productivity growth over the period. But this overstates relative Indian performance. First, the series are not quality adjusted. As mentioned above, the count of yarn spun in England was around twice that of India on average. Assuming the same width and thread counts/picks per inch of cloth, and similar rates of picks per minute on looms, then in an hour India should have consumed twice as much yarn by weight, although lower counts required lower thread densities, which would tend to reduce this maximum somewhat, even if the existing evidence does not suggest by very much (India. Tariff Board, 1927, p.60), (Utley, 1931, p.218). Second, capacity utilisation widely differed between the two industries in the interwar years - the rapid growth in the English lb per loom hour series in the 1930s is entirely due to the scrapping of looms rather than a decline in yarn consumption.

What about jute? Figure 8 plots the consumption of raw jute in lb per loom hour in Bengal and in Scotland over time. I use looms rather than spindles here because the spindle to loom ratio was approximately constant (at 20), and there was no real trade in yarns unlike in cotton. Here, contrary

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then the required factor to adjust for differences in machinery in a given year would be $1 + \frac{0.5*(\alpha_E - \alpha_I)}{1.5 - 0.5\alpha_E}$, where α is the share of mules in total spindleage. For 1912 this formula would be 1.23; for 1939, 1.28.

[20]There is a large drop in Indian productvity in 1900, which is simply due to a plague outbreak in Bombay presidency that disrupted production that year.

[21]This results in a slight overstatement as yarn used for other purposes is not accounted for.

to Clark's data for two years, India appears to have had, before we adjust for quality, equivalent, or perhaps slightly higher, capital productivity.[22] Admittedly, I do not have very many Dundee observations here, and capacity utilisation there appears to have fluctuated considerably. As the Dundee mills focused on finer jute goods, lower machine productivity should be expected. Clark's calculations suggest that this should raise Dundee's output per machine hour by 19.4 per cent or so.[23] The blue line makes this adjustment. Now India's productivity advantage disappears.

In neither industry did India have a substantial capital productivity advantage once the quality of production has been accounted for. If capital productivity did not differ particularly much between India and Britain, then from the elementary accounting identity:

$$\frac{Y}{L} = \frac{Y}{K}\frac{K}{L} \tag{5}$$

We can see that differences in labour productivity must be due to differences in manning ratios, i.e. the number of spindles or looms per operative, which is what Clark's argument (for 1900-10 at least) was based upon. Since we do not have separate data for spinning and weaving employment for cotton, I have not constructed series on labour productivity for that fibre. But we can do so for jute, which is presented in Figure 9, showing that there were persistent differences in labour productivity between Dundee and Bengal over the period. Scottish (quality adjusted) labour productivity was 80 per cent or so higher than in Bengal, which, while big, is actually quite small given the wage difference: it is no surprise that India was successful here.

[22] For 1912, one of his years, my figures do have a Scottish productivity advantage. For the other my source has a lower number of working hours a week for India, and using Clark's number almost entirely wipes out the Indian lead.

[23] Clark's baseline figure was that output per loom hour in India was 0.8 of that in Dundee. He then does a few calculations and concludes that, adjusting for quality, output per machine hour in India was only 0.67 of that in Dundee, and 0.8/0.67 = 1.194.

4 Manning Rates

This section examines these manning ratios by regressing employment on machine counts. Note that this (alone) does not allow us to determine whether these differed due to capital-labour substitution, poor management, or worker preferences. Following Wolcott and Clark (1999), as well as Gupta (2011, Tab. 6), for the cotton industry I run the following regression separately for each country (indexed by i):[24]

$$\text{Workers}_{i,t} = \gamma_{1,i}\text{Spindles}_{i,t} + \gamma_{2,i}\text{Looms}_{i,t} + \epsilon_{i,t} \tag{6}$$

Where i denotes the country. The coefficients here can be interpreted as the marginal increase in employment from a unitary increase in spindles and looms, i.e. manning rates. Results from these regressions are presented in Tables 2 and 3. This specification does not allow for changes in marginal manning requirements over time. To see whether this is a reasonable assumption, we can plot the predicted residual expressed in percentage terms. If there were secular trends in manning ratios over time then this would show up as initially under-predicting workers then towards the end of the period overestimating them. If there were not then the residuals would be a stationary process and we can assume that manning rates were constant. The percentage residuals from these regressions (predicted minus observed as a percentage of predicted workers) are plotted in Figure 10. Between 1880 and 1940, i.e. the majority of the time period, the residuals for India fluctuate without trend between -10 and +10 %. Thus it is unlikely that manning requirements changed over time.

There, however, is one Indian exception to this: Around 1880 there is a discrete jump in the residuals, that occurs at shift in the data source: the statistics switch from Bombay Presidency only to All

[24] Note that I do not have separate data on ring and mule spindles unlike these authors. They also have firm level observations, while I just have industry level ones. Wolcott and Clark pool all firms and years and run one regression for Bombay city only between 1907-38. Gupta has data from the rest of Bombay Presidency too and runs a separate regression for each of the five years she has data for. Both find little variation in manning rates over time, although Bombay city and Ahmedabad (where most firms were) had persistently lower manning rates than elsewhere.

India figures. This may suggest that Bombay's lower manning requirements, which were noted by Gupta, may have originated from a very early date - before the rise of trade unionism, implying that unions cannot have been the source of relatively high productivity, by Indian standards, there (Gupta, 2011). This is still a surprisingly large jump, for at that time Bombay Presidency had 80 percent of all cotton factory workers in British India. Alternatively, employment may have been under counted as there were no official statistics in these years. In any case, this growth in the residuals implies that manning requirements were increasing over time, rather than decreasing. Aside from this, manning requirements did not change very much over time in the Indian cotton textile factory sector.[25] Labour productivity, therefore, rose only as capital productivity did. What about England? Here it does a better job at reducing manning requirements than India over time, but the decline is a mere 20-25 per cent over the course of 75 years, part of which is a replacement of child by adult labour, and it is small enough that I will not take it into account.

For jute, the ratio of spindles to looms in both Scotland and Bengal is approximately constant (implying multicollinearity), and so I drop spindles from the regression equation. There is, however, another issue in the case of jute: the jute industry in India had major changes in the working hours of machinery over time that did not directly correspond to the hours per worker thanks to the use of a multiple shift system.[26] The Bengal industry, for example, took to multiple shifts at an early date but then switched to single shifts in the 1930s. For jute, therefore, I instead run:

$$\text{Worker Hours}_{i,t} = \theta_i \text{Loom Hours}_{i,t} + \epsilon_{i,t} \tag{7}$$

Again, the residuals for Bengal appear to be stationary. Thus there were no real changes in manning requirements, except for the phasing out of child labour 1928-1932, which I have accounted for.[27]

[25] Interestingly, the hand loom sector after 1900 adopted the flying shuttle which did reduce manning requirements.

[26] Using the unadjusted figures (not presented here) implies major manning reductions over time (the residuals go from +35 to - 15 per cent).

[27] As discussed by Anna Sailer (2022, Ch. 3). For details of my adjustments to account for it see Appendix A.

For Scotland there are only a limited number of observations, but aside from the earliest and last observations they are close to zero.

As manning rates were generally stationary, and I assume that it is reasonable to take them as being constant, one estimate of the manning ratios between India and the UK is the ratio of the coefficients on spindles and looms here from Tables 2 and 3. For cotton, the spindle coefficient ratio is 4.9, and the loom ratio is 2.748, while for jute the ratio (only for looms) is 1.62. The cotton spinning ratio here is a slight overstatement, as the number of spindles tended by one English ring spinner fell as the count spun did. We need to account for this to make the figures comparable. Thus, from now on I adjust this cotton spinning manning ratio by 0.8 (the ratio implied by the data) to account for this, i.e. to 3.92.[28] Manning rate, and therefore labour productivity (as machine productivity did not differ much comparatively), differences were large and persistent, but, importantly, smaller for jute than for cotton.

5 Comparative Unit Costs: Observed and Implied

This section compares unit costs between Britain and India, both those observed as calculated from the data above, and those implied by various production functions with different assumptions. This allows me to examine whether capital-labour substitution alone is sufficient to explain differences in manning rates. Note that I am only comparing manufacturing charges and not accounting for the cost of raw material, which was lower in India, and freight charges for final goods, which were lower in India if we consider the Indian market, but, by 1890, these could have been only marginally so.[29]

To proceed, we need to select values for the ratio of output per machine hour, $\frac{A_I}{A_E}$. I examined

[28]Timothy Leunig has examined the relationship between the count of yarn and the number of spindles per operative in Lancashire: the number of operatives per 100 ring spindles for 17s yarns was only 25 per cent higher or so than those making 43s yarns (Leunig, 2003, Tab. 1). His evidence tells us that only a small portion of the difference in manning rates comes from differences in product quality.

[29]I do have data on this, but it is not reported in the main text for want of space and because of concerns about quality adjustments, see Appendix B for details.

hourly capital productivity above, and here I attempt to capture general trends rather than yearly fluctuations. In the case of cotton spinning I have adjusted for differences in machinery and counts of yarn above, but the English figures from the 1920s are unusually low thanks to a decline in capacity utilisation. Otherwise, England seems to have a marginal, say 5-10 per cent, advantage. An alternative would be to use the data from Figure 5, which gives a statistically insignificant but economically relevant advantage to England of 12.5 per cent. Weighing the evidence up, I assume a constant 5 per cent English advantage. For cotton weaving I assume an initial English productivity/quality advantage of 1.4, that drops by 0.01 each year after 1920, which attempts to adjust for quality differences and capture the dynamics of Figure 7 while assuming much of the apparent English decline was due to changes in capacity utilisation. For jute, my Scottish loom productivity series is highly erratic. The output per worker one is not as erratic, and since looms per worker were approximately constant, it seems that, contra Clark, Scottish output per loom hour was not dramatically more than the Indian level. So I will merely adjust for quality differences, i.e. by 1.194. These and my other calibration choices for the rest of the paper are outlined in Table 4.

Figure 11 plots the ratio of unit labour costs between Britain and India. What is clear is that, despite the enormous wage difference, unit labour costs were at the very most only twice as high in the cotton industry in the UK compared to India, and were more often only 25 per cent higher.[30] What about the ratio of total manufacturing costs? Figure 12 plots this over time for the three industries. These are generally close to 1, although there is a secular trend in India's favour over time that is more marked for jute than cotton. These are costs at observed factor proportions, and their closeness to one should give us some confidence in my figures since both countries were competing in open markets with low transport costs - this is what we would predict. But is it what my production functions would predict? I now examine comparative costs at three different sets of factor proportions: those implied by a Cobb-Douglas production function and the two edge cases represented by Leontief production functions calibrated to each country's proportions respectively.

[30]Twice is a maximum as I suspect that my Indian wage series for 1890-1910 understates marginal labour costs. Figure D.4 plots my unit capital cost ratios, but the bulk of the deviation from 1 is largely due to differences in output per machine hour rather than the cost per machine hour.

Suppose that we have a Cobb-Douglas production function with constant returns to scale, which permits a good degree of substitution between capital and labour (the elasticity of substitution equals one). The marginal unit cost function resulting from cost minimisation is:

$$c(w, i_t, P_{K,t}) = \frac{1}{Z}\left(\frac{w}{\alpha}\right)^{\alpha}\left(\frac{(i_t+\delta)P_{K,t}}{(1-\alpha)h_t}\right)^{1-\alpha} \tag{8}$$

Here α is the labour share, and Z is total factor productivity. Let us further break total factor productivity into a machine output per hour term, A, and a residual, Z^*, so that $Z = Z^* A^{1-\alpha}$.[31] Now assume that Z^* is the same between India and Britain.[32] Then the ratio of marginal costs between England and India would be:

$$\frac{c(w_{E,t}, i_{E,t}, P_{K,E,t})}{c(w_{I,t}, i_{I,t}, P_{K,I,t})} = \left(\frac{A_I}{A_E}\right)^{1-\alpha}\left(\frac{w_{E,t}}{w_{I,t}}\right)^{\alpha}\left(\frac{(i_{E,t}+\delta)h_{I,t}}{(i_{I,t}+\delta)(1+\lambda)h_{E,t}}\right)^{(1-\alpha)} \tag{9}$$

Where λ is the percentage difference in capital goods prices between the India and the UK. As this is cost per unit, and my costs are in per worker/machine hour, the $\left(\frac{A_I}{A_E}\right)^{1-\alpha}$ term adjusts for differences in output per machine hour. If differences in labour productivity between India and the UK represented capital-labour substitution alone, then, this ratio should be close to one (much like the total cost ratios from Figure 12).

These cost functions have to be calibrated. One key parameter for the Cobb-Douglas case is the labour share, α. Figure 13 plots my implied labour shares of manufacturing charges for each sector in each country using my hourly factor costs and the manning ratios from Tables 2 and 3.[33] The dashed lines are my selected, constant, value of α for each case. It is worth noting that

[31] These differences in physical capital productivity between countries ought to show up as capital augmented technical change: one hour of capital time reflects different effective units of capital input between countries, and so this difference needs to be weighted by the capital share exponent.

[32] An alternative way to proceed would be to assume equal costs and let Z^* differ between nations. That would be the natural interpretation where technology differs, as in Broadberry and Gupta's paper, but technology was the same here.

[33] For each year and country, $\alpha_{i,t} = \frac{\frac{a}{b}w_{i,t}}{\frac{a}{b}w_{i,t} + \frac{(i_{i,t}+\delta)P_{K,i,t}}{h_{i,t}}}$, where $\frac{a}{b}$ is the manning ratio.

my estimates appear to be on the low side for both the UK and India, which tends to reduce the advantage from lower manning rates. My assumed values of the ratio of output per machine hour, $\frac{A_I}{A_E}$, were explained above. The Cobb-Douglas case permits capital-labour substitution. But we can get lower and upper bound cost ratios by using Leontief production functions calibrated to British and Indian factor proportions respectively. The former is a lower bound because observed British factor proportions were presumably cost minimizing for the UK, but India could always do better, or at least no worse, by substituting labour for capital, and vice versa for the latter case. With a Leontief/fixed proportions production function, the unit cost function is:

$$c(w_t, i_t, P_{K,t}) = \frac{1}{A}\left(aw_t + b\frac{(i_t + \delta)P_{K,t}}{h_t}\right) \tag{10}$$

Where a is the required labour hour input per batch of output, b is the required capital hour input per batch of output, and A is output of batches per machine hour. Let b be the same between countries, as our figures are per loom or spindle hour and differences in capital productivity are already captured by the A term. Then the UK-India cost ratio, for a given $\frac{a}{b}$, becomes:

$$\frac{c(w_{E,t}, i_{E,t}, P_{K,E,t})}{c(w_{I,t}, i_{I,t}, P_{K,I,t})} = \frac{A_I}{A_E}\left(\frac{\frac{a}{b}w_{E,t} + \frac{(i_{E,t}+\delta)P_{K,E,t}}{h_{E,t}}}{\frac{a}{b}w_{I,t} + \frac{(i_{I,t}+\delta)(1+\lambda)P_{K,I,t}}{h_{I,t}}}\right) \tag{11}$$

Where $\frac{a}{b}$ is the manning ratio. Now $P_{K,t}$ no longer drops out of the cost ratio. These cost ratios again have parameters that need to be calibrated or estimated, but my manning ratio regressions above conveniently allow me to calibrate the $\frac{a}{b}$ coefficients as per Tables 2 and 3. I use the same production per hour differences as in the Cobb-Douglas case, as outlined in Table 4. Figures 14, 15, and 16 plot my predicted UK to India cost ratios when assuming Cobb-Douglas and Leontief production functions, both for Indian factor proportions and English factor proportions, for cotton spinning, cotton weaving, and jute respectively. Note that while I change $\frac{a}{b}$ when changing the baseline proportions, I do not change my $\frac{A_I}{A_E}$ ratio.[34]

[34] As British machine efficiency was around 90 per cent, higher manning rates could have only increased its hourly

The raw data suggests that the UK should have done relatively better for jute rather than cotton and actually have succeeded in neither, both of which are contrary to the empirical evidence. At Indian factor proportions (men per machine), England would not have been able to compete at all at both cotton spinning and weaving - costs are at least 1.3 times, and after 1890 are around twice, those in India. The Leontief series with English factor proportions suggests that, after 1890 at any rate, the British should have had a cost disadvantage even at our lower bound for the cost ratio at British factor proportions, which is inconsistent with the capital-labour substitution explanation. The Cobb-Douglas case explicitly allows capital-labour substitution, which still results in a major British cost disadvantage. Thus capital labour-substitution alone cannot explain Indian manning rates: Some other factor was making India's apparent cost advantage an illusion.

So far I have examined the "What". It is time to examine the "Why". Observed differences in manning rates have been ascribed to three factors: (1) Capital-Labour substitution, (2) poor management in India, and (3) worker preferences. Our results above suggest that the first can be written off, at least as the sole factor. I now examine the other two.

6 Managerial Failure?

If labour and capital inefficiency were due to managerial failures, then there would be profits to be reaped by appointing better managers. The question here is their size. Gupta, for example, claims that low wages, supposedly set by the agricultural sector, strongly reduced the incentive to raise labour productivity in Indian industry resulting in inefficiencies that weren't worth addressing (Gupta, 2011, p. 78).[35] Note, however, that if we take the labour efficiency story seriously, then low wages in Indian agriculture may have reflected low actual labour inputs per worker, and so

output by 11 per cent or so. This is a strong point against the potential for K-L substitution.

[35] Gupta contrasts India with Japan (where output per worker in textiles rose dramatically), but if the performance of the agricultural sector raised Japanese cotton wages, then we should expect a decline in Japanese export competitiveness in textiles (even with K-L substitution). Given that Japan began to dominate both India and Britain in cotton textile export markets in this period, such a story as the sole explanation for the increase in K/L in Japan is implausible - the Wolcott and Clark story about increased labour intensity fits the stylised facts much better here (Wolcott and Clark, 1999).

labour was not actually cheap in textiles even if wages (for a given level of effort) were set by the agricultural sector. This would be consistent with India's low land yields despite high population densities. Thus this argument does not contradict the labour efficiency story.

