

Do Local Institutions Affect All Foreign Direct Investors in the Same Way? Evidence from the Interwar Chinese Textile Industry

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Abstract

This paper analyzes the impact of local employment institutions on Japanese-, British-, and Chinese-owned textile firms operating in the China during the 1920s and 1930s. Though firms in Britain had higher TFP levels than firms in Japan, Japanese-owned firms in China enjoyed an approximate 60 percent TFP advantage over their British-owned and Chinese-owned competitors. Japanese textile companies' superior performance is explained by their use of proprietary knowledge to solve problems in Chinese labor institutions—problems that British- and Chinese-owned firms could not surmount. Though knowledge is usually thought of as a global public good, the case examined here indicates that the application of knowledge can be contingent on institutional factors. Where this is the case, countries sharing similar institutions will experience more productive transfers of knowledge.

Introduction

In the first half of the twentieth century, Japan rapidly absorbed industrial technologies from the West, while other Asian countries such as China and India lagged behind. In textiles, British managers and investors established plants in India, but productivity in these firms remained at a constant level from the turn of the century to the onset of World War II, and many of the firms became unprofitable in the face of a flood of cheap imports produced by high productivity-low wage firms in Japan (Clark and Wolcott 1999). A key question in understanding twentieth century development is why Japanese firms were able to transform productivity

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levels in their economy, while other developing country firms, some of them run by experienced Western managers, tried and failed. To understand this puzzle, I investigate attempts of British and Japanese firms to transfer textile technology to China during the 1920s and 1930s. The analysis reveals some of the pitfalls which developed country firms may face in transferring technologies to countries with unfamiliar institutions, and explains why transfers may occur more readily across countries sharing similar backgrounds.

The process of technology transfer is often seen in deceptively simple terms: firms in developing countries learning what firms in developed countries already know. In the popular knowledge-capital model due to Markusen (2004), for example, multinationals deliver knowledge of ‘best-practices’ to foreign affiliates. Whether ‘best-practices’ exist and can be transferred, however, is questionable. Some knowledge is specific to characteristics—such as factor endowments, institutions, and culture—which vary across time and place. An organizational technique which improves productivity in one country may function poorly in a country with different characteristics. As a consequence, developing countries can be better off sourcing technologies from neighboring countries with similar institutions, rather than from the worlds’ technological leaders.

Economists and business scholars often classify knowledge based on its transferability. I argue that transferability can depend on characteristics of the donor and recipient. For example, Burstein and Monge-Naranjo (2009) calibrate a macro-level knowledge-capital model which divides productivity sources into transferable managerial know-how and location-bound factors. If know-how were fully transferrable, one would expect successful firms to be organized the same way the world over. Bloom, Sadum and Van Reenan (2009), however, observe that

institutional and cultural differences influence the propensity of firms to centralize decision-making. Centralization does not break down cleanly by developmental level; for example, firms in Japan are among the world's most centralized, while British firms are among the least. When these firms set up affiliates in foreign countries, they tend to be organized more like their parent firm than like local competitors. How these multinational affiliates perform vis-à-vis local firms depends on whether the practices they transfer meet local needs. In some cases, the transfer of inappropriate practices can put multinationals at a disadvantage.

I study such transfers of organizational practice through a comparative analysis of developed and developing country multinationals operating in a common environment. I focus on Japanese and British investment in Chinese textiles during the interwar period because the outcome of their competition raises interesting questions for the theory of FDI. At this time, Japan was a relatively poor developing country and still relied heavily on British textile technology. Productivity in Japan's domestic textile sector lagged behind that in Britain, but, nonetheless, Japanese corporations were able to dominate British competitors in China, increasing their share of the spinning capital stock from 21 to 42 percent between 1918 and 1936, while the British share declined from 35 to 6 percent.

Japanese success poses a puzzle: how can a change of venue allow a laggard multinational to leapfrog over a technological leader? I argue that institutional features of the Chinese labor market favored the use of Japanese management techniques, disadvantaging firms which did not have access to this technology. The argument integrates the analysis of institutions and technology, and identifies important interactions between the two. Interactions imply that a multinational's choice of location will be affected by the type of

knowledge capital it holds. A multinational may be a technological leader in one location, but uncompetitive in another, even though it employs the same technology everywhere.

The remainder of this paper analyzes the sources of Japanese success. In the succeeding two sections, I use annual production statistics compiled by the Chinese Cotton Mill Owners Association and supplementary statistics describing product quality to compare the total factor productivity (TFP) levels in Japanese-, British-, and Chinese-owned textile mills. The results, the first analysis of textile TFP in pre-Communist China in the literature, indicate Japanese-owned firms were the most productive in the industry and British-owned firms the least. The next two sections examine the effects of the social context on the operation of British-, Chinese-, and Japanese-owned mills. Building on business histories of textile corporations in China, particularly the work of Cochran (2000) and Kuwahara (1986), I first show how local employment institutions constrained the managers of British- and Chinese-owned mills and explain why the mill owners found these institutions so difficult to reform. Next, I examine the organizational structure which Japanese investors imported from Japan, and show how this structure was able to improve worker incentives and enhance labor efficiency. I identify this organizational structure as the key knowledge asset which motivated Japanese investment in Chinese textiles. The success of Japanese mill organizations inspired attempts at imitation among local competitors. In the penultimate section, I use bank investigations of organizational conditions and a case-study of reforms at the largest Chinese-owned firm to show that successful reform was associated with productivity growth. Finally, I conclude by reviewing the implications of context-specific knowledge assets for international flows of investment and ideas.

Productivity in the Spinning Industry: Measurement

The measurement of productivity in spinning always requires careful attention to variation in yarn count, the principal measure of yarn quality.² Pound for pound, high count yarn is much more costly to produce than low count yarn, and this complicates productivity comparisons across mills spinning different counts (Leunig 2003).³ Chinese sources record mill-level yarn output in units of weight, but mill-level data rarely record information on yarn count. Complete information on count is available in aggregate statistics which show the distribution of yarn counts spun in the Japanese-, Chinese, and British-owned sectors. These data indicate that Japanese-owned mills spun significantly higher counts than other ownership sectors. Since value-added per pound is increasing in count, weight-based measures grossly understate output in Japanese-owned mills, and are not appropriate for productivity comparisons.