In any case, we can measure this incentive to raise labour productivity by calculating the implied ratio of profits for a marginal Indian firm between the cases with British and Indian manning rates while holding output per machine hour constant, implying that this is a lower bound, as better management would presumably also raise output per machine hour or enable the adoption of double shifts that reduced overhead costs. I also think it is a lower bound, as my implied labour share of manufacturing costs is probably a lower bound.[36]

While large managerial failures may plausibly persist over the course of a year or five, even in a competitive market with free entry such as Colonial India, we are considering productivity differences that persisted over the course of at least 70 years. Thus any increases in profits from better management that reduced manning ratios could not have been persistently large (under the assumption that hiring better managers was not particularly expensive) if that factor is to explain persistently low labour productivity. This is essentially an arbitrage argument, and management was easily hired from abroad if it was lacking at home. The same is true today - witness the remarkable success of Indian expatriates as CEOs in Western corporations. In this period, the flow, however, tended to go the other way: most managers in India had been trained in the British industries.

Figure 17 plots the ratios of the aforementioned hypothetical profit ratios. Before 1920, for cotton spinning, such a firm could see, at least, a 40 to 50 per cent increase in its profits from lowering manning rates, while a weaving firm would be able to double them. These figures are not small, except for the line for jute. Why would managers systematically fail in one industry but not the other? In any case, they are large enough for cotton to make managerial failure implausible. After 1920 the implied increase in profits skyrockets. Yet manning rates did not change very much at all -

[36]Clark's calculations along similar lines imply a tripling of profits around 1912 for a combined spinning and weaving enterprise (Clark, 1987, Tab. 2).

see Figure 10. Susan Wolcott and Gregory Clark have a simple answer, based on the experience of the Bombay industry where some firms did in fact explicitly try to reduce manning rates, as to why they did not: the implied profit increases were illusionary since workers demanded higher wages for higher effort levels to an extent that wiped them out (Wolcott and Clark, 1999). It is important to note that the exact same thing occurred in England at the same time, with the failure of the interwar ”More Looms System” (Bowden and Higgins, 1999). Managerial failure implies large amounts of money being left on the proverbial table by shrewd capitalists, and would also be odd since many of the managers in India had been trained in Britain - men with knowledge of British productivity suddenly becoming unproductive when they set foot in India reinvents the ”local effects” story but now for white collar workers. If we accept it for them can we really deny it for blue collar ones?

7 Implied and Observed Differences in Labour Efficiency

It is now time to see if we can reject the labour efficiency hypothesis. This section explores the labour efficiency story to see if it is quantitatively important. Note that I cannot directly determine the cause of labour inefficiency. But as we have ruled out managerial failure, it may have been due to Indian workers' preferences for a low effort and low wage bundle over one with more of both along British lines, as Clark suggests. How do we go from unit costs to implied labour efficiency ratios? If we re-write the Cobb-Douglas production functions with productivity in labour augmenting form, these cost ratios to the power of the inverse of the labour share become ratios of labour in efficiency units per hour.[37] For the Leontief case the formula is somewhat more complicated.[38]

Figures 18, 19, and 20 plot the ratio between observed differences in labour efficiency, as measured by ratios of manning rates, and those required to equate unit manufacturing costs expressed in percentage terms, for the Cobb-Douglas and the two Leontief cases respectively, over time:

[37]Let $\frac{C_2}{C_1} = D\left(\frac{W_1}{W_2}\right)^{\alpha}$, where D is a stand in for the other variables. Suppose that one hour of labour in one country was worth e hours of labour in efficiency terms in the other. Then to equate unit costs we would have $1 = D\left(\frac{W_2}{W_1 e}\right)^{\alpha}$. Some re-arrangement tells us that $e = \left(\frac{C_2}{C_1}\right)^{\frac{1}{\alpha}}$.

[38]See Appendix C.

$$\frac{\text{Observed Efficiency Ratio}_{i,t}}{\text{Implied Efficiency Ratio}_{i,t}} \tag{12}$$

This ratio measures the share observed efficiency differences take in accounting for equivalence in manufacturing costs. Note that the top and bottom components of this ratio rely on independent data sources, with the exception of machine counts - there is no inherent tautology here.[39] It is also worth mentioning that these plots only show the share that differences in labour efficiency explain conditional on differences in output per machine hour. Before 1890 or so this ratio is above 100, implying that some other factor enabled India to compete: labour efficiency differences over-explain things.[40] But given the relative size of the two industries in that period, this is not an unexpected result. After that year, more often than not the series lie below the dashed line, implying that something else enabled Britain to compete, although even at the minimum differences in labour efficiency account for 50 per cent of the implied productivity gap around 1890-1910.[41] For cotton my suspicion is that this is a lower bound, as my Indian nominal wage series lags persistently behind nominal exchange rate fluctuations, and after 1910 the series are rather close to 1. For jute, by contrast, the series consistently declines over time, implying that some other factor, the importance of which increased over time, enabled Dundee to compete as the years went by, and in most of the figures, for most of the period, it is the lowest line, particularly in the Leontief case with Indian factor proportions (which were comparatively close to Scottish ones) as the baseline. Thus differences in labour efficiency were not large enough to help Dundee.

As new investment in the jute industry there was next to zero after 1890, that factor was the erosion of quasi-rents on the existing capital stock embodied in factories and machines with no other use but jute manufacturing: profits were presumably negative (for the marginal firm at least) if the opportunity cost of capital was measured with the replacement value of the required capital stock.

[39]These are used to generate the regression coefficients upon which the observed efficiency ratios are based and to calibrate the Leontief production function input requirements. The former takes the ratio of the coefficients from two separate regressions, and the latter uses one of the coefficients from one of the regressions depending on the industry and the baseline country.

[40]Before 1880, transport costs provided a substantial degree of protection, see Appendix Figures D.2 and D.3.

[41]And so there is some limited room for external economies of scale, e.g. Broadberry and Marrison (2002).

Labour may have also paid, although the extent of this has already been accounted for by my figures, for wages in Dundee were some of the lowest in Britain, being 35 per cent or so lower than in cotton, for example. In any case, had Dundee had cotton level manning ratio advantages over Bengal it is almost certain that it would have beaten Calcutta, and vice versa with jute ratios for Manchester and Bombay, which is the answer to the question posed in the title of this paper.

8 Conclusion

We cannot reject the Clarksian story: India failed at cotton while it succeeded at jute, it seems, largely because the Britain-India ratio of machines per worker was relatively lower than that of wages in jute compared to cotton. Capital-labour substitution alone cannot explain why Britain was able to dominate at cotton despite paying far higher wages, for even if India were restricted to British factor proportions it should have had a major cost disadvantage. The degree of managerial failure required to explain this would imply implausibly large amounts of Rupees being ”left on the sidewalk” for almost a century. The worker-preference-manning-rate story does the best job at fitting the facts quantitatively. While may be easy to claim Lancashire’s relatively high work intensity as an exception, merely another aspect of the cotton trade being ”in the air” there, most of the evidence suggests that it was instead jute that was the exceptional case, in particular that the number of machines per worker in Dundee relative to Bengal (for jute alone) was unusually low compared to most UK-India differences in such ratios (Hanson, 1988, p. 669).[42] If this was indeed true more generally, we should invert Arthur Lewis’s (1954) famous theory for Colonial India: Openness ensured an unlimited supply of capital at low interest rates; the limit to industrialisation, and to higher incomes more generally, was the labour supply. The will was lacking and not the way. Jute was the exceptional industry that proves the rule.

[42] Bengal’s cotton industry, for example, was unable to compete with Bombay, let alone England.

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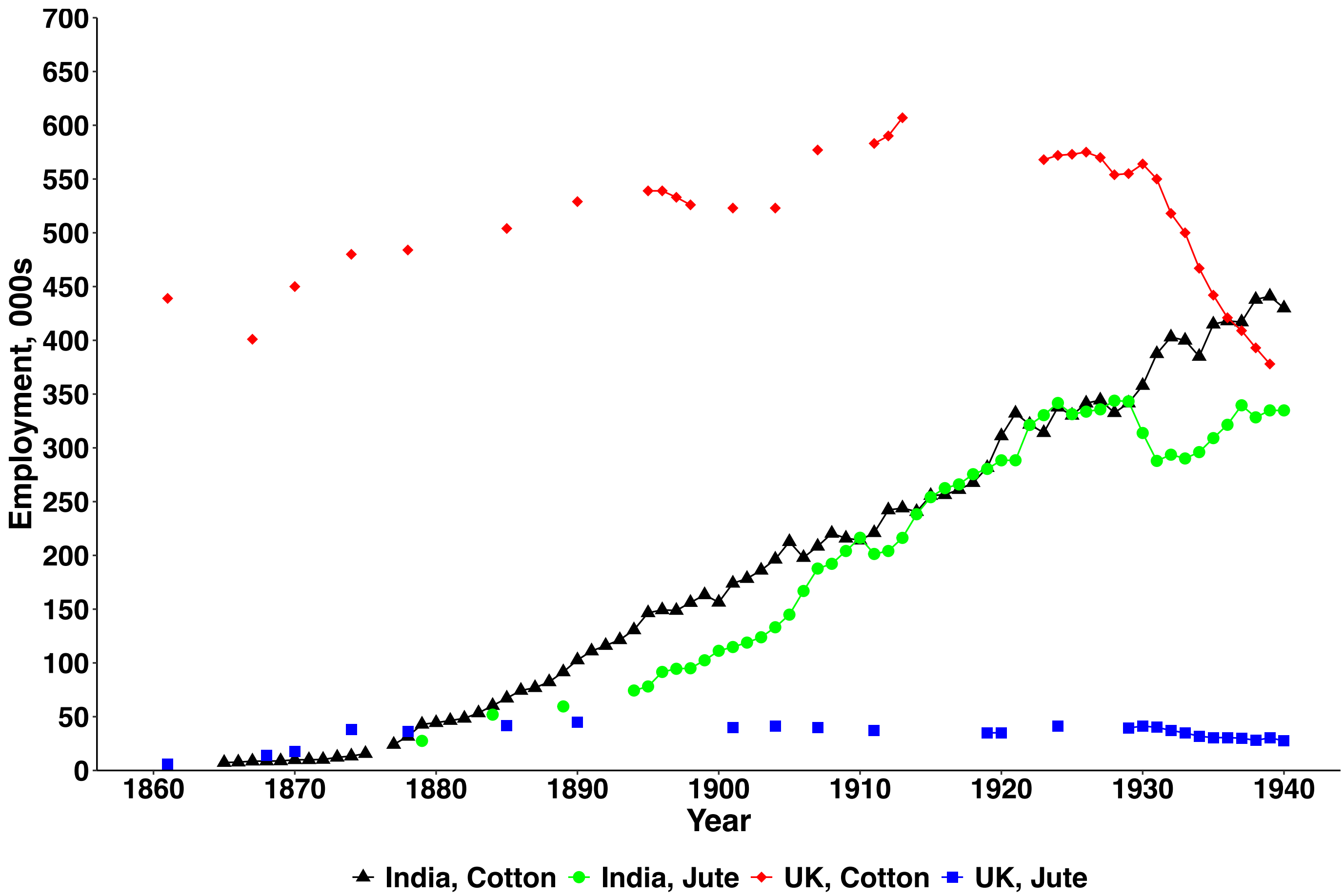
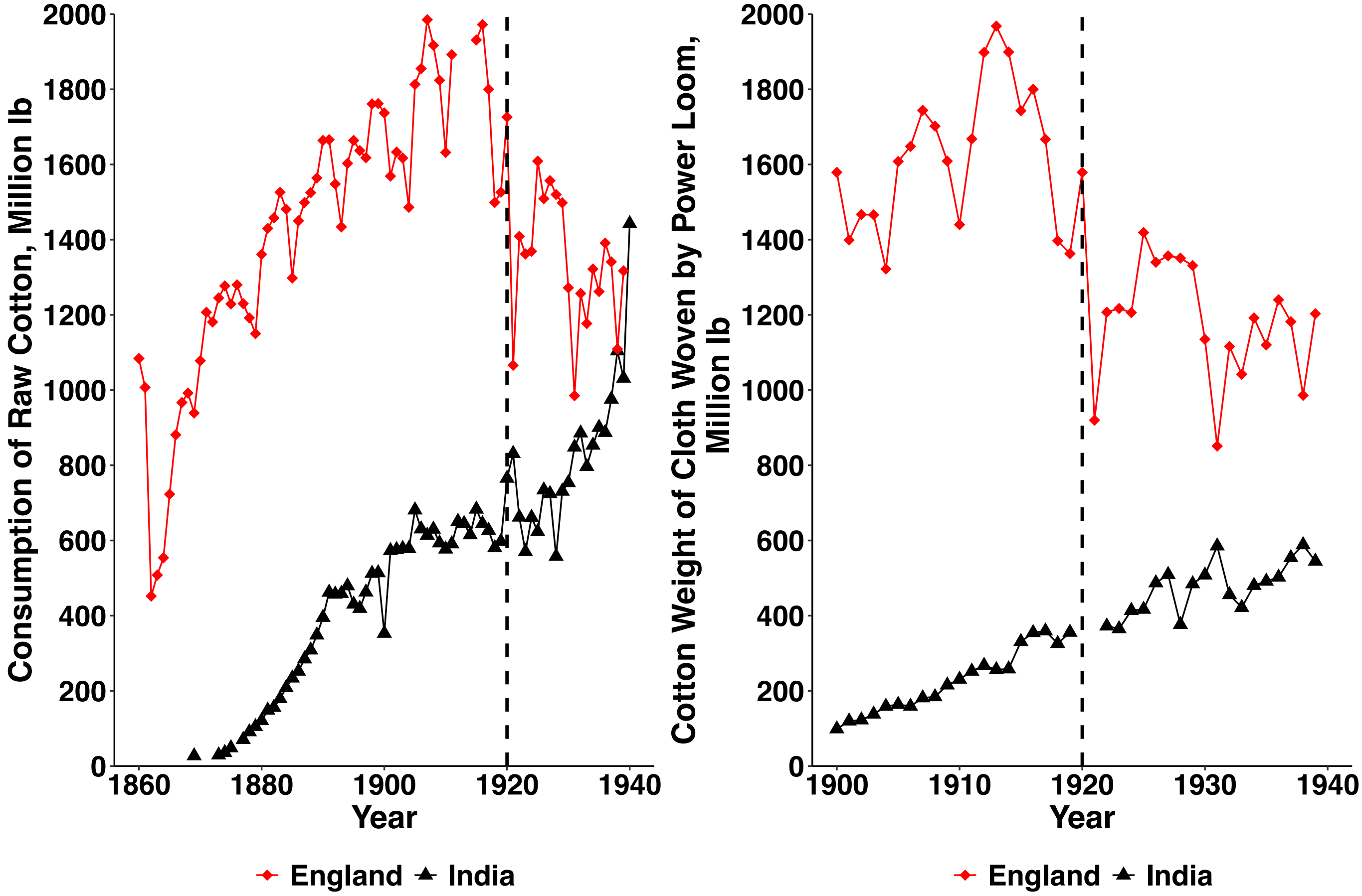
Figure 1: Employment Over Time



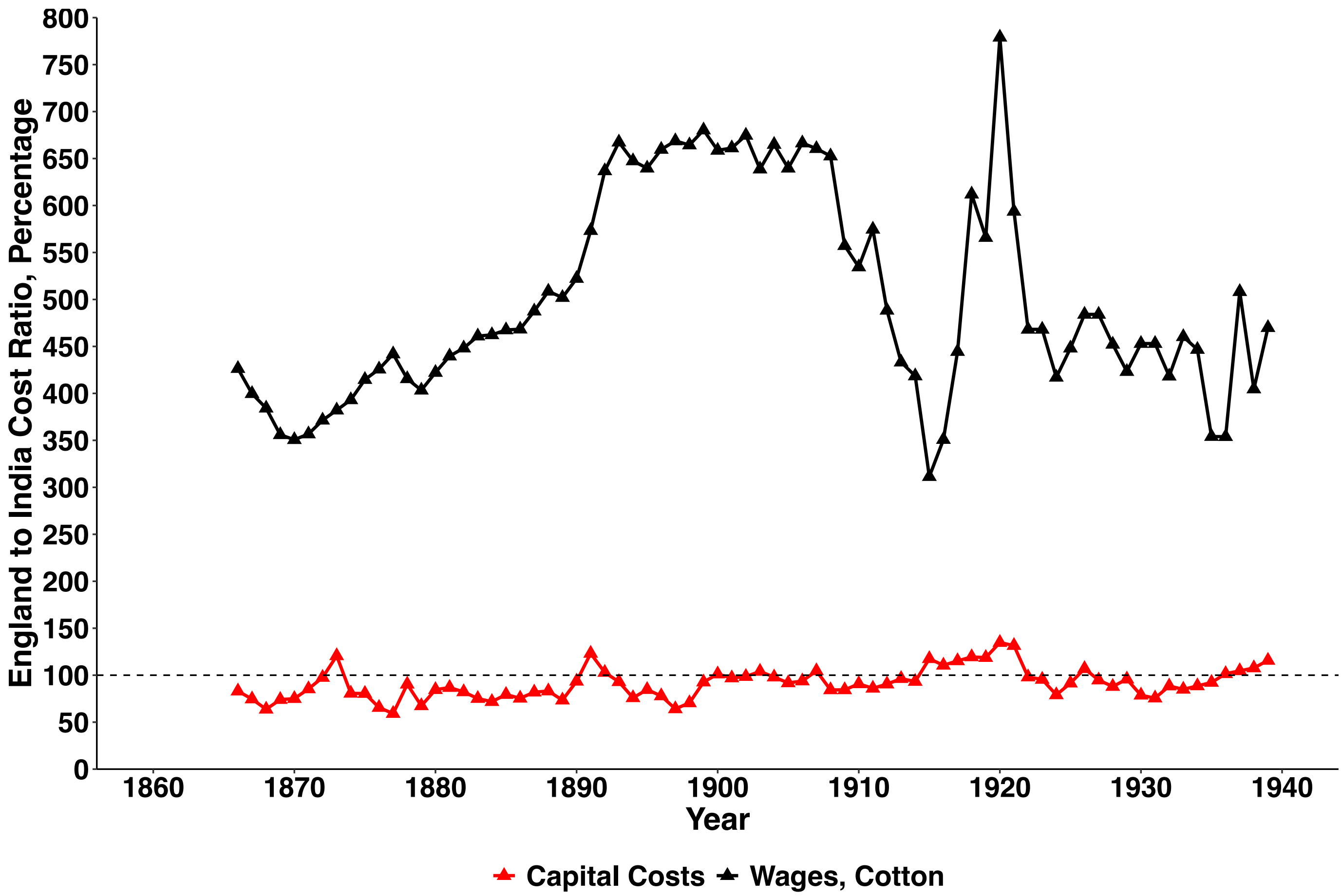
Sources: See Appendix A.