I resolve the count issue by estimating the elasticity of unit capital and labor requirements with respect to count, and using the results to adjust productivity levels for count differences. The estimating equations (1) and (2) are shown below, where variables and indexes are defined as follows: i indexes firms, j indexes product types, and t indexes time, l_{it} is labor productivity at mill i at time t , measured in either pounds of yarn per worker-day or pounds of yarn per unit of wage expenditure, k_{ijt} is capital productivity measured in pounds per spindle-day at mill i in product type j at time t , c_{it} is the average count produced at mill i at time t , c_{ijt} is

² A yarn's count is defined as its length (measured in hanks) divided by its weight (measured in pounds), where a hank is a unit of length equal to 840 yards.

³ Leunig (2003) observes that, at the turn of the 20th century, unit costs net of materials in extremely high count yarn (300 count) were 75 times those in extremely low count yarn (4 count). In the textile industry in modern America, doubling count approximately doubles the capital costs per ton-year of capacity (Lord 2003).

the exact count of product type j at mill i at time t , Z_{it} is a vector of control variables which vary across data sources, and v_{it} and v_{ijt} are error terms.

$$\ln l_{it} = \beta_0^l + \varepsilon_{l,c} \ln c_{it} + \delta^{l'} Z_{it} + v_{it} \quad (1)$$

$$\ln k_{ijt} = \beta_0^k + \varepsilon_{k,c} \ln c_{ijt} + \delta^{k'} Z_{it} + v_{ijt} \quad (2)$$

The primary coefficients of interest here are $\varepsilon_{l,c}$, the elasticity of labor requirements with respect to count, and $\varepsilon_{k,c}$, the elasticity of capital requirements with respect to count. Using the estimated elasticities, I convert observed spindle and labor productivity levels for each sector-year into “20 count equivalents” which are predictions of what productivity levels would be if all firms had produced a common yarn count, 20 count yarn. This conversion is standard in the textile productivity literature, but it is often performed incorrectly.⁴ The quality-adjusted productivity levels are formulated according to the following equations, (3) and (4), where $h = \{Japanese, British, Chinese\}$ indexes the sector under comparison, L^h and K^h are labor and spindle productivity in sector h in terms of 20 count equivalents, l^h and k^h are unadjusted levels of labor and spindle productivity in sector h , $\varepsilon_{l,c}$ and $\varepsilon_{k,c}$ are the elasticities of labor and spindle productivity with respect to count, and f_c^h is the fraction of yarn count c produced in sector h , where c is one of seven possible yarn counts: 9.5, 12, 15.6, 20, 32, 42, and 60.

$$L^h = l^h \left[\sum_{c=9.5,12,15.6,20,32,42,60} f_c^h \left(\frac{20}{c} \right)^{\varepsilon_{l,c}} \right] : 0 \leq f_c^h \leq 1 : \sum f_c^h = 1 \quad (3)$$

⁴ In studies using Japanese data, for example, authors generally rely on Fujino, Fujino, and Ono (1979) who converted yarn into 20 count-equivalents on the basis of yarn prices. This conversion is only appropriate for comparing productivity indices which include all inputs used for production: capital, labor, and material. Since materials decrease rapidly as a share of costs as count increases, price-based adjustments should not be used for comparisons of single factor productivity, or for comparisons of productivity indices calculated through the value-added approach.

$$K^h = k^h \left[\sum_{c=9.5,12,15.6,20,32,42,60} f_c^h \left(\frac{20}{c} \right)^{\epsilon_{k,c}} \right] : 0 \leq f_c^h \leq 1 : \sum f_c^h = 1 \quad (4)$$

The raw levels of labor and spindle productivity, l and k , are not comparable across sectors because each sector produces a different set of products, $\{f_c\}$. Changes in this product set, $\{f_c\}$, will alter raw labor and spindle productivity levels, l and k , even though the real performance level in the sector remains fixed. To control for this, I use observations of $\{f_c\}$ and estimates of the elasticities $\epsilon_{l,c}$ and $\epsilon_{k,c}$ to convert l and k into levels of spindle and labor productivity in terms of a single product, 20 count yarn. These values, L and K , are invariant to the product set produced, allowing comparisons between sectors producing different counts. The subsequent section describes the data I use to carry out these estimations, and the results obtained.

Productivity in the Spinning Industry: Data and Results

Annual statistics collected by the Chinese Cotton Mill Owners Association (CCMOA) between 1924 and 1936 provide the most extensive source of data in the Chinese cotton textile industry.⁵ The data record the number of workers, spindles, and looms at each mill, and the number of bales of yarn and bolts of cloth produced, together with the weight of cotton consumed. The CCMOA data suffer from a number of minor flaws. The data on yarn production sometimes exclude yarn woven into cloth. Since cotton consumption statistics do not have this

⁵ The CCMOA data are available in *Zhongguo mianfang tongji shiliao* (1950) [Chinese Cotton Textile Historical Statistics]. British language tabulation of most of the data is available in Kraus (1980).

problem, I use these data to measure yarn output.⁶ Another problem is that the data record the total number of mill workers at each plant, but do not indicate how many were engaged in yarn production. Workers participated in three activities: spinning (yarn production), weaving (cloth production), and doubling (thread production). To divide workers across activities, I regress the number of workers at each mill on the number of spindles, looms, and doubling spindles in an OLS framework to obtain estimates of average machine-staffing levels.⁷ I then combine these coefficient estimates with data on each mill's machinery to estimate the fraction of workers required for each activity, and multiply this by the number of employees to yield the estimated number of spinning, weaving, and doubling workers. The last minor problem relates to variations in working hours across mills. According to Pearse (1929), Chinese- and British-owned mills operated 24 hours per day, whereas Japanese-owned mills operated only 22 hours per day. To account for reduced working hours, I adjust labor productivity levels in Japanese mills by a factor of 12/11.

The problem of count differences is more serious, as the data indicate that each mill group produced different products. Data on the yarn counts sold by each ownership group is reported in Zhao and Chen (1997) and Yan (1965). This data is only available for 1929 and 1932-

⁶ Data in Wang and Wang (1935) and the Qingdao Mill Yearbooks (1948) indicate that the ratio of yarn produced to cotton consumed was similar for all mills. Based on this data I assume that 1 bale of yarn was spun for every 3.5 piculs of cotton consumed.