Figure 2: Input Consumption in Cotton Spinning and Weaving



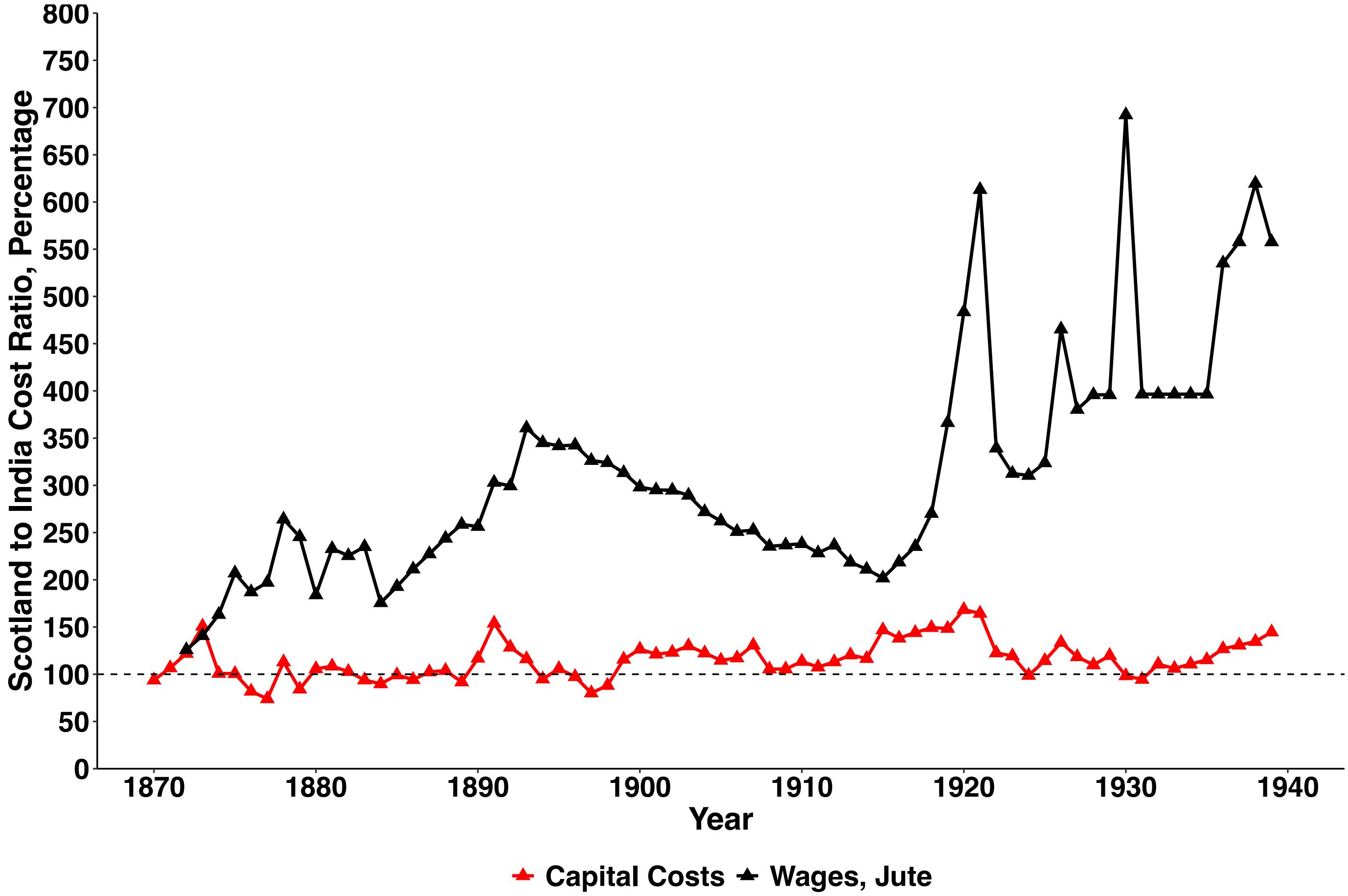
Sources: See Appendix A. **Notes:** The bulk of the gap between Indian spinning cotton consumption and power loom weaving yarn consumption is due to sales of yarn to the local hand loom industry. Before 1920 India also exported a large volume of yarn to China (for use by hand loom weavers there). The dashed line at 1920 indicates when India turned protectionist.

Figure 3: Relative Factor Costs, Cotton



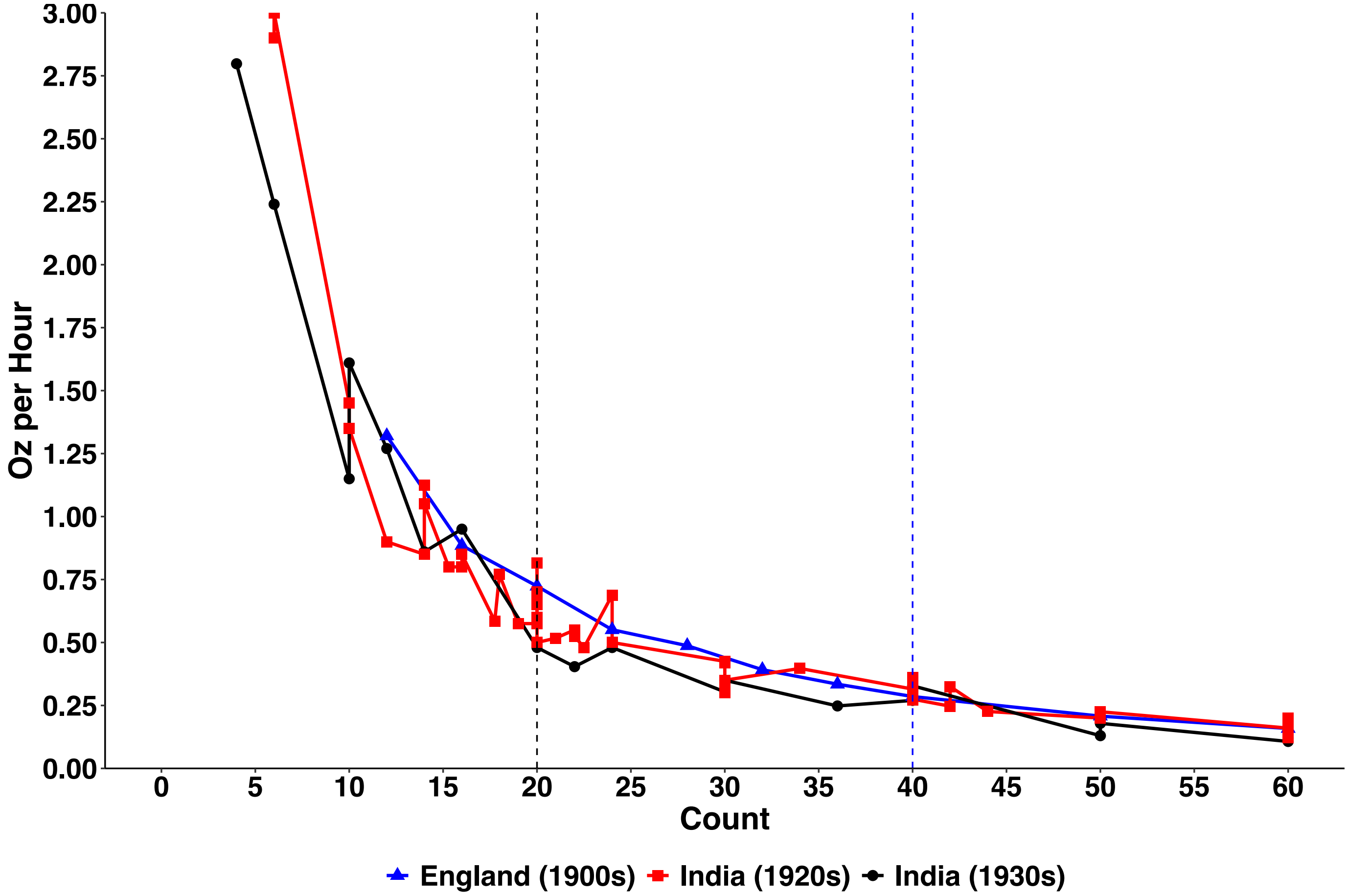
Sources: See text and Appendix A. **Notes:** Wage ratios converted at the smoothed version of the current nominal exchange rate. Capital costs here have a 25 per cent increase in Indian capital goods prices relative to British ones.

Figure 4: Relative Factor Costs, Jute



Sources: See text and Appendix A. **Notes:** Wages ratios converted at the smoothed version of the current nominal exchange rate.

Figure 5: Capital Productivity by Count of Cotton Yarn



Sources: B. S. Benjamin (1942), Pearse (1930), and Leunig (2003). **Notes:** The English and 1930s India series are for ring spinning machines. The 1920s India series is predominantly for ring spinning, but a few mills had a mix of mules and rings. The black dashed line is 20s, the average Indian count, and the blue one is 40s, the average English one. Some Indian figures share the same count, but have productivity differences based upon whether the yarn was a warp or weft one.

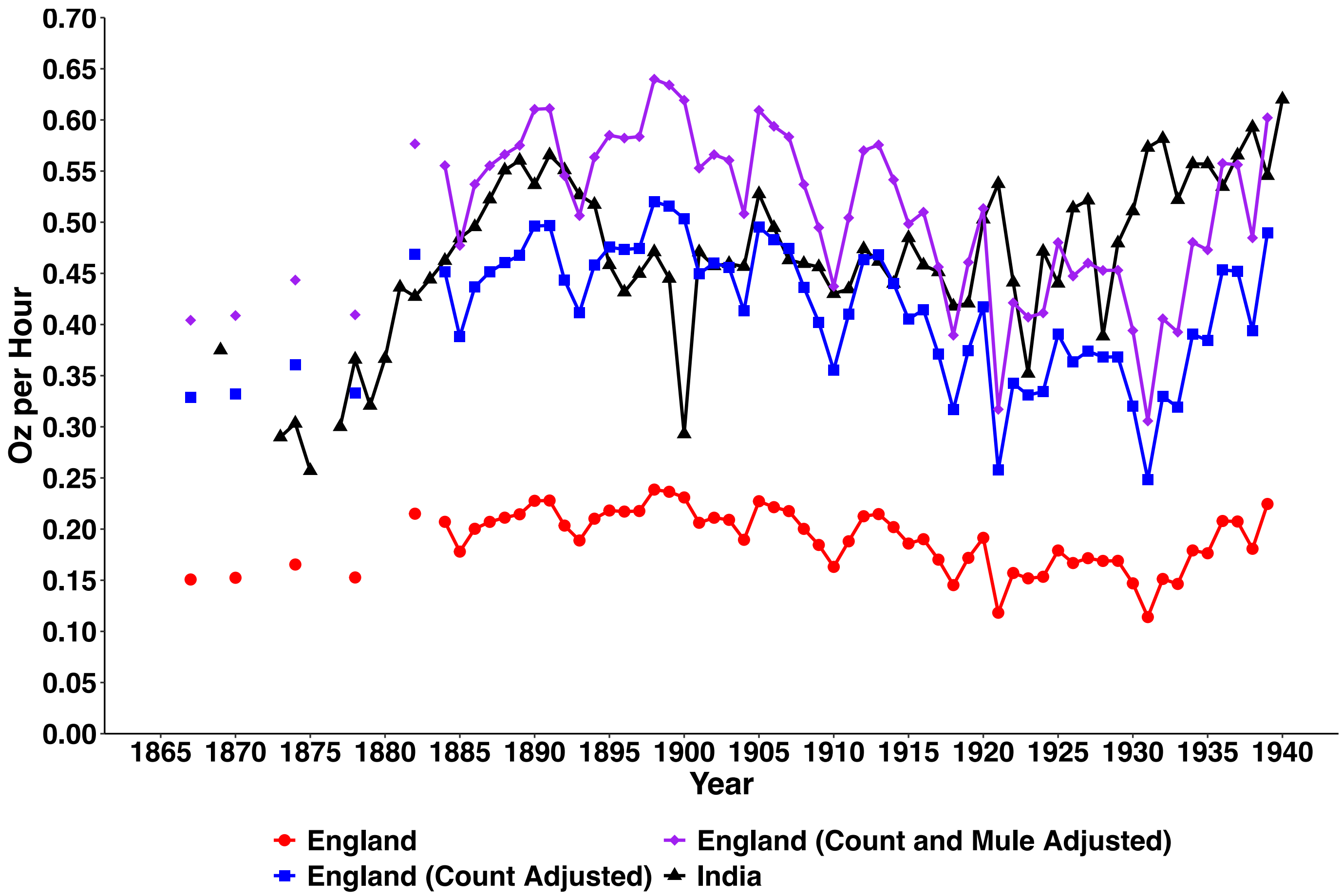
Table 1: Capital Productivity by Count Regression

	Dependent variable:
	Ln(Oz per Hour)
Constant	0.366***
	(0.058)
Count	−0.038***
	(0.002)
England Dummy	0.118
	(0.089)
Observations	93
Adjusted R^2	0.873

***p<0.01

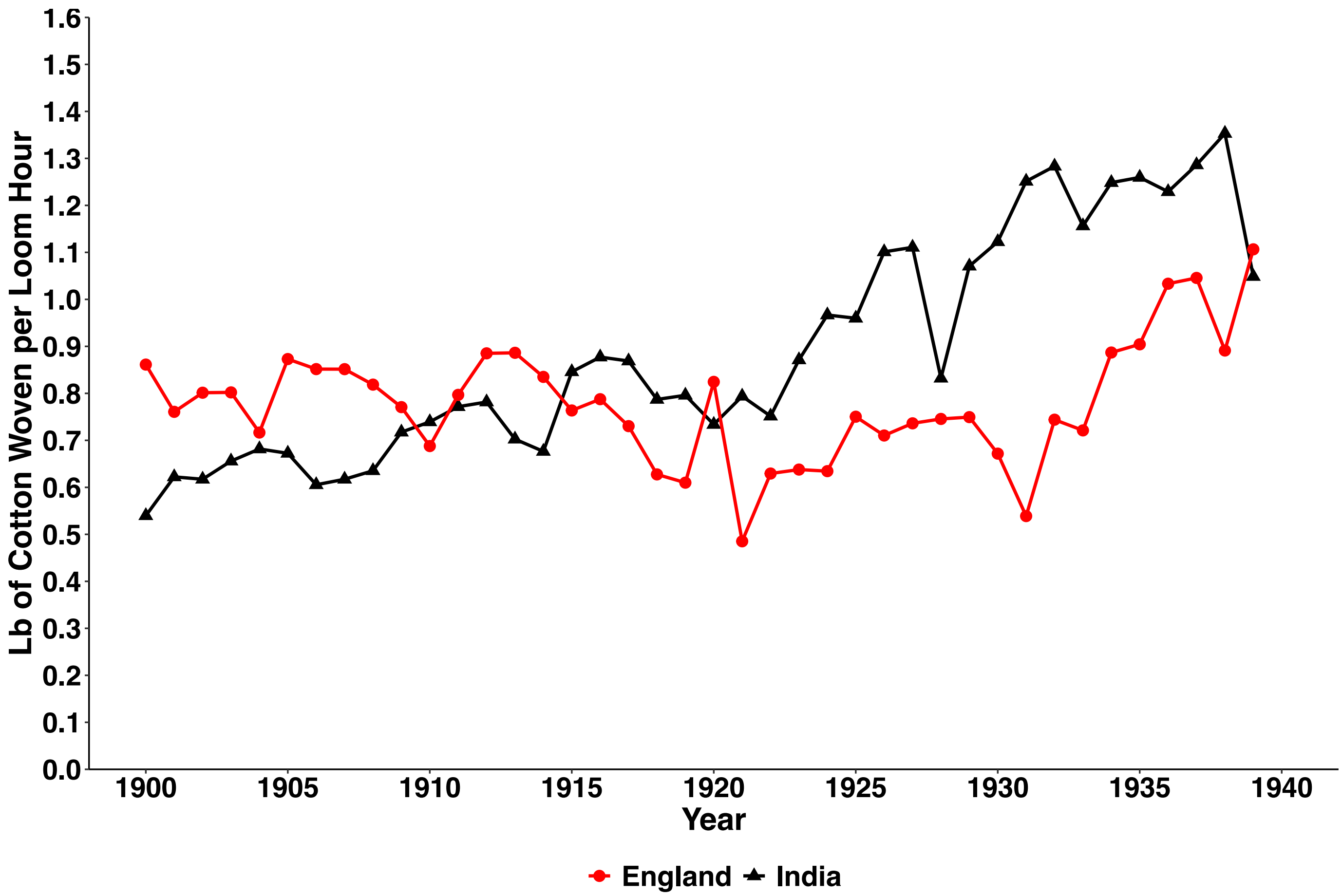
Notes: Standard errors in parentheses.

Figure 6: Capital Productivity Over Time, Cotton Spinning



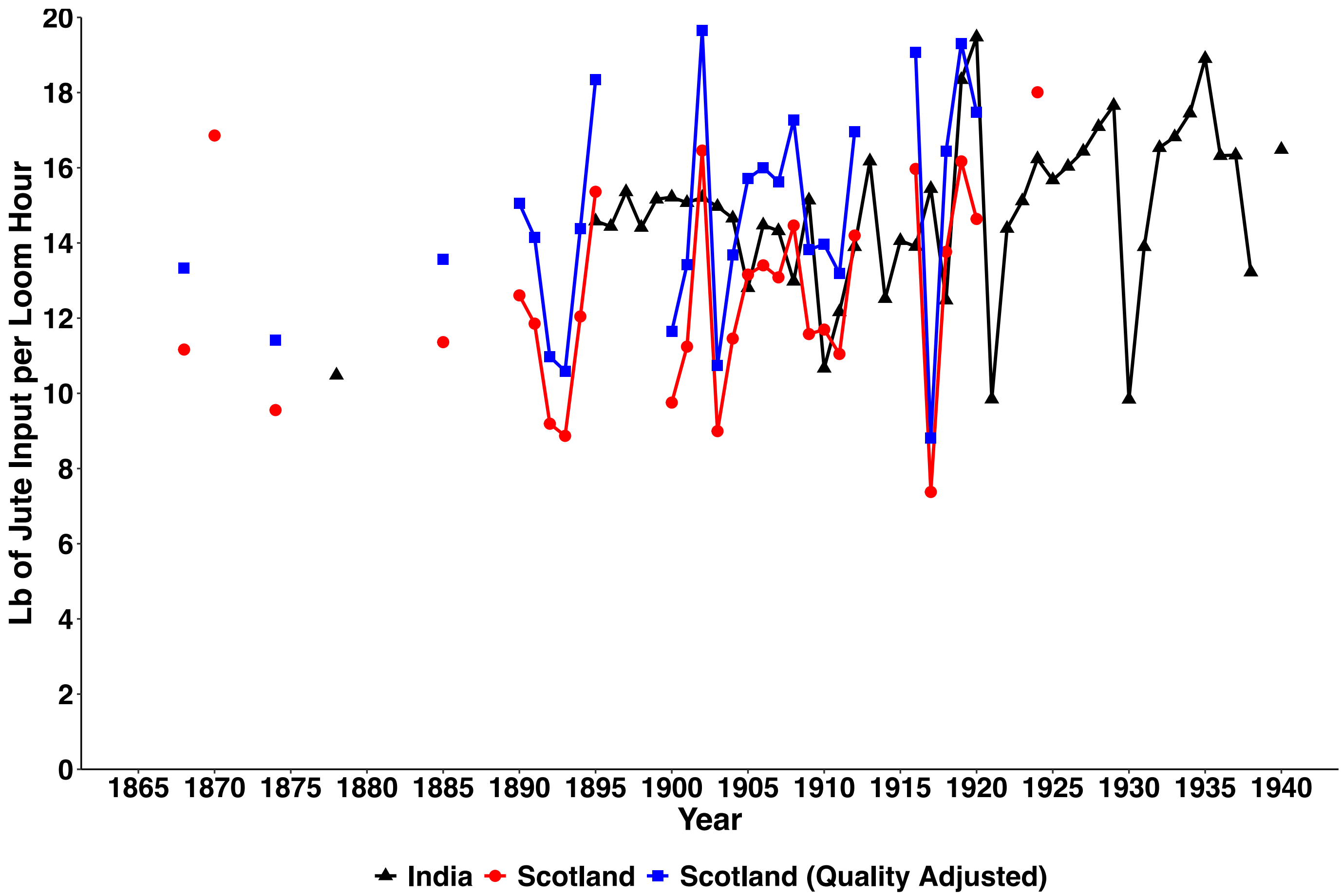
Sources: See text and Appendix A. **Notes:** These figures are not adjusted for capacity utilisation beyond the normal working week. Details of the adjustments for count and mules are explained in the text.

Figure 7: Capital Productivity Over Time, Cotton Weaving



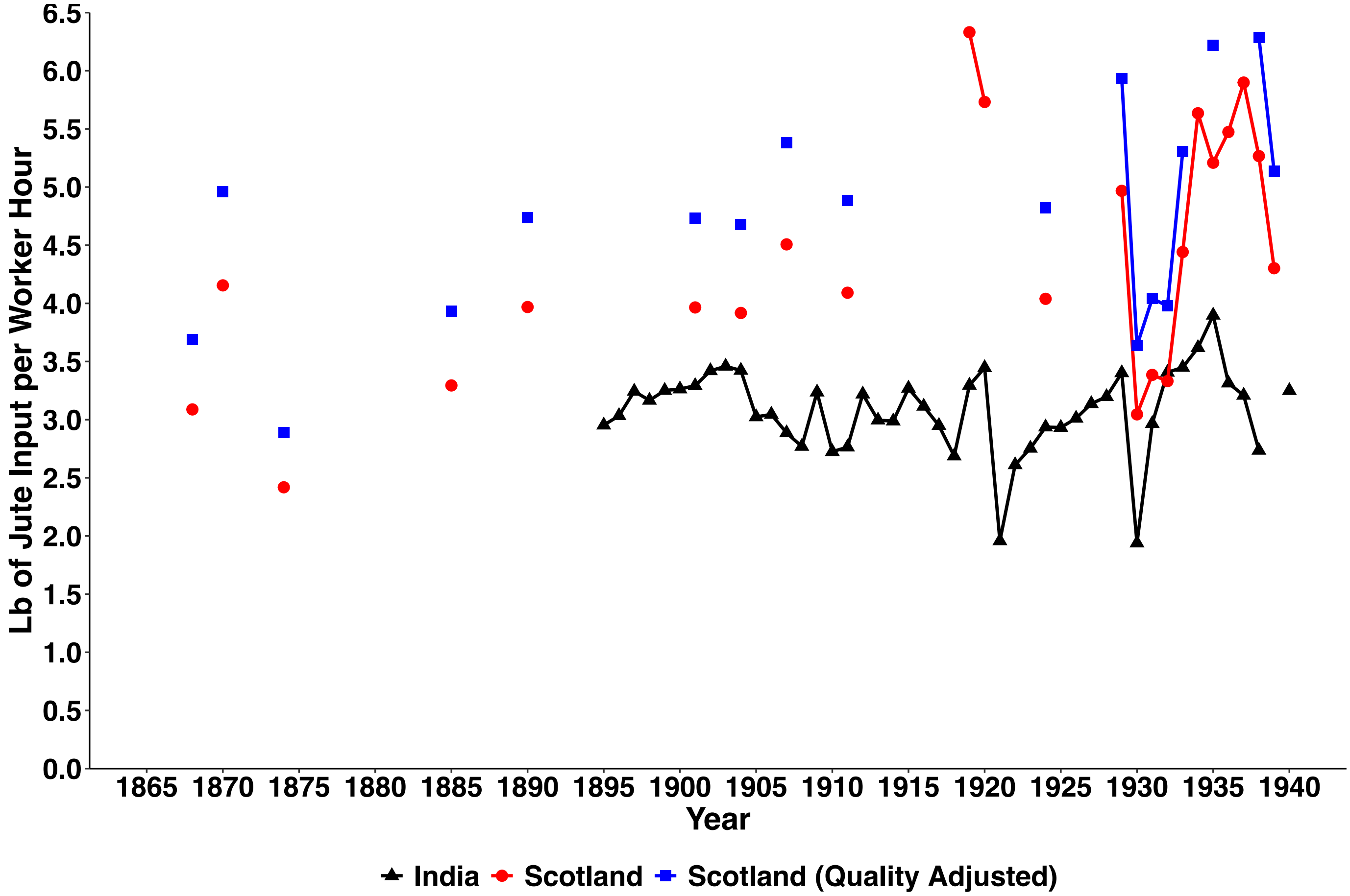
Sources: See text and Appendix A. **Notes:** These figures are not adjusted for capacity utilisation beyond the normal working week. I have also not made any quality adjustments.

Figure 8: Capital Productivity Over Time, Jute



Sources: See text and Appendix A. **Notes:** As the spindle to loom ratio was approximately constant, this figure plots annual raw jute consumption by each country divided by annual loom hours in each industry. The quality adjustment for Scotland is by a factor of 1.194 from Clark's calculations.

Figure 9: Labour Productivity Over Time, Jute



Sources: See text and Appendix A. **Notes:** As the spindle to loom ratio was approximately constant, this figure plots annual raw jute consumption by each country divided by annual worker hours in each industry. The quality adjustment for Scotland is by a factor of 1.194 from Clark's calculations.

Table 2: Cotton Manning Ratio Regressions

	Dependent variable: Employment		
	India	England	Ratio
	(1)	(2)	
Looms	1.212***	0.4410***	2.748
	(0.0737)	(0.1608)	
Spindles	0.0235***	0.0048**	4.9
	(0.0013)	(0.0020)	
Observations	77	36	
Adjusted R^2	0.9963	0.9864	

*p<0.1; **p<0.05; ***p<0.01

Notes: Standard errors in parentheses. If we adjust the English spindle coefficient to account for differences in yarn counts (by 0.8) the India-UK ratio becomes 3.92, which is the figure I use from now on.

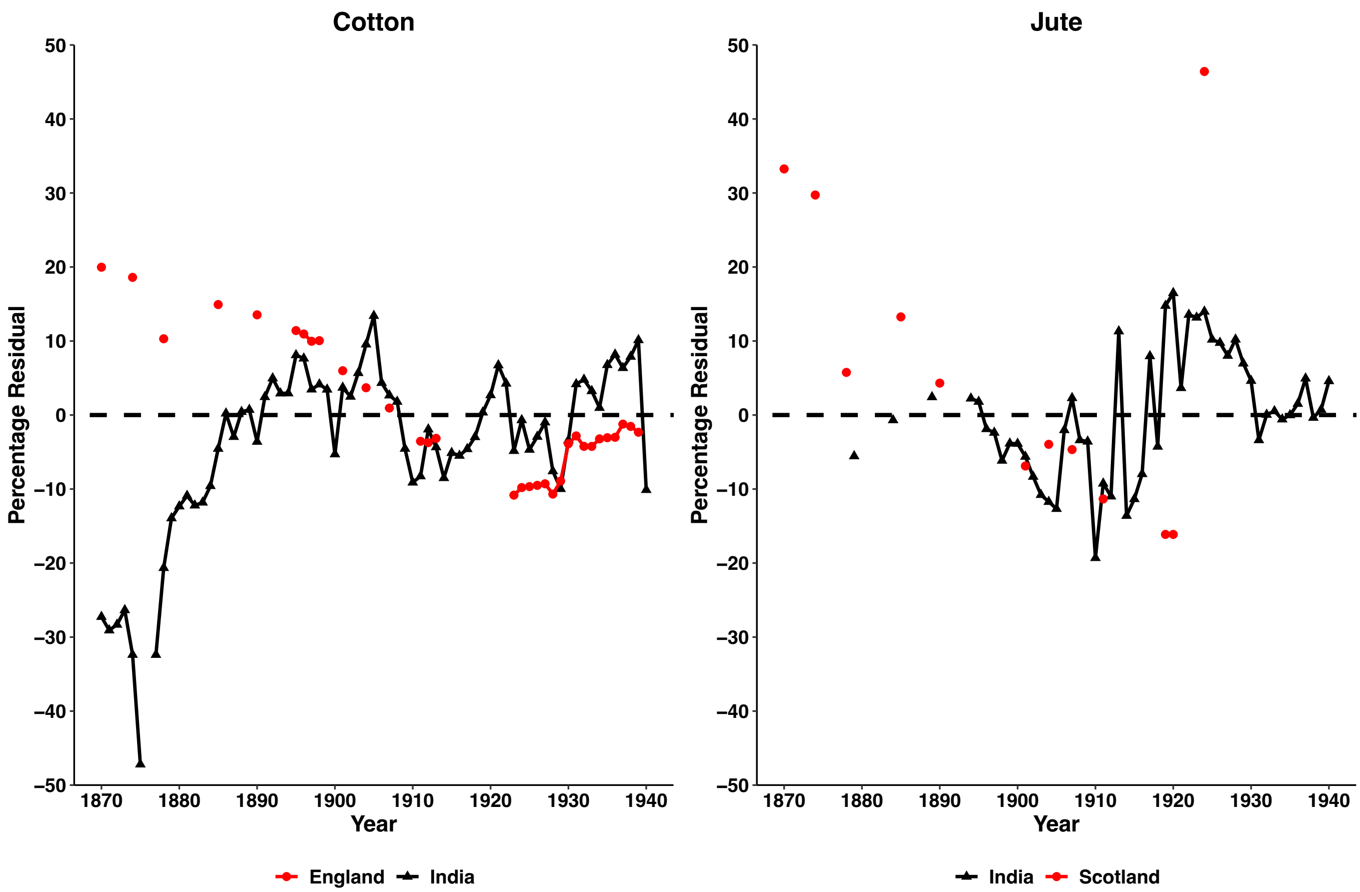
Table 3: Jute Manning Ratio Regressions

	Dependent variable: Employment		
	India	Scotland	Ratio
	(1)	(2)	
Looms	4.851***	2.976***	1.630
	(0.063)	(0.113)	
Observations	51	13	
R^2	0.992	0.983	

*p<0.1; **p<0.05; ***p<0.01

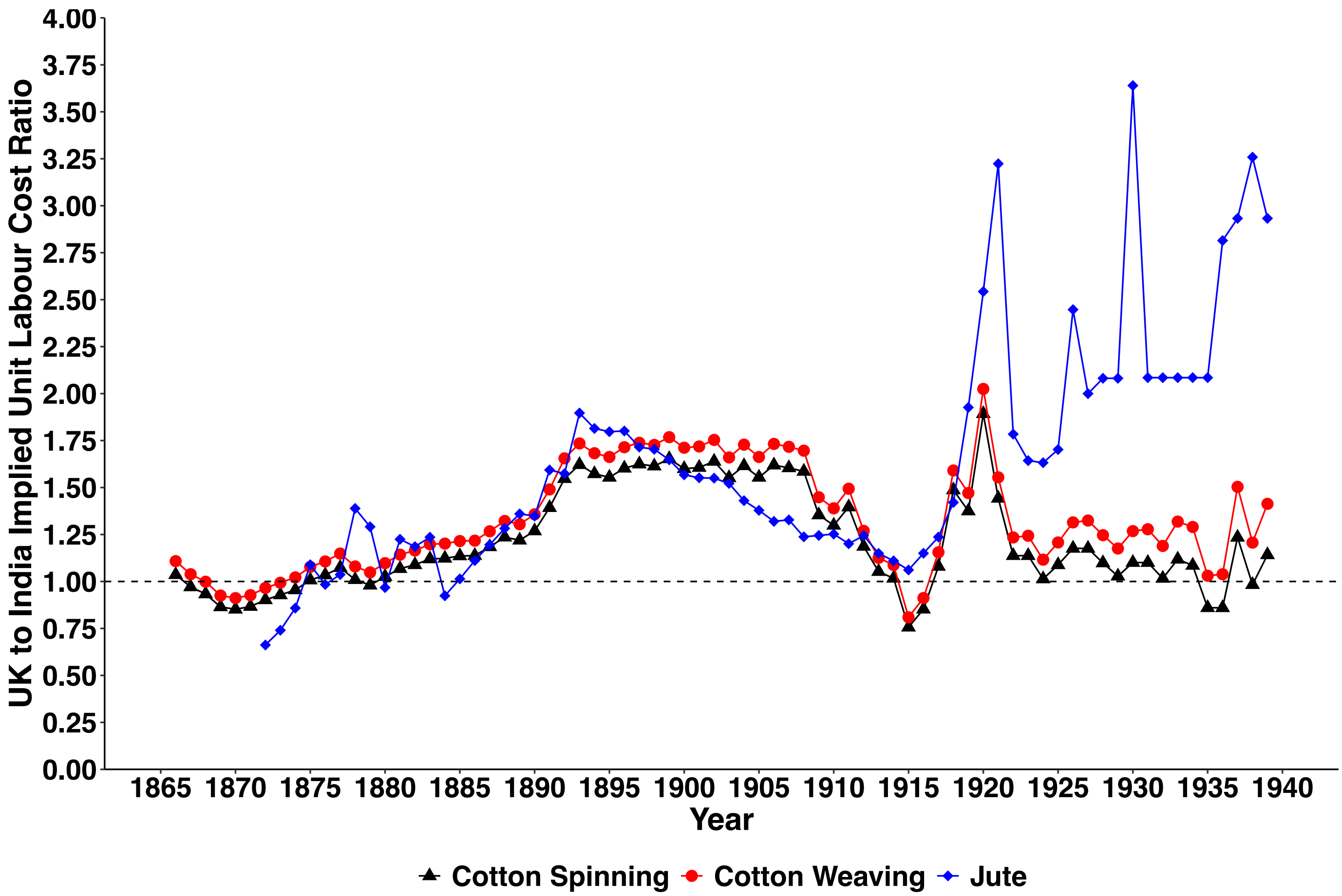
Notes: Standard errors in parentheses. The Indian regression adjusts for hours.

Figure 10: Residuals from Manning Ratio Regressions



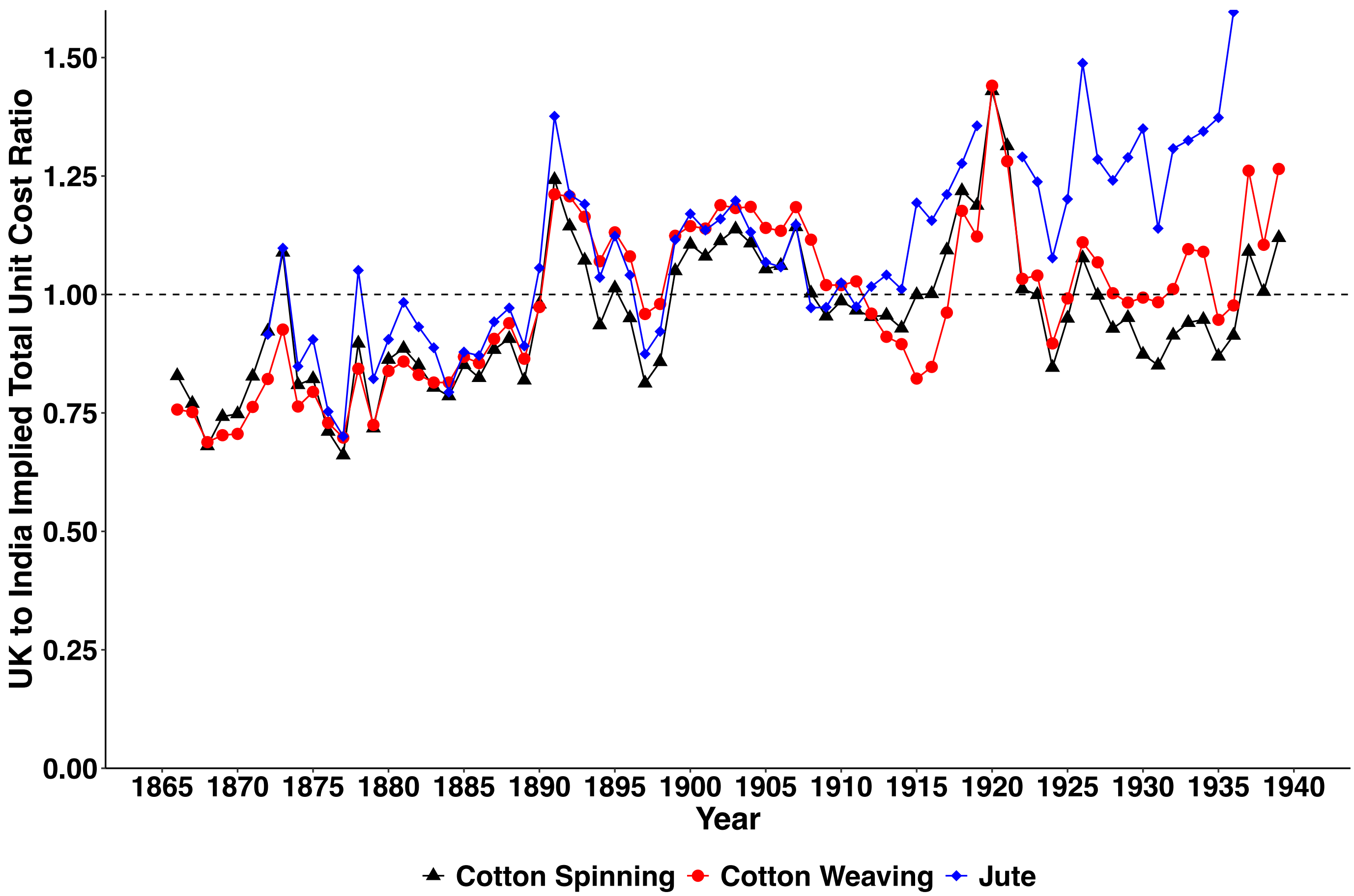
Sources: See text and Appendix A. **Notes:** This figure plots the percentage residuals from the manning ratio regressions from Tables 2 and 3 over time.