⁷ Regression estimates indicate a population average of 0.047 workers per spindle, 1.30 workers per loom, and 0.019 workers per doubling spindle. A representative mill might have 40,000 spindles, 400 looms, 2,000 doubling spindles, and 2,500 workers. I assign workers, denoted L , to spinning and weaving as follows:

$$L_{\text{spinning}} = L \frac{0.047(\text{spindles})}{0.047(\text{spindles})+1.30(\text{looms})+0.019(\text{doubling spindles})} : L_{\text{weaving}} = L \frac{0.047(\text{spindles})}{0.047(\text{spindles})+1.30(\text{looms})+0.019(\text{doubling spindles})}$$

1935, but evidence from *The Situation of the Jiangsu Textile Industry* (1920) and estimates from Reynolds (1975) suggest that all mills spun similar counts to one another in the early 1920s.⁸ I assume that all mills produced the same counts circa 1924-1925, and use linear interpolation to fill in the count distribution for the intervening periods (1926-1928, 1930-1931, and 1936). Table 1 reports implied average counts for each mill group, and shows that Japanese-owned mills spun significantly higher counts than Chinese- and British-owned mills.

[Insert Table 1]

Since high count yarn requires more spindles and labor to produce, and Japanese-owned firms produced primarily high count yarn, unadjusted weight-based productivity measures would greatly understate their performance. To correct for this problem, I estimate the elasticities of spindle and labor requirements with respect to count. Accurate estimation of the elasticities of spindle and labor productivity with respect to count, $\epsilon_{l,c}$ and $\epsilon_{k,c}$, is essential to the validity of the adjustment for count.⁹ To ensure the reliability of the adjustment, I

⁸ *The Situation of the Jiangsu Textile Industry* (1920) gives the counts marketed by all mills in Shanghai and Jiangsu where about 2/3 of the industry was located, but not the amount sold of each type. However, since mills produced a relatively narrow range of counts in 1920, the simple and weighted averages of these counts should not differ significantly.

⁹ One reason to be careful about the count issue is that it has been troublesome for previous researchers. For example, Clark (1988) estimates the productivity gap between Japanese- and Chinese-owned mills in 1930 and finds (erroneously) that it was only 8%. Yet Clark's source, H.D. Fong (1932), reports that raw labor productivity of Japanese-owned mills was 21% higher than that of Chinese-owned mills, even before adjusting for yarn quality differences or the greater proportion of labor devoted to weaving in Japanese-owned mills. Moreover, using unadjusted data in Clark's sources, Fong (1932) and Reynolds (1975), to compare the productivity of Japanese- and Chinese-owned mills spinning similar counts shows a 48% gap in labor productivity circa 1930. Nevertheless, Clark relies on count-adjusted spindle-labor ratios to measure productivity. In his framework, increasing count should result in a downward adjustment to productivity as crudely measured by capital-labor ratios. While this is correct, performing meaningful adjustments depends on using accurate count data. Unfortunately, he greatly overestimates the counts produced at Japanese-owned mills in China, and thus overdoes this adjustment. For example, he estimates that 7 out of 16 Japanese-owned mills in Shanghai produced average counts in excess of 42, though even in the aggregate Japanese-owned mills did not produce such yarns in 1929, the year from which his data derives (Zhao and Chen 1997). Also, he estimates that the average count produced at Chinese-owned mills in Shanghai was 23.8 and at mills Chinese-owned mills elsewhere was 23.1, though mill-level statistics in Wang and Wang (1935) for 1932 would indicate figures of 19.1 and 16.3, respectively. Assuming his count data for Japan to

estimate elasticities using two separate Chinese sources, one from 1932 and the other from 1946-1948, and I also repeat the calculations using British data from 1912 and 1947 reported in Leunig (2003) and Vincent and Tippet (1953), respectively. The first Chinese data source is a cross-section of production statistics from 42 Chinese- and British-owned mills in seven Chinese provinces, published in Wang and Wang (1935). These statistics contain 90 machine-level observations of output per spindle-hour from 39 different mills which allow the precise estimation of the elasticity of capital requirements with respect to count. Information about labor usage is limited to 19 mill-level observations. Aggregation to the mill-level poses a problem because of the possibility of a correlation between unobserved productivity differences and the mill's pattern of specialization; if more technically adept mills produce higher counts, then the elasticity estimate will be biased towards zero. To correct for this issue, I include the average wage rate paid at each mill as a proxy for differences in productivity. The results from these regressions, reported in Table 2, suggest that the elasticity of spindle productivity with respect to count is close to -1.15. The elasticity of labor productivity with respect to count is estimated as -0.61, but this result is imprecise and not robust. In particular, removal of the control for wages significantly decreases the magnitude of the estimated coefficient. Before analyzing and discussing results from other data sources, it is helpful to give an example to show what these results mean in terms of productivity adjustments across sectors. The estimated elasticities imply that in 1932 the average 25.8 count spun by Japanese-

be accurate, these mistakes would lead to an underestimate of Japanese-owned productivity relative to Chinese-owned productivity, and an underestimate of the productivity of Chinese- and Japanese-owned mills relative to that of mills in Japan proper; and this is what his results show.

owned mills required 60.4 percent more spindle hours per pound and 28.5 percent more labor hours per pound than the average 17.1 count spun in Chinese-owned mills.

[Insert Table 2]

The second Chinese data source is a panel of exceptionally detailed monthly production statistics from eight government-owned mills in Qingdao operating between 1946 and 1948, as published in the company's yearbook.¹⁰ These mills collected monthly information on wage costs in the production of each count. Assuming that workers are paid the same regardless of the count they produce, these wage data, available for July–December 1946, provide an ideal way to estimate the elasticity of labor requirements with respect to count. Other useful data in the yearbooks include monthly observations of yarn output per worker and the average count spun at each mill, as well as yearly machine-level observations of output per spindle. This second set of observations allows the cross-sectional regressions used for the Wang and Wang (1935) dataset to be repeated in a panel setting. This is useful because the inclusion of mill fixed effects reduces the potential for correlation between count and unobserved productivity to bias the estimates. The results of these two regressions are reported in Table 3. The estimates of the elasticity of labor productivity with respect to count based on product-level wage accounts and aggregated mill-level production statistics yield similar results: elasticities of -0.65 and -0.77, respectively. The estimate of the elasticity of capital productivity with respect to count is -1.15, the same as that estimated from the Wang and Wang (1935) dataset.

[Insert Table 3]

¹⁰ I collected the Qingdao Mill Yearbooks (1948) from the modern documents collection at the Shanghai Municipal Library.