Figure 11: Implied Unit Labour Cost Ratios



Sources: See text and Appendix A. **Notes:** Unit labour cost for a given country is $\frac{w_{i,t}}{A_{i,t}\frac{a}{b}_{i,t}}$, i.e. nominal wages divided by the product of output per machine hour and machines per worker. This figure plots the UK to India ratio of these unit costs. The English manning ratio has been increased by 1.25 to adjust to a 20s yarn baseline.

Figure 12: Implied Total Unit Manufacturing Cost Ratios



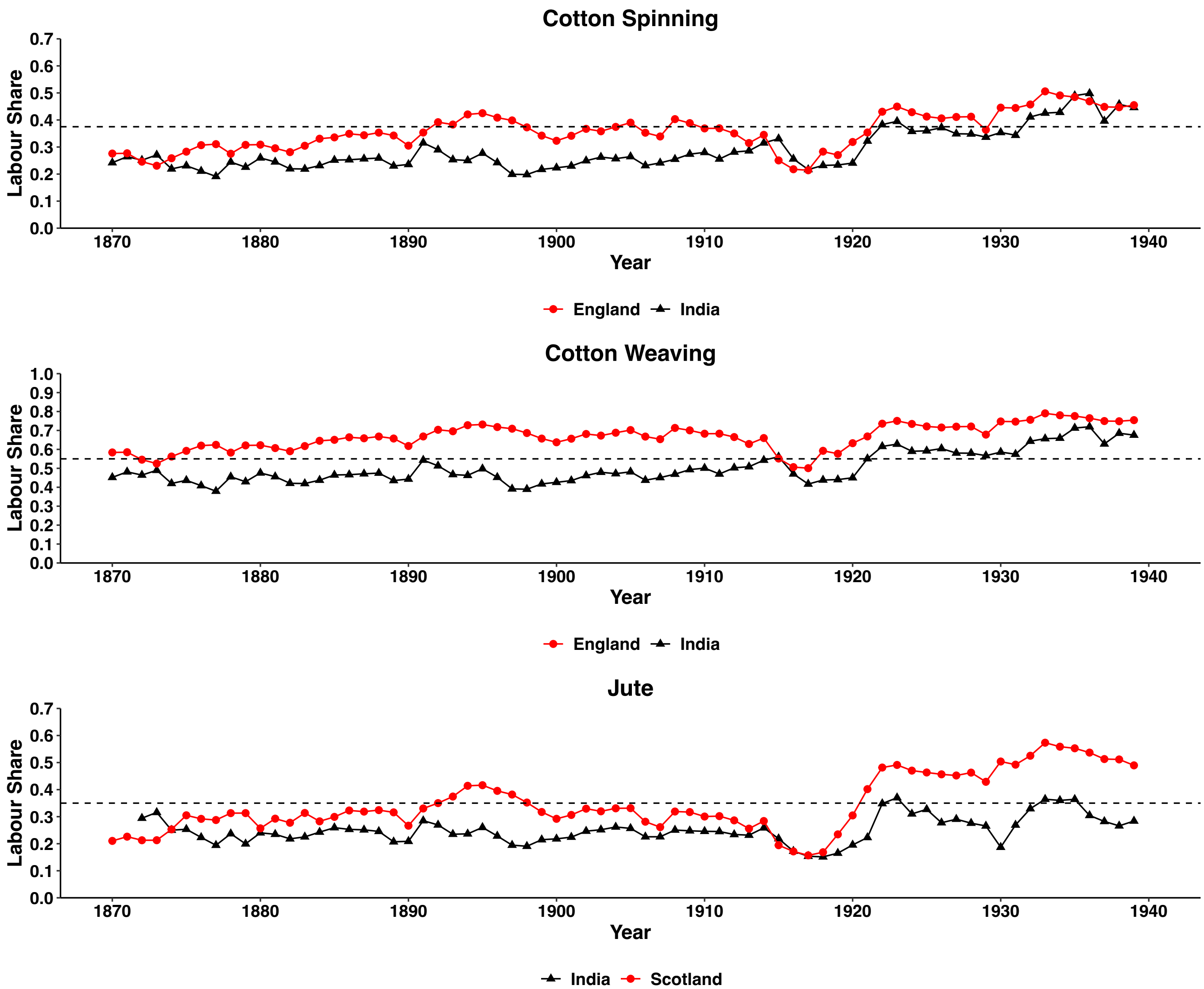
Sources: See text and Appendix A. **Notes:** Unit total manufacturing costs is the sum of unit labour and capital costs. This figure plots the UK to India ratio of these.

Table 4: Calibration of Parameter Values

Parameter	Value	Reason
λ	0.25 for cotton, 0 for jute.	Freight for cotton, no difference for jute according to Clark (1987).
α	0.375 for cotton spinning, 0.55 for cotton weaving, 0.35 for jute.	To match observed labour shares.
$\frac{A_E}{A_I}$	1.05 for cotton spinning, 1.194 for jute, 1.4 for cotton weaving before 1920, $1.4 - 0.01(\text{Year} - 1920)$ for cotton weaving from 1921 onwards.	To match observed output per hour and quality differences.

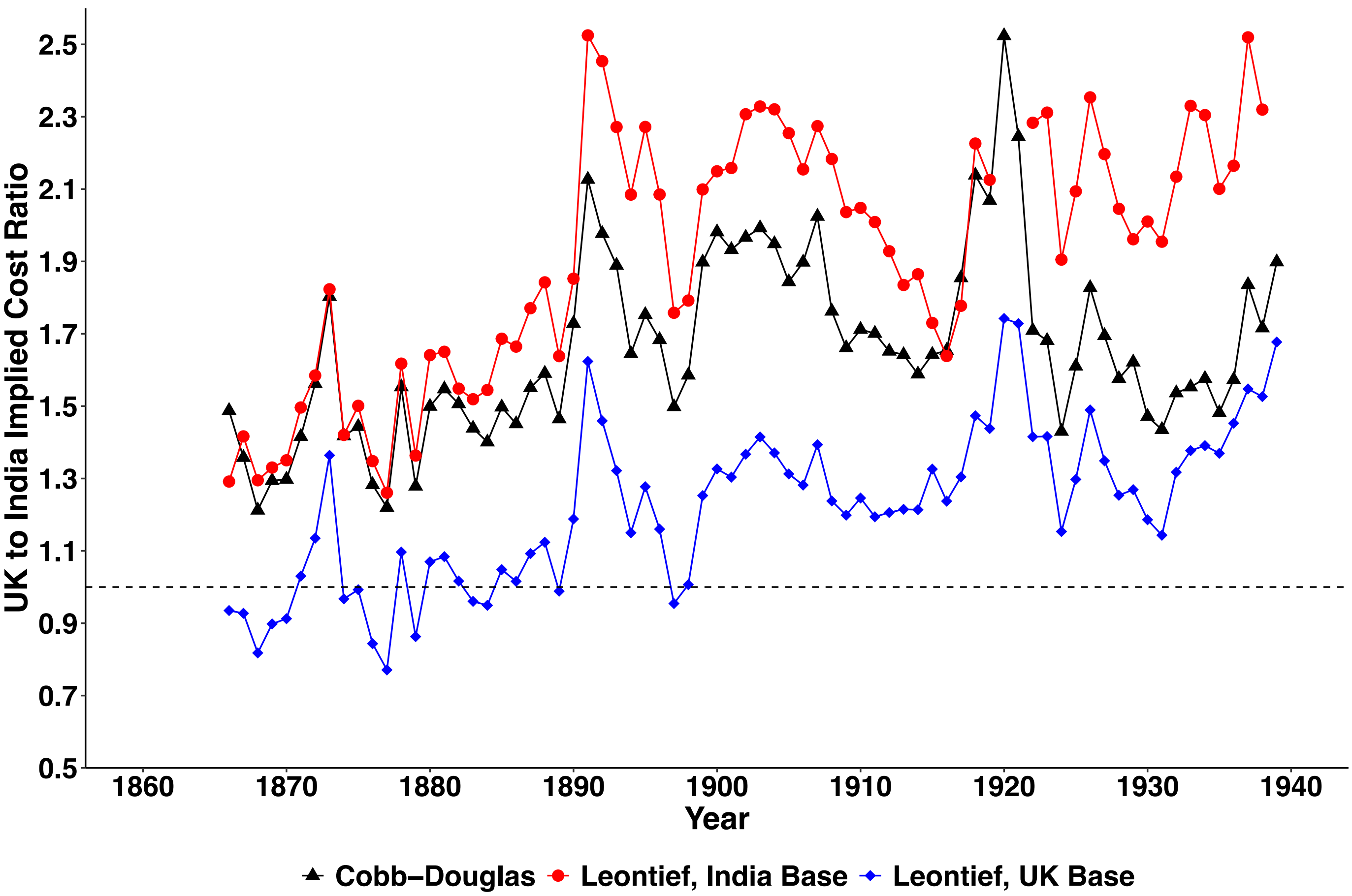
Notes: λ is the capital goods mark up for India. α is the labour share for the Cobb-Douglas cost functions. $\frac{A_E}{A_I}$ is the (quality adjusted) ratio of output per machine hour between England and India.

Figure 13: Implied Labour Shares of Manufacturing Costs



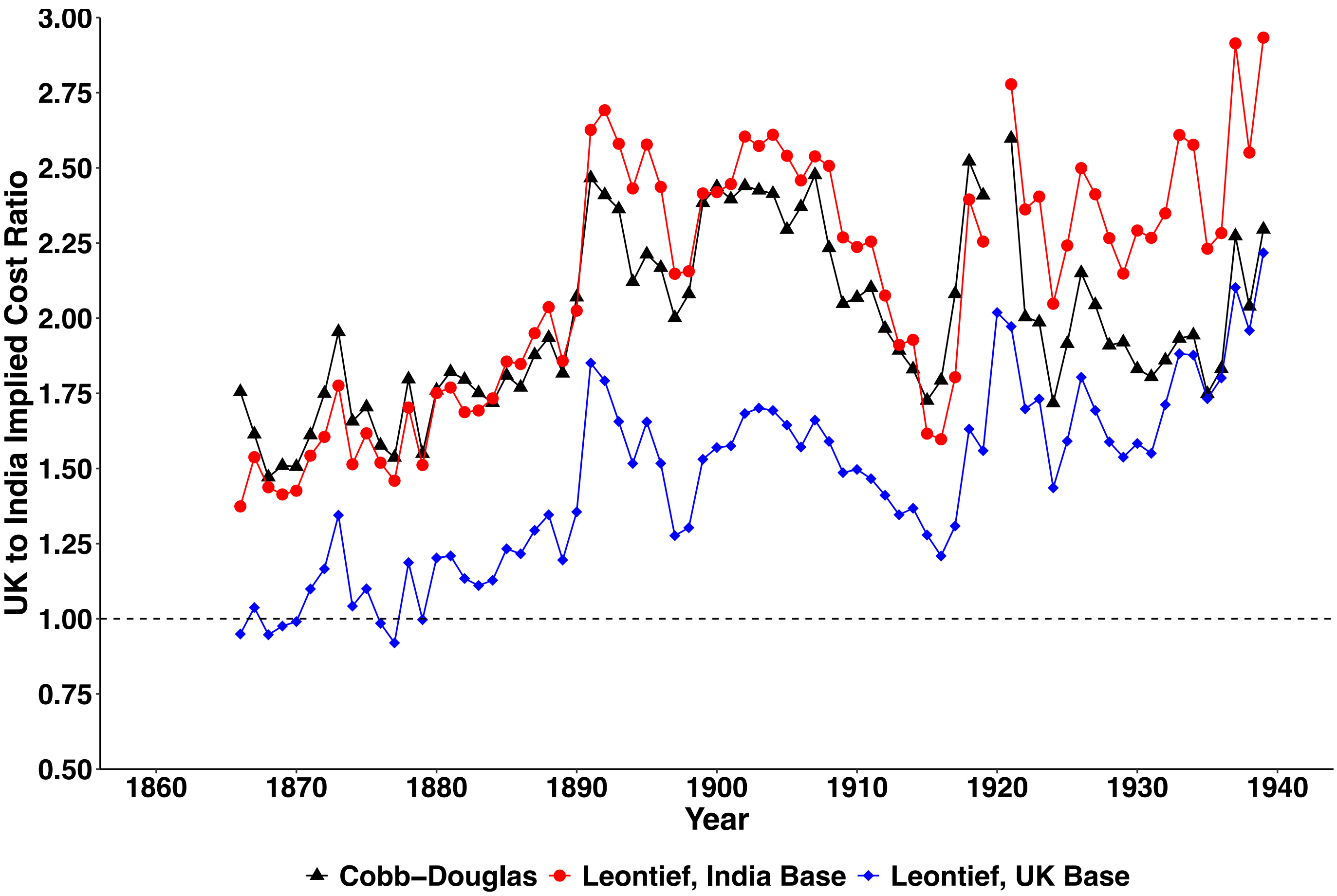
Sources: See text and Appendix A. **Notes:** The dashed lines are my assumed figures for the Cobb-Douglas calculations. For each year and country, $\alpha_{i,t} = \frac{\frac{a}{b} w_{i,t}}{\frac{a}{b} w_{i,t} + \frac{(i_{i,t}+\delta) P_{K,i,t}}{h_{i,t}}}$, where $\frac{a}{b}$ is the manning ratio. The English manning ratio has been increased by 1.25 to adjust to a 20s yarn baseline.

Figure 14: Implied Manufacturing Cost Ratios, Cotton Spinning



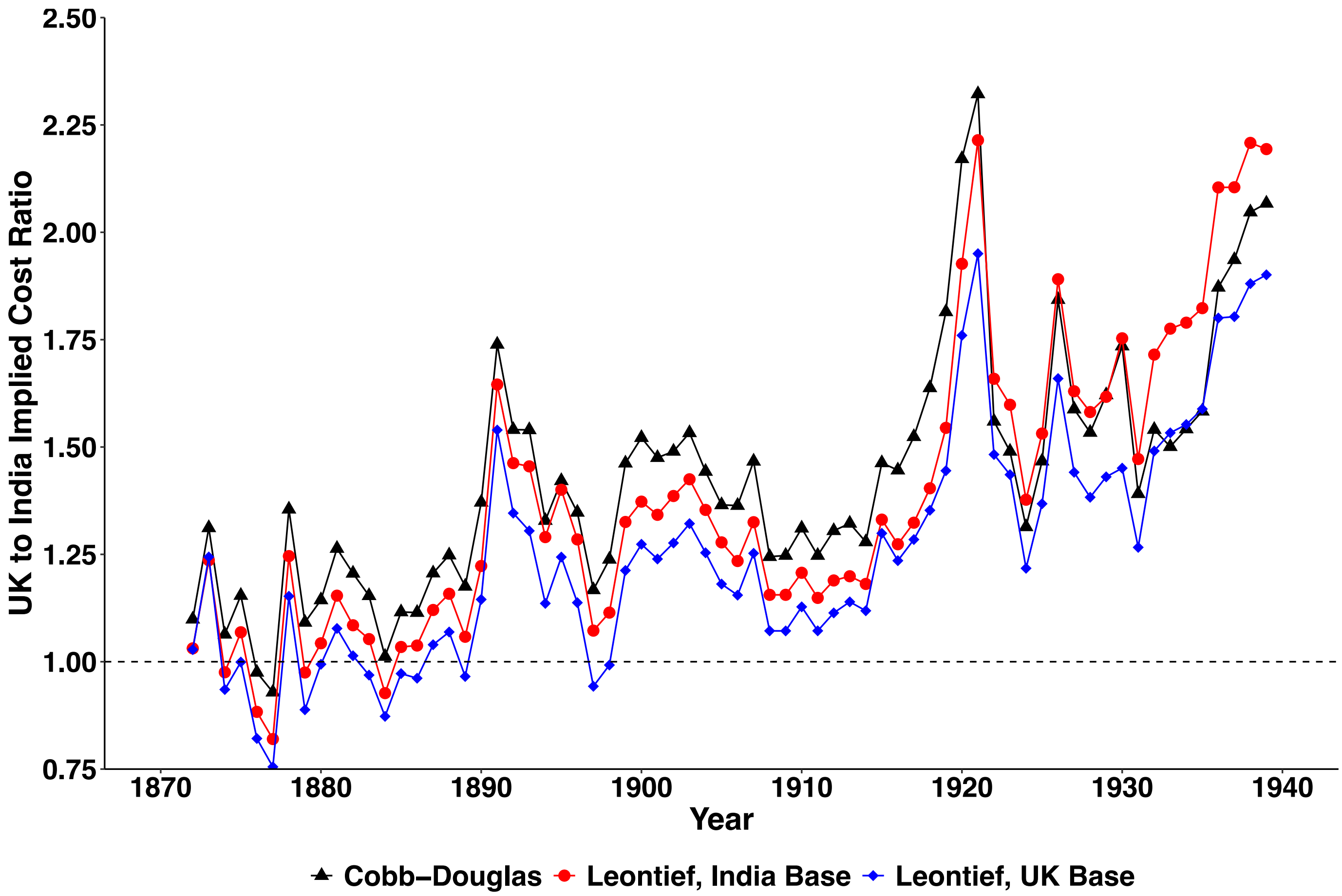
Sources: See text and Appendix A. **Notes:** This figure plots $\frac{c(w_{E,t}, i_{E,t}, P_{K,E,t})}{c(w_{I,t}, i_{I,t}, P_{K,I,t})}$ for different production function assumptions as explained in the main text. The English manning ratio has been increased by 1.25 to adjust to a 20s yarn baseline.

Figure 15: Implied Manufacturing Cost Ratios, Cotton Weaving



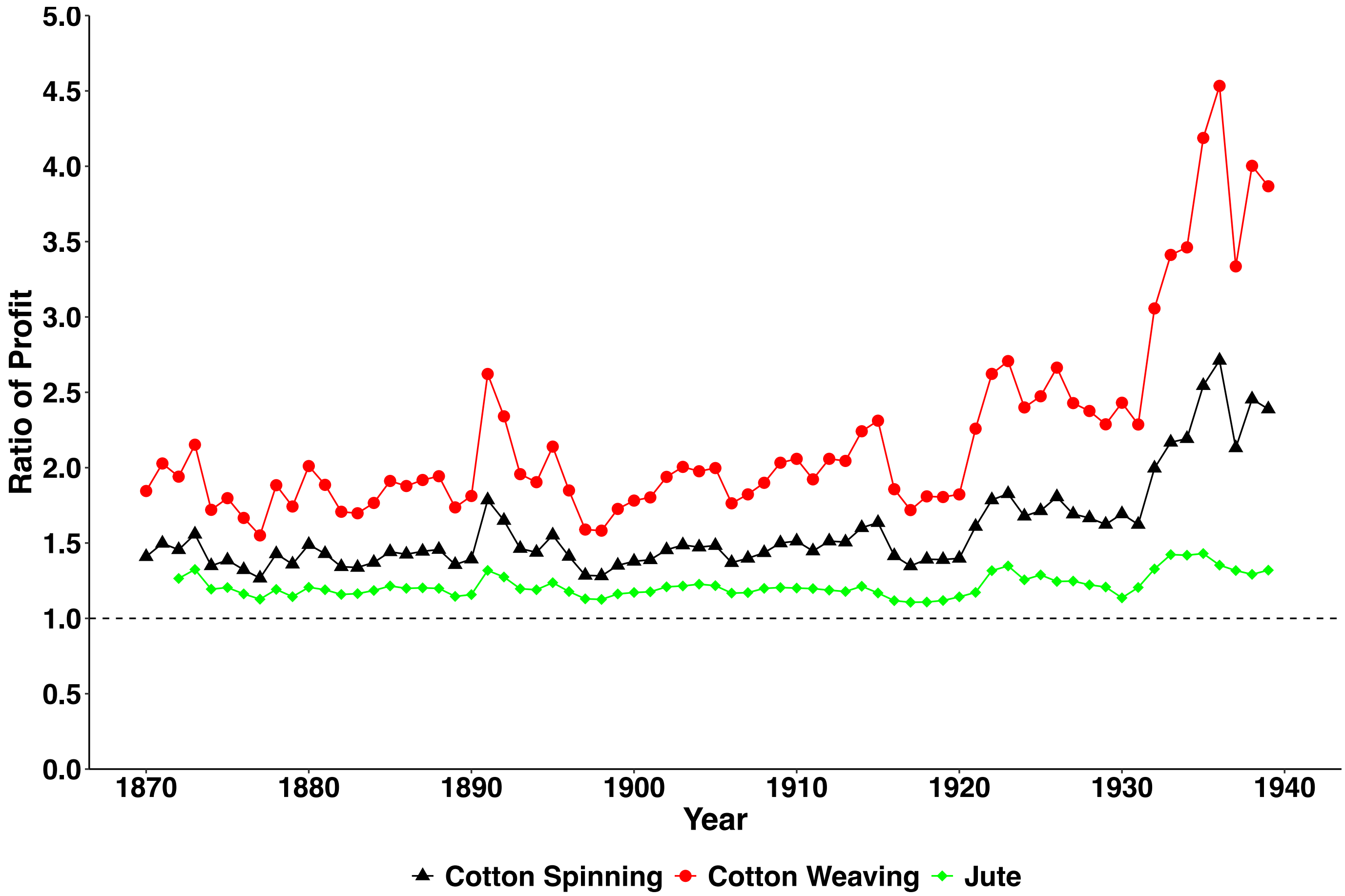
Sources: See text and Appendix A. **Notes:** This figure plots $\frac{c(w_{E,t}, i_{E,t}, P_{K,E,t})}{c(w_{I,t}, i_{I,t}, P_{K,I,t})}$ for different production function assumptions as explained in the main text.

Figure 16: Implied Manufacturing Cost Ratios, Jute



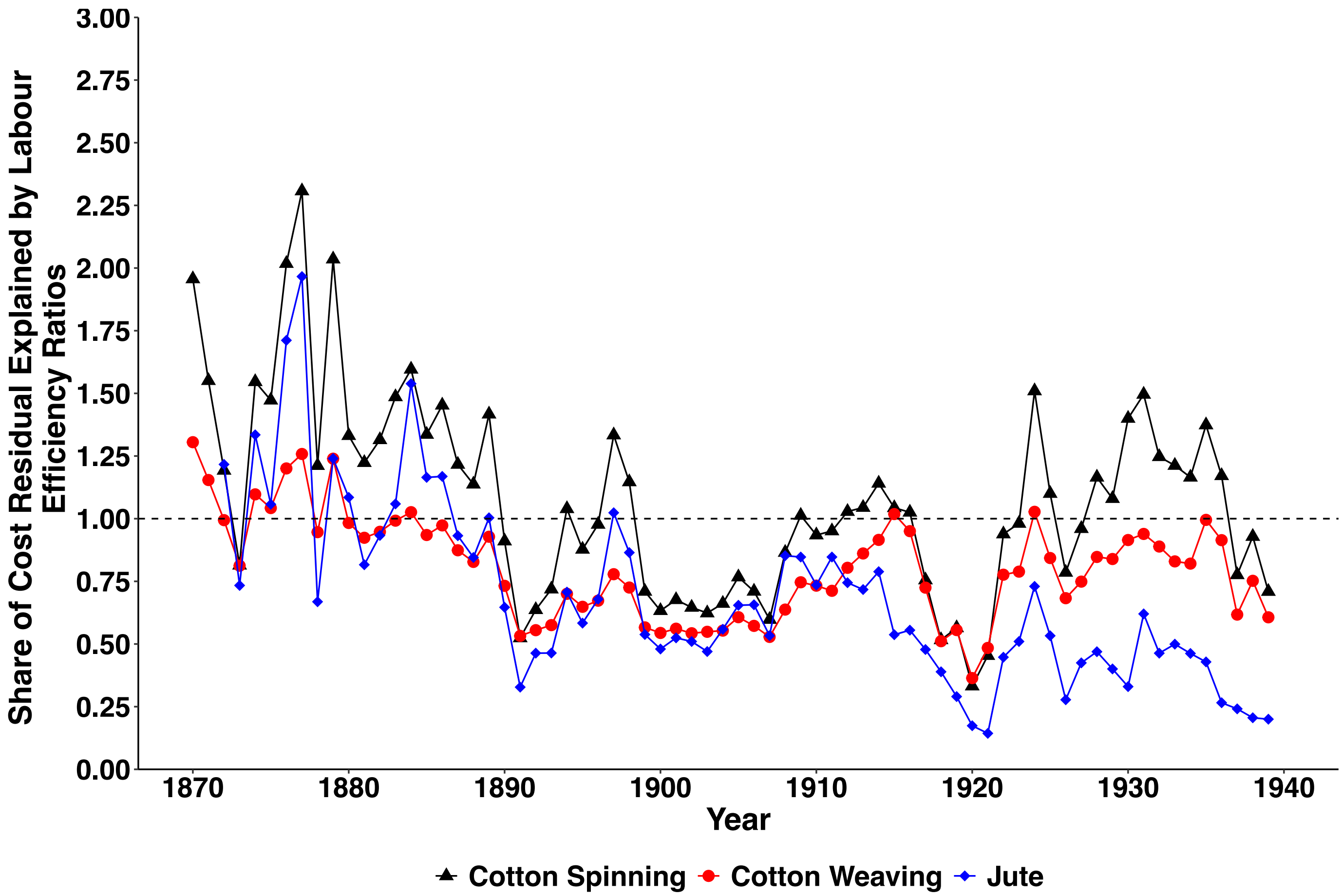
Sources: See text and Appendix A. **Notes:** This figure plots $\frac{c(w_{E,t}, i_{E,t}, P_{K,E,t})}{c(w_{I,t}, i_{I,t}, P_{K,I,t})}$ for different production function assumptions as explained in the main text.

Figure 17: Profitability Increase From Reducing Manning Rates to British Levels



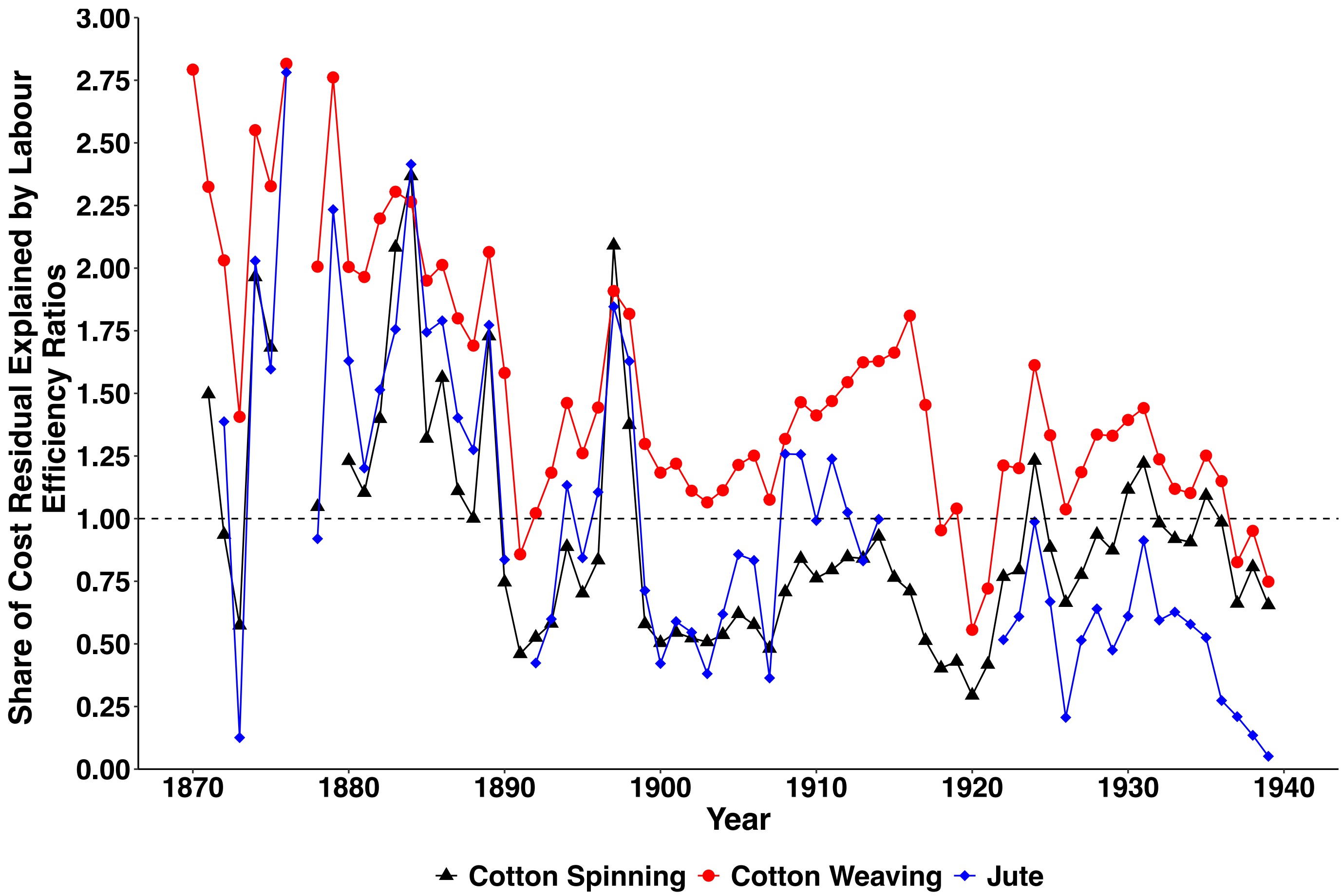
Sources: See text and Appendix A. **Notes:** This series plots the implied ratio between the profits of the marginal Indian firm if it managed to reduce manning requirements to English levels, holding everything else equal, to the profits of such a firm under existing conditions as measured by the current nominal interest rate. Revenue in the current period is assumed to be equal to $\frac{a_I}{b}w_t + r_t$, where w_t is the hourly wage, $\frac{a_I}{b}$ is the Indian manning rate, r_t is the hourly user cost of capital. The marginal firm makes zero surplus profits initially and so the increase in profits per machine hour from lowering labour requirements is $(\frac{a_I}{b} - \frac{a_E}{b})w_t$. This is then multiplied by annual machine hours (weekly times 50) and divided by the replacement cost of machinery and plant per spindle or loom as the case may be to give the additional profit. The profit ratio is then $\frac{\text{Increase}_t + i_t}{i_t}$.

Figure 18: What Share Of The Cost Residual Can Be Explained By Differences In Labour Efficiency? Cobb-Douglas Case



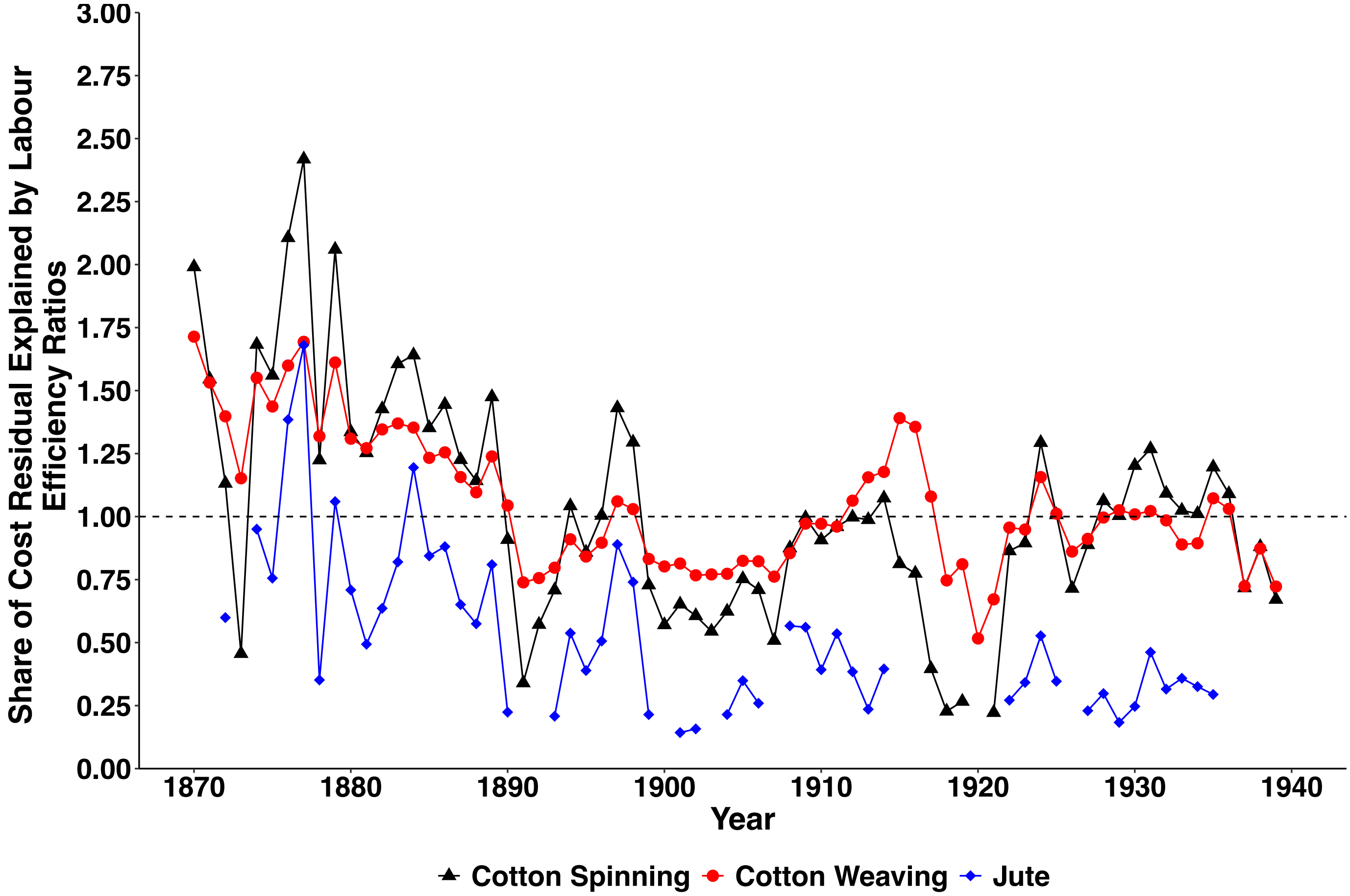
Sources: See text and Appendix A. **Notes:** The underlying series are the Cobb-Douglas cases. The observed efficiency ratio for cotton spinning has been adjusted by 0.8 to adjust the English figure to a 20s yarn baseline.

Figure 19: What Share Of The Cost Residual Can Be Explained By Differences In Labour Efficiency? Leontief with UK Factor Proportions Case



Sources: See text and Appendix A. **Notes:** The underlying series are the Leontief ones with British factor proportions as the baseline. The observed efficiency ratio for cotton spinning has been adjusted by 0.8 to adjust the English figure to a 20s yarn baseline, and for the same reason the English baseline manning ratio for cotton spinning has been adjusted by 1.25.