One final cause for concern is the potential for the elasticity of labor requirements with respect to count to vary across time and place. To see whether such variations occur and what significance they would have for productivity calculations, I exploit data on count and labor productivity reported in previous investigations by Leonig (2003) for England in 1912, and Vincent and Tippet (1952) for England in 1947. The results from these regressions, reported in Table 4, are reassuring.¹¹ Vincent and Tippet (1952) estimated the dependency of labor requirements on count separately for the preparatory and final stages of spinning. They report that the preparatory stage accounts for 41% of labor hours, and the final stage accounts for 59% of labor hours. The estimated elasticities for the preparatory and spinning stages are -0.53 and -0.73, respectively; which yield a weighted average of -0.65; an identical value to that estimated for the Qingdao mills on the basis of wage accounting data. Leonig's data gives a substantially higher elasticity of -1.08 which suggests that increasing count required more additional labor in 1912 than it did in the 1940s. If this is indeed the case, using an elasticity of -0.65 for the period from 1924 to 1936 would, if anything, disadvantage mills spinning high counts. The point made by this series of regressions is that -1.15 and -0.65 are reasonable estimates of the elasticity of capital and labor productivity with respect to count.

[Insert Table 4]

Based on estimated elasticities of spindle and labor productivity with respect to count of -1.15 and -0.65, respectively, I use equations (3) and (4) to generate capital and labor productivity series for the Chinese-, Japanese-, and British-owned sectors in terms of 20 count

¹¹ Vincent and Tippet (1952) also provide information on the country of origin of the yarn used, listed in order of quality: Indian, American, and Egyptian. Since mills in China used Egyptian cotton only in negligible quantities (less than 1 percent), I exclude these observations from the regressions.

equivalents. Since such figures are typically reported in terms of pounds per hour, I covert them into an hourly framework using a 320 day work-year, a 24-hour, two shift workday, and the conversion factor of 420 pounds per bale. In Table 5, I report these results with corroborating evidence taken from Zhao and Chen (1997) and Duus (1989), as well as figures for formerly Japanese-owned Qingdao mills in 1947 as calculated from the Qingdao yearbooks. As Table 5 shows, my estimates of the productivity gap between Japanese- and Chinese-owned mills are similar to reports from contemporaries collected in Zhao and Chen (1997) and Duus (1989). Data from the Qingdao mills, which were Japanese-owned prior to 1945 but were nationalized following World War II, provide a useful check on the results because they include explicit information on the counts produced, the division of workers across spinning and weaving, capacity utilization, and the number of days worked. Assuming that productivity did not change significantly during World War II, then the Qingdao figures for 1947 should give estimates of capital and labor productivity in Japanese-owned mills similar to those in 1936, and this is indeed what the data shows.¹²

[Insert Table 5]

Using these adjusted labor and capital productivity figures, it is simple to produce a TFP index comparing the performance of the Japanese-, Chinese-, and British-owned sectors in spinning. Pearse (1929) reports estimates of Chinese spindle costs, labor costs, interest rates, and depreciation allowances which suggest equal spindle and labor cost shares in 20 count

¹² Wang (2004) suggests that productivity declined slightly after mills were transferred to state ownership, but I do not find strong evidence for this.

spinning.¹³ Accordingly, I calculate TFP as the exponent of the average of quality-adjusted log spindle and log labor productivity. To normalize the index, I use the Japanese productivity series reported in Table 5 to estimate the average TFP level in Japan from 1930 to 1934. Mills in Japan, Japanese-owned mills in China, and British- and Chinese-owned mills in China operated for 16, 22, and 24 hours a day, respectively (Pearse 1929). Shorter operating hours imposed higher capital costs on Japanese mills. Thus, in my TFP calculation, I adjust the Japanese and Japanese-owned capital productivity series downwards by factors of 16/24 and 22/24, respectively. In Figure 1, I report annual TFP levels in the Japanese-, Chinese-, and British-owned sectors between 1922 and 1936 as a percentage of Japan's benchmark TFP. During the 1930s, average TFP levels in the Japanese-, Chinese-, and British-owned sectors were 0.94, 0.58, and 0.45, respectively, indicating that the Japanese-owned sector enjoyed a large productivity advantage. In fact, in percentage terms the TFP gap between Japanese and Chinese mills in China was more than nine times as large as that between mills in Japan and Japanese mills in China.¹⁴

[Insert Figure 1 here]

To understand China's international competitiveness, it is useful to estimate costs of production and compare them with those of Japan, a leading textile exporter. I formulate a production cost index for 1930-1936 by adjusting the TFP index for wage differences. For China,

¹³Pearse (1929) estimates total capital costs for a newly constructed plant at 40 taels per spindle, and suggests 12% as the typical interest rate. Assuming, as in Clark (1987), the average spindle to be 25% depreciated, this yields average annual rental costs of 3.6 taels per spindle. Producing one bale of 20 count yarn required 1.56 spindle-years of capital input, which implies annual rental costs of 5.6 taels per bale of yarn. Pearse suggests adding 2.75 taels per bale as depreciation costs; this gives total capital costs of 8.4 taels per bale. Pearse estimates typical unit wage costs to be 9.00 taels per bale. Together, these figures imply a labor cost share of 52% and a capital cost share of 48%.

¹⁴ Alternatively, one could neglect the effect of differences in the length of the workday on capital productivity and calculate relative TFP levels from the series reported in Table 4 directly. On this basis, TFP levels in the Japanese-, Chinese-, and British-owned sectors relative to those in Japan would be 0.80, 0.47, and 0.37, respectively.

I use wage data in Pearse (1929) and estimates of relative wages in Duus (1989) to generate wages for the Japanese-, Chinese-, and British-owned sectors. For Japan, I use a spinning wage series reported in Ramseyer (1993). I convert wage data into US dollars using annual exchange rates available in Officer (2008). The results indicate that Japanese-owned firms in China were exceptionally competitive internationally. Normalizing unit costs in Japan at 1, I estimate production costs for the Japanese-, Chinese-, and British-owned sectors as 0.75, 1.22, and 1.58, respectively.

These cost levels are consistent with the Japanese-owned sector's export performance. While Chinese-owned firms focused on supplying low count yarns to domestic consumers, Japanese-owned firms in China exported increasing quantities of yarn to Japan, India, and Southeast Asia.¹⁵ In fact, starting in 1928 and continuing until at least 1932, China exported twice as much yarn as Japan annually.¹⁶ Given the low costs enjoyed by Japanese-owned mills in China, it made sense to outsource yarn production to low wage Chinese labor and reserve expensive Japanese labor for weaving, where Japan continued to enjoy a comparative advantage.¹⁷

As one would expect, outsourcing promoted the convergence of spinning wages in China and Japan. For Chinese labor, Japanese FDI in textiles was a great boon; employment in

¹⁵ Pearse (1929) and Moser (1930) state that Chinese-owned mills produced almost exclusively for domestic consumption, whereas Japanese-owned mills exported increasing amounts of yarn. Figures are available only in 1936, when Japanese-owned mills accounted for 80% of Chinese exports of yarn and cloth (Chin 1937).