Figure 20: What Share Of The Cost Residual Can Be Explained By Differences In Labour Efficiency? Leontief with Indian Factor Proportions Case



Sources: See text and Appendix A. **Notes:** The underlying series are the Leontief ones with Indian factor proportions as the baseline. The missing years for the jute series are when the required efficiency ratio becomes negative, which is possible for the Leontief case (see Appendix C). The observed efficiency ratio for cotton spinning has been adjusted by 0.8 to adjust the English figure to a 20s yarn baseline.

A Data Appendix

Wages

India, Cotton

How to Develop Productive Industry in India and the East (Cola, 1867).

Prices and Wages in India, 1902.

Report on the Enquiry into the Rise in Prices in India, Datta, Vol 3.

Bombay Factory Act Report, various years.

A Guide to Bombay, Historical, Statistical and Descriptive By James Mackenzie Maclean 1876. (Maclean, 1876).

Eastern Experiences, L Bowring, 1871 (Bowring, 1871).

Report on an Enquiry into conditions of labour in the cotton mill industry in India, (Deshpande, 1946a).

Report of the Textile Labour Enquiry Committee, Vol 1, 1953.

Report of the Textile Labour Enquiry Committee, Vol II, Bombay Wage bill divided by day plus night employment divided by 288 working days.

Royal Commission On Labour In India Evidence Vol-i Part-1(1930), Bombay (Whitley, 1931b, Vol 1).

Buchanan, Development of Capitalist Enterprise in India, (Buchanan, 1934).

Report of the Indian Tariff Board Regarding the Grant of Protection to the Cotton Textile Industry (Tar, 1932).

All reelers were assumed to be women.

Assumed Skilled Roles:

Jobber Engineman Mechanic Fitter Carpenter Bricklayer Head Knitter Mason Engine-Driver Boiler-Man

India, Jute

Jute in Bengal, N. C. Chaudhury, (Chaudhury, 1908).

Prices and Wages in India, 1919.

Report on the Administration of Bengal, 1878-79.

Report on the Administration of Bengal, 1872-73.

D. Buchanan, The Development of Capitalistic Enterprise in India, (Buchanan, 1934).

Annual Report on the Administration of the Indian Factories Act in Bengal, various years (1923-1939).

The Economist Monthly Trade Supplement, March 15, 1884.

Assumed Skilled Roles:

Dust Shaker Sirdar, Head Wood Turner, Sirdar, Oiler, Mason, Tinsmith, Finisher Sirdar, Batcher Sirdar, Teaser Sirdar, Rover Sirdar, Winder Sirdar, Fireman Tindal, Chinese Carpenter, Head Painter, Foreman, Carder Sirdar, Spinner Sirdar, Weaver Sirdar, Indian Head Carpenter, Head Turner, blacksmith, Softer Sirdar, Mistry, Drawer Sirdar, Twister Sirdar, Beamer Sirdar, Head Mason, Carpenter, Head Mistry, Carding Sirdar, Hammerman.

UK, Cotton

The history of wages in the cotton trade during the past hundred years, G. H. Wood, (Wood, 1910a).

Oldham Piece Rate list (cotton spinning): The Barefoot Aristocrats, (Fowler et al., 1987, p. 246).

Spinners and weavers had similar wages.

UK, Jute

Dundee and its Textile Industry, Lenman, Lythe and Gauldie, (Lenman et al., 1969).

Dundee and the Empire: Juteopolis 1850-1939, Jim Tomlinson, (Tomlinson, 2014).

The Statistics of Wages in the United Kingdom During the Nineteenth Century. (Part XVIII.) The Cotton Industry, G. H. Wood (Wood, 1910b).

A. L. Bowley, Prices and wages in the United Kingdom, 1914-1920 (Bowley et al., 1921).

Machinery

India, Cotton

The Philosophy of Manufactures, Ure, 1861 edition, p. 572, Bombay Only (Ure and Simmonds, 1861).

The Cotton Fabrics of the Bombay Presidency, p. 5, R. E. Enthoven, 1897, Bombay Only (Enthoven, 1896).

Arno Pearse, All India Figures, The Cotton Industry of India, 1930, p. 22. (Pearse, 1930).

Statistical Abstract for British India, various years.

Govil, K. L., The Cotton Industry of India, 1944, p. 40. (Govil, 1945).

India, Jute

Wallace, Romance of Jute (1909 and 1928 eds), (Wallace, 1909), (Wallace, 1928).

Chaudhury, Jute in Bengal (Chaudhury, 1908).

Statistical Abstract for British India, various years.

Jute Labour Enquiry Report (Deshpande, 1946b).

Bengal Admin Report, 1878-9 p. 206.

Note that for 1878, I have used Wallace's loomage figures rather than Chaudhuri's as they were inconsistent with the rest of the data.

UK, Cotton

Spindle and Loom counts: Abstract of British historical statistics, Mitchell and Dean (Mitchell et al., 1971).

UK, Jute

Journal of the Statistical Society of London, Volume 34, p. 522.

Statistical Abstract for the United Kingdom 1878-1894: 40-42, pp. 190-91, Table No. 71.

US Tariff Guide p. 13, Tariff Information Surveys Bags of Jute and Cotton, 1922 (”In point of number of looms and operatives, the Jute industry of Dundee has remained practically stationary for the last 30 years”).

United States. Department of Commerce and Labor, Jute Industry in Scotland (all UK estimate), p. 103.

Final Report on the Third Census of Production of the United Kingdom: (1924) The Textile Trades (Great Britain. Board of Trade, 1930, p. 143).

Raw Material Consumption

India, Cotton

The Cotton Fabrics of the Bombay Presidency, p. 5, R. E. Enthoven, 1897, Bombay Only. (Enthoven, 1896).

Pamphlets of the Hour on Tariff and Free Trade, 1875, p. 80

Arno Pearse, All India Figures, The Cotton Industry of India, 1930, p. 22. (Pearse, 1930).

Statistical Abstract for British India, various years.

Govil, K. L., The Cotton Industry of India, 1944, p. 40. (Govil, 1945).

Report of the Fact-Finding Committee (Handlooms and Mills). Delhi, 1942, (FFC, 1942, p. 285).

India, Jute

Bengal Admin Report, 1878-9 p. 206

Wallace, Romance of Jute, 1928 ed (Wallace, 1928).

Statistical Abstract for British India, various years.

Recent Social and Economic Trends in India, 1946, p. 42 (Subramanian and Homfray, 1946).

UK, Cotton

Lb of cotton yarn spun and yarn exports: Abstract of British historical statistics, Mitchell and Dean (Mitchell et al., 1971).

UK, Jute

The linen trade, ancient and modern by Warden, Alex J. (Alex Johnston), 1864, p. 633 (Warden, 1967 - 1864).

The Industries of Scotland, Bremner 1869, p. 252 (Bremner, 1869).

United States. Department of Commerce and Labor, Jute Industry in Scotland (all UK estimate), p. 96.

Studies In Industrial Organization by Silverman, H.A., p. 237 (Silverman, 2003 - 1946).

Consular Reports: Commerce, Manufactures, Etc, Volume 44 By United States. Bureau of Foreign Commerce, The Jute Trade of Dundee, p. 360 (Net imports into Dundee only).

Raw Jute Imports into UK, Statistical Abstract for the United Kingdom, 1913-1937, pp. 400-1, Table No. 285.

Annual Abstract of Statistics / Central Statistical Office 1935-1946: Iss 84, p. 186, Table 222 (Retained Imports).

Managing Decline: The Jute Employer's strategies, Morelli, Tomlinson, and Wright, Table 2.

US Consul McDougal's Report on Oils and Jute at Dundee,(Appendix in another book), (Hall, 2014, Appendix V, p. 613).

Employment

India, Cotton

The Cotton Fabrics of the Bombay Presidency, p. 5, R. E. Enthoven, 1897, Bombay Only. (Enthoven, 1896).

Arno Pearse, All India Figures, The Cotton Industry of India, (Pearse, 1930, p. 22).

Statistical Abstract for British India, various years.

Govil, K. L., The Cotton Industry of India, 1944, p. 40.

India, Jute

Bengal Factory Act Report (Bengal (India). Chief Inspector of Factories, issuing body.).

Vera Anstey, Economic Development of India, 4th Ed,1957, Table XIV, p. 622.

Jute Labour Enquiry Report, p. 6 (Deshpande, 1946b).

N. C. Chaudhury, Jute in Bengal, (Chaudhury, 1908).

Statistical Abstract for British India, various years.

Note that between 1929 and 1940 I have adjusted actual workers to account for two factors: (i) for 1932-4 and 1939-40, the figures were for Bengal only rather than all India - these I adjusted by 6.9 per cent (the figure implied by the last year of overlap), and (ii) between 1928 and 1932 the Bengal industry virtually did away with child labour, which was circa 12 per cent of employment beforehand. As child labour was paid far less than adult males, this does not represent much of a real labour cost saving. For 1930, I raise the figure by 2 per cent, 1931 4 per cent, 1932 8 per cent, and in the years after that 10 per cent, based upon figures from Sailer (2022). Many child workers were half timers.

UK, Cotton

Abstract of British historical statistics, Mitchell and Dean (Mitchell et al., 1971). Combined figure for spinning and weaving.

UK, Jute

Journal of the Statistical Society of London, Volume 34, p 522

Statistical Abstract for the United Kingdom 1878-1894: 40-42, pp. 190-91, Table No. 71

Tomlinson, Managing Decline: The Case of Jute, Table 1 (Tomlinson, 2011).

United States. Department of Commerce and Labor, Jute Industry in Scotland (all UK estimate), p. 127

Endgame for Jute: Dundee and Calcutta in the Twentieth Century by Gordon Stewart (Stewart, 2019).

US Tariff Guide p. 13, Tariff Information Surveys Bags of Jute and Cotton, 1922 ("In point of number of looms and operatives, the Jute industry of Dundee has remained practically stationary for the last 30 years").

Jute and its manufacture by Carter, Herbert R, (Carter, 1921, p. 162)

Studies In Industrial Organization by Silverman,H.A., p. 247 (Silverman, 2003 - 1946).

Managing Decline: The Jute Employer's strategies, Morelli, Tomlinson, and Wright, Table 2

Working Hours

India, Cotton

1860-1889: 72 hours a week.

1890-1908: 78 hours a week (increase due to electric lighting).

1909-1923: 72 hours a week (decrease due to factory act).

1924-1933: 60 hours a week (decrease due to factory act).

After 1933, hours of machinery and labour diverge. For labour they remain at 60 hours a week. For machines, hours increase by 2 every year to account for the spread of double shifts, implying that by 1940, 23.3 per cent of machines are under double shifts.

India, Jute

Wallace, Romance of Jute, 1909 ed, p. 65 (Wallace, 1909).

Alexander R. Murray, The Jute Industry, Journal of the Royal Society of Arts, Vol. 82, No. 4263 (August 3rd, 1934), (Murray, 1934). These are figures from the Indian Jute Mill Owners Association, which tended to be lower than those of independent mills.

Bengal Factory Act Report (Bengal (India). Chief Inspector of Factories, issuing body.).

Jute Labour Enquiry Report, p. 55, Appendix 1 (Deshpande, 1946b).

Royal Commission on Labour in India, Report, (Whitley, 1931a, p. 38).

After 1930 single shifts were the rule in the jute industry, and so worker hours were the same as machine hours.

UK, Cotton

1850-1885: Mark Blaug, Productivity of Capital, p. 381. (Blaug, 1961).

1885-1940: Scott and Apadavecchia, Did the 48 Hour Week Damage Britain's Industrial Competitiveness? (Scott and Spadavecchia, 2011).

To confirm machine and labour hours tracked one another, the latter were taken from The Barefoot Aristocrats, pp. 246 and 248, and cross checked (Fowler et al., 1987).

As multiple shifts were not used in Britain, machine and worker hours were equivalent.

UK, Jute

In the absence of any evidence, I use the same figures as from the cotton sources.

Interest Rates

India

1850-1903: The history of the Bank of Bengal, Symes Scutt, (G. P. Symes Scutt, 1904, pp. 150-1).

1904-1919: G. F. Shirras, Indian Finance and Banking, (Shirras, 1920, p. 471).

Other Years: Statistical Abstract for British India.

UK

Bank of England Bank Rate from BoE Millennium Dataset (Thomas and Dimsdale, 2017).

Depreciation

I set depreciation at 3.5 per cent per year. This does not vary with hours worked.

The Indian income tax system allowed 7.5 per cent depreciation expenses for cotton textile machinery and 2.5 per cent for buildings. A 50-50 split would have 5 per cent depreciation. Lars Sandberg argues in favour of rates between 10 and 7 per cent for cotton textile machinery. In actual practice cotton textile machinery could last a very long time, but part of this was due to repair expenditure. So too could mills, as the skylines of Manchester and Bombay illustrate. Higher rates of depreciation, however, would tend to reduce the advantage in capital costs for Britain (arising from lower interest rates gross of depreciation), and so, again to be conservative, I stick with the lower figure. A higher figure would also raise the capital share of manufacturing charges, and I consider my estimates from Figure 13 to be upper bounds on the capital share.

Should depreciation charges vary with hours worked? R. Robson mentioned the ”doubtful extent that depreciation is less on stopped machinery than on running” (Robson, 1957, p.197).

Machinery Prices

All machinery price figures are based upon a few baseline years and Feinstein's capital goods price index.

Capital goods Price Index: C. H. Feinstein, 1972, National income, expenditure and output of the United Kingdom, 1855-1965, (Feinstein, 1972, Tab. 63, p.T136-7).

Cotton Machinery: 1886 figures of £1 per spindle and £20 per loom from M. Blaug, Productivity of Capital, (Blaug, 1961, p.374).

R. Robson mentioned that, before the First World War, the cost of establishing a mill was around £1 per spindle and that during the recapitalisation boom of 1920, it cost £3 per spindle, both of which are close to my figures constructed as outlined above. He does not give loom prices before the Second World War, but his ratio between the cost of an ordinary loom and a spindle for 36s yarn is 18.75, not far from Blaug's estimate 71 years earlier (20), implying that the relative price of spindles to looms had not changed by much over time. (Robson, 1957, pp. 161 and 326).

Jute Machinery: 1866 £413.64 per loom for an integrated factory, (Cola, 1867, p.124) (machinery cost doubled for land, construction etc, see p.126). 1913 figure of £450 per loom for an integrated factory, United States. Department of Commerce and Labor, Jute Industry in Scotland, p.105. The series constructed from these two baseline years agreed with one another, and so I averaged them together.

Exchange Rates

Nominal exchange rate from the Statistical Abstract for British India, various years.

B Raw Materials and Output Good Prices

I exclude raw materials from my analysis and focus instead on manufacturing costs. But I do have data on their prices and those of output goods in the two countries. Figures D.2 and D.3 plot these over time for the cotton and jute industries respectively. Before 1885 there were significant cost differentials, usually in India's favour, in the sense that input prices were lower and output prices relatively higher. Late 19th century globalisation reduced these differences to insignificant levels by 1900. The sole exception is the cost of Hessians, which rises in Dundee relative to Calcutta abruptly after 1890. This may simply be due to some change in reporting or perhaps it represents Dundee focusing on finer goods and leaving the coarser market to Calcutta.

I have tried to adjust for quality differences, where possible, in these figures and the rest of this appendix explains the sources used and my adjustment method.

Raw Materials and Output Good Prices Sources

Cotton Cloth Prices, England

Lars Sandberg, Lancashire in Decline, Table 43.

Trade and Navigation Reports for the United Kingdom, Various Years, Values of cloth exports to India divided by yardage of cloth.

These are the prices of British cloth exported to India, which tended to be lower than the average cloth produced in Lancashire for the home and other export markets.

Cotton Cloth Prices, India

Index Numbers of Indian Prices, 1861-1931.

Statistical Abstract for British India (1930-40), p. 486.

Statistical Abstract for British India (1928-37), p. 388.

Statistical Abstract for British India (1926-35), p. 559.

Prices and Wages in India, 1902, Table 39, Calcutta prices.

Prices and Wages in India, 1919.

Three types of cloth were reported, with different coverage for different years, in these sources. I regressed prices per lb on annual dummies and dummies for type with the baseline being Cotton grey shirtings from Britain and the other two T-cloth and long cloth from Bombay. So the cloth price series in India should be comaprable to those exported by Britain to that country.

Cotton Yarn Prices, England

R. Robson, Cotton Industry in Britain, pp. 336-7, Price of 32s yarn from 1883 onwards. I divide this by 1.3 to proxy the price of 20s yarn in England.

Cotton Yarn Prices, India

Prices and Wages in India, 1902.

Index numbers of Indian Prices 1861-1931, p. 7, Table V.

Bengal Trade Reports (See Bengal Yarn Consumption Sheet).

Statistical Abstract for British India, Various Years.

Statistical Abstract For British India (1922-32), p.758.

Yarn prices were either reported for 40s or 20s in price per lb. The Bengal Trade reports gave import volumes and import values, so the price per lb could be easily calculated. I assume that this yarn was on average 40s.

I regress yarn prices on annual dummies and a dummy for 40s yarn, i.e. the baseline price is for one lb of 20s yarn.

Raw Cotton Prices, England

Mitchell and Deane, Abstract of British Historical Statistics, p. 491, Price of American Middling Cotton.

Raw Cotton Prices, India

Prices and Wages in India, 1902, Table 41 (Export/Factory Price).

Prices and Wages in India, 1919, Table 7 (Export/Factory Price).

Statistical Abstract For British India, Various years (Export/Factory Price).

Datta, Report on An Enquiry into the Rise of Prices, Vol. 2, pp. 162-3, 206-7 (Export/Factory Price).

Natu, 1949, Abstract of Agricultural Statistics, p. 300 (Cotton Growing Region Price).

Index Numbers of Indian Prices, 1861-1931 (Export/Factory Price).

Jute Cloth Prices, UK

Statistical Abstract for the United Kingdom 1865-1882: 27-30, p. 106.

Statistical Abstract for the United Kingdom 1865-1882: 27-30, p. 42.

Statistical Abstract for the United Kingdom 1871-1885, pp. 120-1.

Statistical Abstract for the United Kingdom 1885-1900: 47-48, pp. 158-9.

Statistical Abstract for the United Kingdom 1900-1914: Vol 62, pp. 280-1.

Statistical Abstract for the United Kingdom 1911-1925: Iss 70, pp. 342-3.