¹⁶ For Japanese export data, I use Seki (1956). To match CCMOA data on exports, only available prior to 1933, I measure output by weight.

¹⁷ Kuwahara (1986) finds that Japanese firms which concentrated in spinning were more likely to invest in China than integrated firms engaged in both spinning and weaving. This claim is consistent with the pattern of the Sino-Japanese textile trade during the 1930s. To provide an example, in 1934 China exported 14 million dollars of yarn (35 percent of Chinese yarn exports) to Japan, and imported 34 million dollars worth of cloth from Japan (6 percent of Japanese cloth exports) (Field 1935).

Japanese-owned firms provided Chinese workers the opportunity to earn wages perhaps 21 percent higher than those paid by Chinese-owned firms and 27 percent higher than those paid by British-owned firms.¹⁸ For Japanese labor, the contrary effect may have held. After Chinese yarn exports began to outpace Japanese yarn exports around 1928, spinning wages in Japan fell sharply; by 1936, real daily wages in Japanese spinning were only 60 percent of what they had been in 1928, and this decline was considerably larger than concurrent wage declines in agriculture and non-textile manufacturing industries.¹⁹

Measuring Productivity in Weaving

Weaving productivity is much easier to measure than spinning productivity because heterogeneity in product quality is less important. The CCMOA data measure cloth output in units of length (bolts) and area (square meters) which are far less sensitive to quality differences than weight-based measures. The principal element differentiating one cloth variety from another is yarn quality. High-quality fine yarn yields a thin, light cloth, which has significantly higher value-added per unit of weight, but not per unit of area or length. A second factor differentiating cloth quality, weave density, does exert a direct influence on value-added per unit of area. However, data in Wang and Wang (1935)'s investigation suggest that cross-mill variation in weave density (as measured in 'picks per inch') was not large enough to have had a

¹⁸ These figures are cited in Duus (1989). Lee (1925) estimates the wage gap between Japanese-owned and Chinese-owned firms at 5 to 15%. Pearse (1929) provides limited data consistent with either estimate.

¹⁹ I use Ramseyer's (1993) real wage series and adjust for the 10-hour work day in 1928 and the 8-hour day in 1936. Of course, other phenomena affect wages, but given 20% of Japanese spinning capacity was located in China, wage competition must have exerted a strong effect.

quantitatively important effect on output. Accordingly, unadjusted measures of cloth length and area provide suitable measures of weaving output in Chinese mills.²⁰

The availability of a single meaningful measure of output allows weaving productivity to be assessed in a simple Cobb-Douglas framework. Three types of information from the CCMOA data provide a basis for this analysis: cloth output in bolts, loom utilization, and total workers. The sample of weaving industry data is significantly smaller than the spinning sample, both because comprehensive weaving data only becomes available after 1928, and because fewer mills engaged in weaving, the exact number varying between 10 in 1928 and 37 in 1936. The number of loom tenders is estimated using the procedure described in the spinning section. In years where cloth output was reported in square yards, the output measure is converted into bolt equivalents.²¹ The adjusted data is used to estimate a constant returns-to-scale Cobb-Douglas production function in first differences.²²

Under the assumption of constant returns to scale, the coefficient estimates reported in Table 6 imply capital and labor factor shares of 0.51 and 0.49, respectively.²³ These factor

²⁰ These conclusions are based on analysis of loom-level production statistics reported in Wang and Wang (1935). In this data, weave density and cloth weight are not significantly correlated with output per weaver or output per loom.

²¹ The conversion factor of forty square yards to one bolt is taken from Wang's (2004) study of the post-WWII Chinese textile industry.

²² Heteroscedasticity robust standard errors are reported in parentheses below coefficient estimates, and coefficients which are significant at the 5 percent level are starred. A flexible returns Cobb-Douglas function was also estimated, and this exercise suggested the possibility of decreasing returns to scale. The use of a decreasing returns framework would generate similar results. As is true for the spinning data, mills which closed during a year were dropped from analysis. In addition, mills which reported 50 percent or higher decreases in output in a single year were inferred to have been closed for a portion of the year, and were dropped from analysis. Japanese-owned mills never closed or suffered output drops, except during the Shanghai Incident of 1932 (Wu 1935). All Japanese mills in Shanghai are dropped in 1932.

²³ A flexible-returns specification, which suggested decreasing returns, was also estimated. The alternative decreasing returns framework would increase relative productivity levels imputed to Japanese- and British-owned plants, which had larger weaving operations on average.

shares were used to calculate plant-level production function residuals, which provide a measure of total factor productivity (TFP). Since Shanghai was China's largest textile center and plants there may potentially have been more productive, I analyze Chinese-owned plants inside and outside of Shanghai separately. Figure 2, which plots the mean TFP estimates for Japanese-, British-, and Chinese-owned plants, indicates that Japanese-owned firms may have been even more dominant in the weaving sector than they were in spinning. Shanghai plants do appear to have enjoyed a productivity advantage, but this advantage eroded over time. By 1936, Japanese-owned plants' TFP in weaving exceeded that of Chinese-owned plants in Shanghai by 80 percent, that of Chinese-owned firms outside of Shanghai by 81 percent, and that of British-owned plants by 221 percent.²⁴ Extremely low productivity among British-owned plants reflects intermittent shutdowns of their weaving operations (Yan 1965). During the 1930s, many Chinese- and British-owned mills closed intermittently, and frequently changed ownership, often passing into Japanese hands.

[Insert Table 5 here]

[Insert Figure 2 here]

²⁴A portion of this gap was due differences in the technologies used in each sector, but it is easy to show that this was relatively unimportant. During the 1930s, Japanese-owned mills began installing automatic looms, while Chinese- and British-owned mills continued to install traditional plain looms (Pearse 1929; Wang 2004); by 1936, about 60% of the looms in Japanese-owned mills were automatic (Izumi 1980). The use of automatic looms increased capital costs by about 33% (Pearse 1929; Bowden and Higgins 1998). Combining these figures suggests that, in 1936, Japanese-owned capital costs (on a per loom basis) were 20% higher than those of Chinese- or British-owned mills. Adjusting TFP estimates for this difference reduces the productivity advantage of Japanese-owned mills to 64% with respect to Chinese-owned mills (both in and outside of Shanghai) and 192% with respect to British-owned mills.

Potential Explanations for the Productivity Gap

Why were Japanese-owned mills so much more productive than their competitors in spinning and weaving? Commonly cited reasons for productivity differences, such as political institutions, differences in laborers' educational attainment and experience, and capital quality, cannot explain the performance gap because the mills operated in the same cities, using similar labor sources and machines. Moreover, the economic history literature in textiles suggests these issues were not important factors. Clark (1987) notes that textile machinery was of similar quality worldwide because all machines were imported from a common set of British and American manufacturers.²⁵ Though labor quality was somewhat more heterogeneous internationally, Leunig's (2003) study of New England textile workers indicates that differences in workers' backgrounds did not affect performance. Circa 1905, neither literacy, British fluency, nor place of birth had significant effects on earnings among Eastern European textile workers. While experience did matter, Leunig finds that workers converged to similar levels of productivity after working for one to two years, and evidence presented in Pearse (1929) and Fong (1932) indicates similar tenure levels in Japanese- and Chinese-owned mills. Finally, governance could not have driven performance differences between British and Japanese firms; most of these firms were located in Shanghai's International Settlement, where they operated under Anglo-American law as enforced by Anglo-American courts (for a discussion of Shanghai's institutions, see Ma 2006).

²⁵ This was also true in China. Kuwahara (1991) finds that over 70% of spindles in Japanese-, British-, and Chinese-owned mills came from the same top five British and American spindle makers.

One area in which Japanese-owned firms did differ significantly was in the way they recruited, organized, and trained labor. British- and Chinese-owned firms used subcontracting systems to manage laborers, whereas Japanese-owned firms established centralized systems. Subcontracting is not inherently ineffective. In Britain, subcontracting was the predominant form of manufacturing organization until well after the end of World War II (Tolliday and Zeitlin 1991). Among textile firms in Britain, foremen were given the authority to hire their own assistants, set their wages, and make production decisions (Jewkes and Gray 1935). The efficiency of the British subcontracting system (the piecer-minder system) was supported by external institutions. Industry-wide collective bargaining set stable piece-rates for foremen, protecting them from the “ratchet effect,” the tendency of managers to cut piece-rates in response to increases in productivity. This encouraged foremen to cooperate with management to raise productivity (Lazonick 1981).

In Japanese manufacturing at the turn of the twentieth century, labor organization based on subcontracting was also the norm, but the system had significant problems. Firms engaged foremen (*oyakata*), who controlled labor gangs, to mediate the supply, training, and management of labor. Foremen often engaged in activities which disadvantaged their employers, for example, by refusing to cooperate with workers employed outside their immediate network and resisting technological change (Levine 1965). Japanese corporations responded by replacing subcontractors with corporate hierarchies which emphasized centralization, promotion-based incentives, and formal training (Jacoby 1979; Moriguchi 2003).

In their activities in China, both Japanese and British employers encountered problems similar to those of the subcontracting system in Japan. In Chinese coal mining, the Kailuan

(British) and Fushun (Japanese) mining firms faced tremendous difficulty in managing tens of thousands of laborers, and relied on decentralized contract systems to meet their labor needs. Agency problems made these contract systems woefully inefficient. Contractors refused to maintain mine works and used bribery and violence to usurp managerial authority.²⁶ Unlike the British at Kailuan, the Japanese were able to transfer experience gained from the reform of contract mining systems in Japan to transform the organization of Fushun. British managers enviously noted that unlike at Kailuan, where the contract system continued to discourage innovation, at Fushun “labor management improved so much that the mines (were) able to enjoy all the benefit generated from either the innovation or improvement on coal faces” (quoted in Xu 1990). Following these reforms, labor productivity at Fushun doubled, greatly surpassing performance levels at all other mines in China.²⁷ The problems of the contract system were common to many areas of Chinese manufacturing. As I describe in the next sections, the textile industry suffered from similar agency problems, which Japanese firms handled with far greater success than the British.

²⁶ A digest of Kailuan company records is collected in Xu (1990). The severity of the problems described in this text is extreme. Murakushi (1991) describe the transfer of organizational techniques at Fushun mine and Wright (1981) describes the contract system in China in general.

²⁷ This is based on output and employment series reported in Murakushi (1981) and Xu (1990). The comparison considers six year averages of labor productivity at the two largest mines in China, Fushun and Kailuan. Labor productivity levels at other mines in China were generally inferior to those obtained at these two mines (Torgashev 1930; statistics in Ikkonikov 1977). Preceding the onset of reforms in 1927, average labor productivity levels at Fushun [1920-1926] and Kailun [1920-1926] were 115 and 153 tons of coal per man-year, respectively. After reforms, labor productivity levels at Fushun [1930-1936], Kailun [1930-1936] were 243 and 149, tons of coal per man-year respectively. Concurrent dramatic increases in labor tenure, work attendance, and marriage rates among miners suggest that the transformation of labor institutions probably played a significant role in Fushun’s improved performance.

Organization in Chinese- and British-owned Mills: The Foreperson System

Problems in Chinese- and British-owned mills were closely connected to the influence which factory forepersons exercised over managerial decision-making under what was known as the foreperson system.²⁸ Under the foreperson system, managers ceded control over hiring and production decisions to forepersons. Forepersons placed workers in jobs in exchange for the provision of goods and services. Since arranging placements was profitable to them, forepersons urged managers to approve as many hires as possible, while managers hoped to reduce labor needs by improving efficiency. In this process of negotiation, managers' bargaining power was weakened by opposition from the Green Gang, a criminal organization which represented the interests of forepersons. This opposition made it risky for managers to oppose forepersons' recommendations, even when they disapproved of them.

Most mill labor brokers, forepersons, and guards belonged to the Gang, and membership helped them to negotiate with mill managers over hiring practices.²⁹ In textiles, the Gang sold labor, property protection, and strike prevention services, but was simultaneously active in vandalism and strike instigation.³⁰ Acting both as an informal union for supervisory workers and as labor brokers for unskilled workers, the Gang protested changes which disadvantaged its constituents. Disputes were often related to control over hiring and dismissals.³¹

²⁸ The foreperson system is described in Honig (1986) and Koll (2003).