Statistical Abstract for the United Kingdom 1913-1937: Iss 82, pp. 422-3.

Jute Cloth Prices, India

Statistical Abstract For British India (1922-32), p. 758.

Statistical Abstract For British India (1930-40), p. 487.

tatistical Abstract For British India 1928-29 To 1937-38, p. 389.

Statistical Abstract For British India 1926-27 To 1935-36, p. 561.

Index Numbers of Indian Prices, 1861-1931.

I regressed jute cloth prices on annual dummies with a Hessian (higher quality more comparable to Scotland) dummy. The quality adjusted series uses the predicted hessian price, and the non-quality adjusted series merely uses the gunny sack price.

Raw Jute Prices, Scotland

Prices and Wages in India, 1902, p. 231 (London price was reported).

The linen trade, ancient and modern, Alex J. Warden, 1864, pp. 645-53.

Statistical Abstract for the United Kingdom 1913-1937: Iss 82, pp. 258-9.

Statistical Abstract for the United Kingdom 1900-1914: Vol 62,pp. 262-3.

Statistical Abstract for the United Kingdom 1910-1924: Iss 69, pp. 92-3.

Statistical Abstract for the United Kingdom 1871-1885, pp. 116-7.

Statistical Abstract for the United Kingdom 1865-1882: 27-30, p. 102.

Statistical Abstract for the United Kingdom 1913-1937: Iss 82, pp. 400-1.

Raw Jute Prices, India

Report on the Cultivation of, and trade in, Jute in Bengal, H. C. Kerr, Appendix H.

Bengal Jute Enquiry Report, p. 11.

Index Numbers of Indian Prices, 1861-1931.

I regressed prices on annual dummies and a quality dummy. The baseline was ordinary quality.

C Leontief Implied Labour Efficiency Ratio Derivation

From the main text:

$$\frac{c(w_{E,t}, i_{E,t}, P_{K,E,t})}{c(w_{I,t}, i_{I,t}, P_{K,I,t})} = \frac{A_I}{A_E}\left(\frac{\frac{a_E}{b}w_{E,t} + \frac{(i_{E,t}+\delta)P_{K,E,t}}{h_{E,t}}}{\frac{a_I}{b}w_{I,t} + \frac{(i_{I,t}+\delta)P_{K,I,t}}{h_{I,t}}}\right) \tag{13}$$

Equating the cost ratios we have:

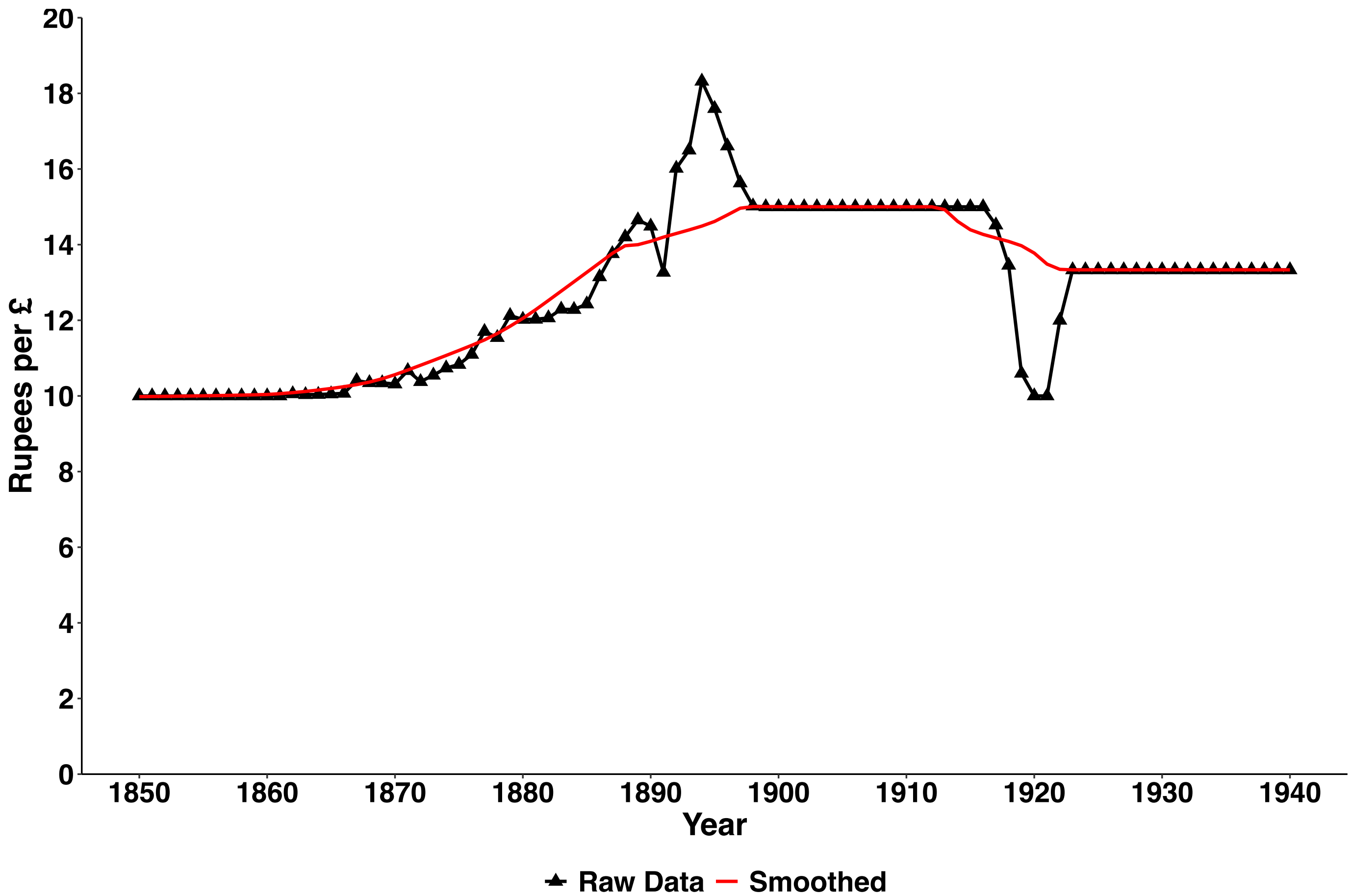
$$\frac{a_E}{b}w_{E,t} + \frac{(i_{E,t}+\delta)P_{K,E,t}}{h_E} = \frac{A_E}{A_I}\left(\frac{a_I}{b}w_{I,t} + \frac{(i_{I,t}+\delta)P_{K,I,t}}{h_I}\right) \tag{14}$$

Let $a_I = \frac{1}{e}a_E$. Then:

$$\frac{1}{e} = \frac{b}{a_E w_{I,t}}\left(\frac{A_E}{A_I}\left(\frac{a_E}{b}W_E + \frac{(i_{E,t}+\delta)P_{K,E,t}}{h_E}\right) - \frac{(i_{I,t}+\delta)P_{K,I,t}}{h_I}\right) \tag{15}$$

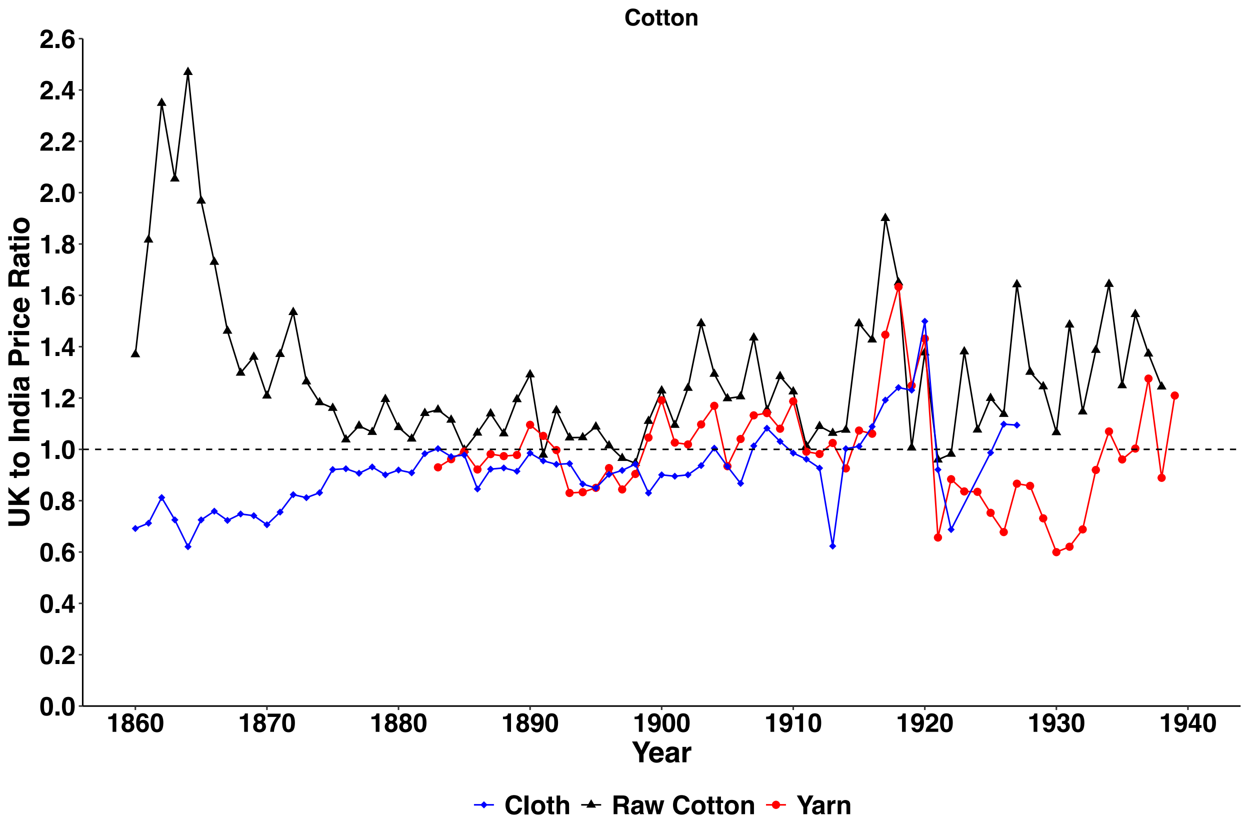
D Supplementary Graphs

Figure D.1: Nominal Exchange Rate



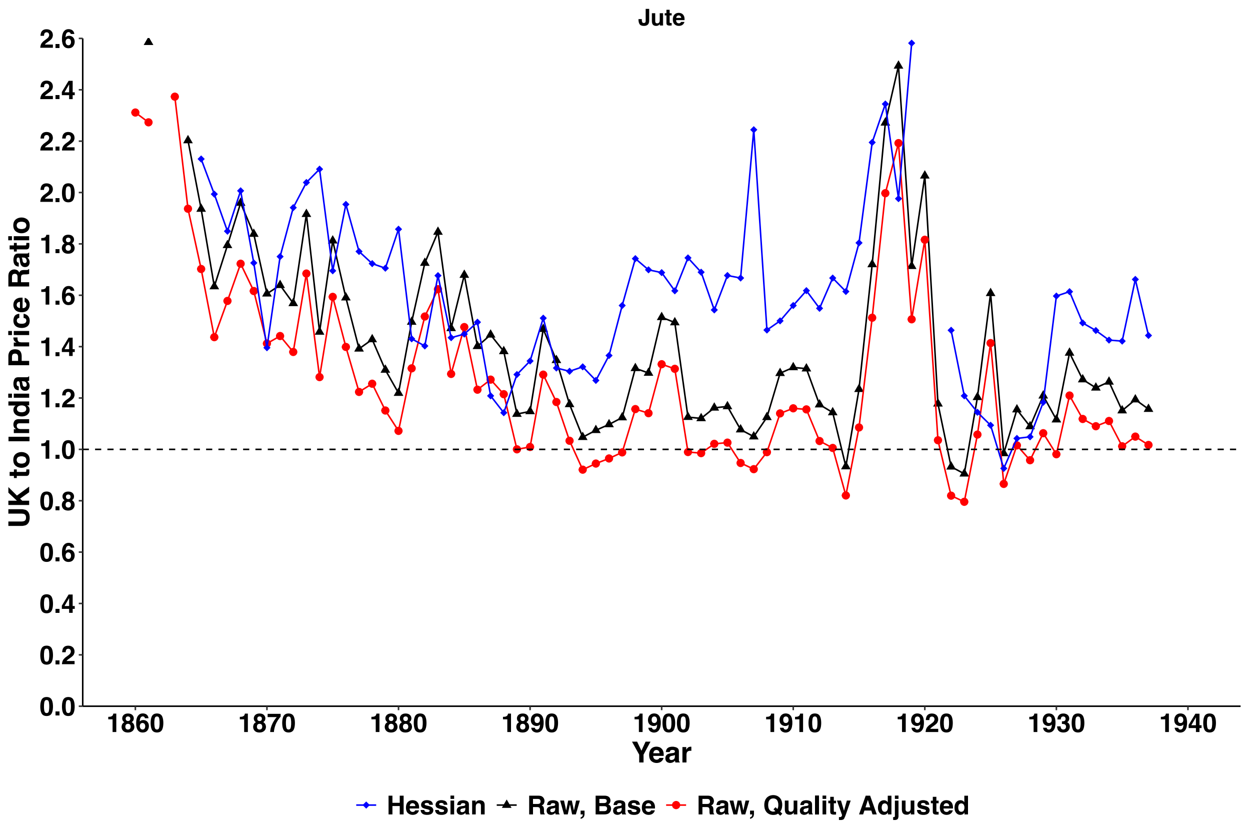
Sources: *Statistical Abstract for British India*, various years. **Notes:** The smoothed series is based upon a loess trend with a span of 0.25.

Figure D.2: Cotton Prices



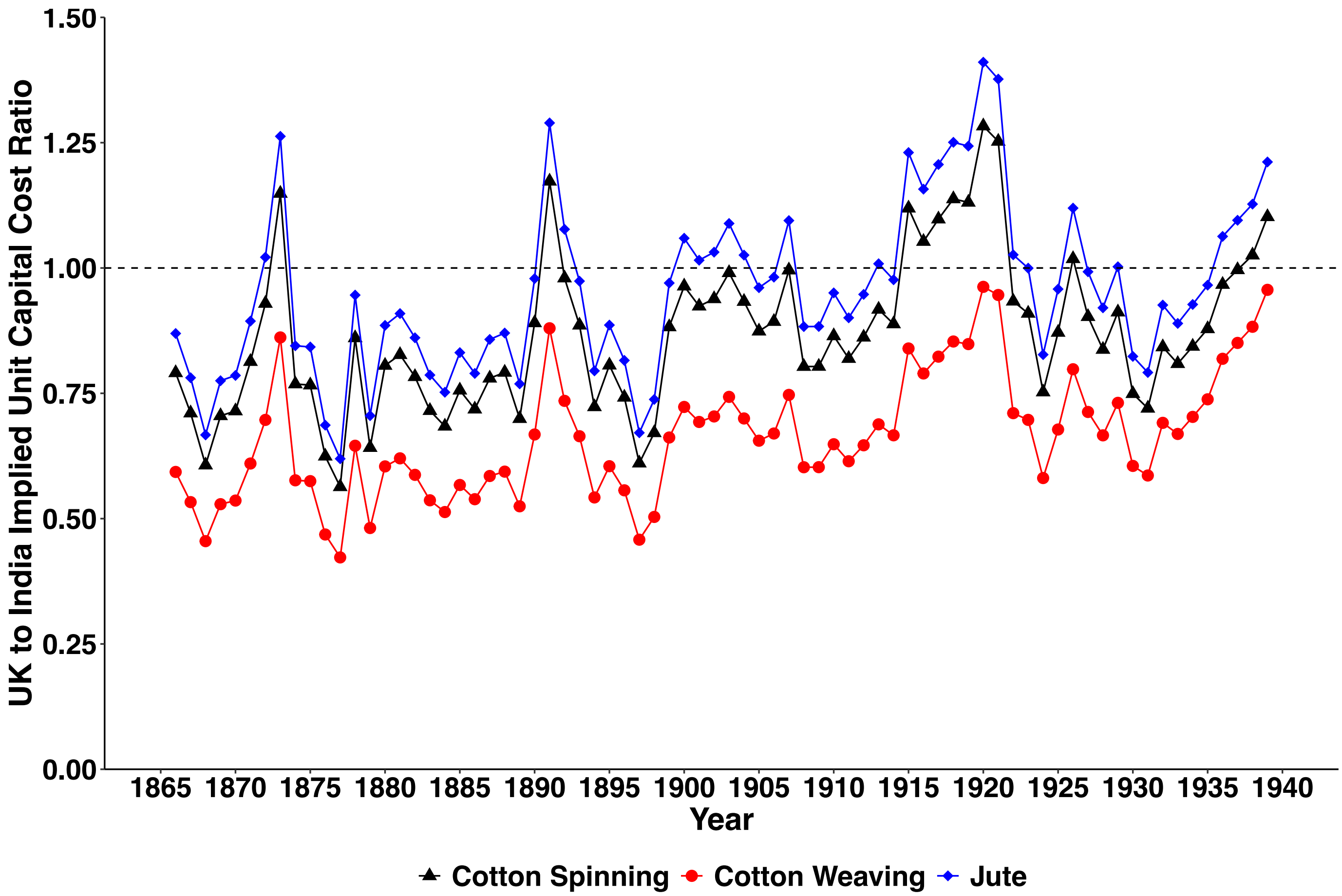
Sources: See Appendix B. **Notes:** The cloth series is that of British cloth exported to India. The yarn series has a 20s baseline. The cotton series compares Indian export grade cotton to American Middling cotton in the UK.

Figure D.3: Jute Prices



Sources: See Appendix B. **Notes:** The unadjusted raw jute series compares the average Indian price for ordinary jute to the observed Scottish price, while the quality adjusted series compares higher quality jute prices in India to Scotland. The jute cloth series takes Hessian cloth as the baseline. I have no explanation for the jump in the cloth series around 1895.

Figure D.4: Implied Unit Capital Cost Ratios



Sources: See text and Appendix A. **Notes:** Unit capital cost for a given country is $\frac{(i_{i,t}+\delta)P_{K,i,t}}{h_{i,t}A_{i,t}}$, i.e. nominal hourly capital costs divided by output per machine hour. This figure plots the UK to India ratio of these unit costs.

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