²⁹ Estimates of Green Gang membership are vague; Smith (2002) reports various estimates and suggests 20% of the labor force.

³⁰ Honig (1983, 1986) describes the Green Gang's involvement in labor racketeering in textiles. Frazier (1994) describes Gang involvement in vandalism, strike instigation, and mediation as means of coercing mill managers.

³¹ Barker and Barker (1934) in their investigation of mills in Shanghai and surrounding areas noted that "in China the principal trouble [in management-labor relations] is that a mill is practically forced to employ more people

Foreperson control over hiring led mills to retain excess labor. In the foreperson system, bribery or 'squeeze' had a central role in job search. Workers obtained positions by offering forepersons sums equivalent to two weeks' pay, and maintained employment through regular gifts. Since adding new workers increased forepersons' income, they hired more labor than tasks demanded.³² Overstaffing led to considerable idleness within mills; supernumerary workers found time to loiter, sleep, and even absented themselves from the mill entirely.³³

Problems associated with the foreperson system raise the question of why it was ever instituted. Mill managers' willingness to cede authority to forepersons reflected the scarcity of personnel with more appropriate skills and education. Letting forepersons make decisions freed up managerial resources to attend to finance, purchasing, and marketing, areas in which education was indispensable. China's lack of professional training institutions meant that few educated personnel were familiar with textile work.³⁴ Forepersons, though poorly educated and often illiterate, developed an experience-based understanding of machinery which could exceed their superiors'.³⁵ Delegation of authority thus enabled better-informed production decisions, even as it allowed the delegates to make opportunistic choices.

Progress in the textile industry depended upon hiring better trained personnel and reforming institutions. However, foreperson resistance made reform a difficult matter. When mills dismissed forepersons, they used Gang connections to take the workers they supervised

than is necessary and wages are only secondary in importance." This focus on expanding employment reflected the interests of the Gang's principal constituents, labor brokers and forepersons.

³²Hershatter (1986) remarks that a government-commissioned study of failing mills in Tianjin noted that foreperson-mediated employment led to the use of three times as many workers as were actually necessary.

³³ Under the 'let-go-policy', forepersons afforded workers leave in exchange for bribes (Lee 1925).

³⁴ The Chinese Cotton Mill Owners Association Annual Report (1933) discusses the inadequacy of training institutions.

³⁵ Fong (1932) relates the latitude extended to forepersons to the incompetence of their managers.

with them. Since workers invested in their relationships with forepersons through bribery and risked blacklisting if they abandoned the relationship, they often preferred to join forepersons in seeking work elsewhere.³⁶ In the event of a contested dismissal, the exit of shop floor workers could number in the hundreds.³⁷ Given the scarcity of experienced supervisors and the high costs of recruitment, managers usually ceded to forepersons' demands.³⁸

Analysis of the more circumscribed role forepersons played in Japanese-owned mills, where operations were kept under the control of trained technicians, suggests that technician-based regimes threatened forepersons' interests. It is worthwhile to consider what forepersons stood to lose from movement to a Japanese-style technician-led regime. Perhaps the most important threatened loss was employment; according to a 1920 survey of industry conditions, Japanese-owned mills used one-tenth as many supervisory personnel per production worker as Chinese-owned mills.³⁹ Though the figure itself is almost certainly exaggerated, it suggests that the Japanese-style regime demanded relatively few low-echelon supervisory personnel, and thus that sector-wide change would have limited forepersons' job opportunities. A second and closely related threat was downward pressure on wages. Since educated technicians shouldered many key foreperson responsibilities in Japanese-owned mills, their forepersons

³⁶ The Gang used blacklists to prevent workers who did not operate through the proper channels from obtaining mill jobs. Switching between labor brokers, for example, could result in blacklisting (Honig 1983).

³⁷ Lee (1925) gives this figure in an account of organizational conditions at Chinese- and Japanese-owned mills.

³⁸ According to Lee (1925), "... [forepersons] generally do not do much work nor know much and usually do not stay in the mills all the time. Most Chinese managers are afraid of them and would not dare to do or say anything directly against their will even when wrongdoings done by them are discovered." (cited in Cochran 2000)

³⁹ *The Situation of the Jiangsu Textile Industry* (1920)

earned significantly less than those in Chinese-owned mills.⁴⁰ In part, wage differences were related to changes in the sex-specificity of job roles; Japanese-owned mills preferred to use female forepersons, sometimes even promoting them to leadership positions.⁴¹ Finally, managerial control of hiring, firing, and monitoring functions eliminated forepersons' ability to exact 'squeeze' from the workforce.⁴² In this respect, consideration of formal compensation alone underestimates the losses forepersons would have suffered from a Japanese-style regime.

The Organization of Japanese-owned Mills in China

Japanese-owned mills were subject to the same constraints as their competitors. Like other firms in the industry, Gang-controlled contractors supplied much of their labor needs.⁴³ Gang-fomented protests of reforms were even more common in Japanese-owned mills than elsewhere.⁴⁴ Indeed, one of these conflicts, occurring on May 15th, 1925 in a Japanese-owned mill in Shanghai, and ending in the shooting death of a gang-connected foreperson, inspired

⁴⁰Data is only available for 3 Chinese-owned mills and 2 Japanese-owned mills in 1925. At these mills, forepersons in Chinese-owned mills earned about 50% more on average (Frazier 1994). Lee (1925) says that forepersons in Japanese-owned mills earned the same or less as those in Chinese-owned mills.

⁴¹Pearse (1929) observes, "Several Chinese mill owners have praised to me the superiority of the Japanese system of training the Chinese workpeople by having a comparatively large number of female overseers..." Data in Wang and Wang (1935) shows these practices affected compensation patterns at Chinese-owned mills in Shanghai, but not elsewhere. Circa 1933, female forepersons at 9 Chinese-owned mills in Shanghai were paid 15% more than male forepersons on average, and this difference is significant at the 1% level. Outside of Shanghai, female forepersons at 12 Chinese-owned mills earned 25% less than male forepersons on average (significant at the 5% level); a paired t-test is used to test for differences between means.

⁴²Lee (1925) reports that 'squeeze' was limited in Japanese-owned mills, and that this angered forepersons.

⁴³In Communist historiography, reliance on labor brokers is associated strongly with foreign, and especially Japanese, companies. Honig (1983) shows, however, that all types of mills relied heavily on brokered labor.

⁴⁴Frazier (1994) hypothesizes that Japanese-owned mills endured the most strikes because they pushed through significant organizational reforms which angered forepersons. For example, male forepersons, angered by the promotion of female forepersons to positions as 'team leaders', incited a strike at the Rihua mill in 1919, shortly after Japanese purchased the mill (Frazier 1994; see also *The Situation of the Jiangsu Textile Industry* 1920). Control over the hiring of spinning assistants—the Japanese replaced children with adult females—was also disputed. Forepersons probably wanted the child workers reinstated because they received income from keeping them in jobs.

mass protests throughout the city. Despite these conflicts, the organization of Japanese-owned mills remained more firmly under managerial control. This difference reflects variations in managerial practices in Japanese-, British-, and Chinese-owned firms. When Japanese textile interests arrived in China, they imported a managerial system from Japan which placed production and hiring decisions under hierarchal control.

Why did Japanese firms organize hiring more directly than British-owned firms? Partly this reflects problems they encountered in retaining quality workers in Japan. In the early twentieth century, Japanese mills relied on a network of rural recruiters to supply their labor needs. However, recruiters often relied on deception to arrange placements, and as a result many workers quit shortly after their arrival, imposing costs on their employers. Japanese textile firms responded by developing a company-mediated system of recruitment and training, which avoided reliance on external agents. For operations in China, however, a simple knowledge of practices was not enough however, mills also needed to know how to implement them in a Chinese context. Here, the key step was the formation of a body of China experts, who carried out the initial transfer of Japanese organizational techniques. Unlike British-owned mills, which relied heavily on local agents to mediate interactions with the workforce, Japanese-owned mills used their expertise to manage workers directly. Much of this expertise was formed through experience in the Chinese wholesale trade, not in textile manufacture; Japanese trading firms, not textile companies, carried out most of the initial investments in China. The success of Japanese-owned firms thus arose jointly from knowledge of techniques and the knowledge of how to apply them in China.

To convey the importance of the latter type of knowledge, it is useful to discuss the Naigai Cotton Company, which though initially not a textile company, was the first company to export Japanese textile management techniques to China. Like all Japanese companies entering the Chinese textile industry prior to World War I, Naigai began as a general trading company (GTC).⁴⁵ Naigai provides an excellent example of a foreign investment strategy based on contextual knowledge rather than on technical expertise.⁴⁶ Engaged in the textile trade, Naigai perceived an opportunity for entry into the Chinese market which escaped Japanese textile producers.⁴⁷ To acquire knowledge of textile manufacturing, Naigai bought two Japan-based plants in 1903 and 1905 to serve as training bases for the companies' managers, engineers, and technicians. In 1906, Naigai began transferring its specialists in Chinese wholesale trade to management positions in its Japanese plants, thus preparing them for their future work as textile managers in China. Three years later, Naigai began construction on the first of 14 China-based plants, and recruited 30 Chinese forepersons for training in Japan. In 1911, Naigai's first Shanghai plant opened, employing a full cohort of Japan-trained managers, engineers, technicians, and forepersons. Within two years, the results of Naigai's novel managerial strategy were already evident: a Naigai executive noted that, "Whereas in spinning companies under Chinese or German management everything is done according to Chinese methods and

⁴⁵ The first three Japanese entrants into the Chinese textile industry were Naigai, Mitsui, and Nihon Menka (Abe 2005, Odell 1916). Known as 'the big three', these GTCs controlled most of the Japan-China trade (Cochran 2000).

⁴⁶ The ensuing discussion of Naigai is drawn entirely from Cochran (2000) and Kuwahara (1986).

⁴⁷ Japan's leading textile producers were skeptical of this move; the following quote from a Japanese economics journal provides some insight: "The productivity of the Chinese spinning industry is low...[some] think that, if one were to improve the cotton blend, renovate the machinery, train the workers properly, and modernize the management of the plant, then the results could be ameliorated. But the real reason for the poor performance of the Chinese spinning industry lies in the weather, specifically the temperature. Consequently, China is an unsuitable place for cotton spinning." (Quoted in Kuwahara 1986)

confusion reigns within the mill, in this [mill] Chinese go to work under the same systematic rules that Japanese do” (quoted in Cochran 2000).

To subject workers to systematic rules, Japanese firms used central hierarchies to control key managerial functions. This process began in long-distance trade, where a reliance on compradors, bilingual Chinese managers, gave rise to significant principal-agent problems. To eliminate compradors, Japanese trading companies set up language schools to train personnel in direct management and negotiation. The new personnel enabled Japanese companies to distribute textile goods at a fraction of the cost of their British competitors.⁴⁸ As Japanese trading companies entered Chinese manufacturing, they applied these skills to industrial management, carrying over the advantages they enjoyed in trade.

Central to the control of the production process was the provision of formal training. Training included basic classroom education for operatives, technical education for forepersons, and professional education and training, including even financed trips to British and American institutes, for the managerial elite. This system allowed significant merit-based mobility between skill tiers.⁴⁹ For instance, operatives in Japanese-owned mills, though they started at lower wages, earned raises as they passed through training programs, allowing experienced operatives to earn significantly more than was possible in other firms. International mobility was also important; experienced Japanese forepersons were often promoted to leadership

⁴⁸ British distribution costs were estimated to be more than triple those of Japanese textile traders in China (Tien-I Yang 1984, cited in Duus 1989). Also, see Sugiyama (2001) on direct marketing and Japanese-British competition in the Chinese sugar trade.

⁴⁹ Kuwahara (1991) notes that the provision of general training supported upward mobility among Chinese workers.

positions in Chinese mills, where their status as outsiders discouraged 'squeeze.'⁵⁰ Promotion opportunities gave workers stronger incentives to comply with managerial directives.

Formal training was part of a larger system which structured information flows within Japanese-owned firms. At one such firm, the Yuhon Cotton Spinning Company, Japanese 'process chiefs' oversaw each step of the multi-stage spinning process. Their work was facilitated by a 'number one' who interpreted for the process chief and an instructor who taught new workers techniques. Unlike at Chinese-owned mills, where naive workers on the production line disrupted organization, new hires at Yuhon obtained experience with machines specifically devoted to training.⁵¹ Below the process chief, the number one, and the instructor stood the shop floor supervisor and the forepersons, who oversaw the machine operatives. Although initially filled by Japanese, supervisory positions below process chief were increasingly delegated to Chinese, many of whom received training in Japan. Executive positions, from the process chief and upwards, were filled under a temporary assignment system which rotated managers and engineers between China- and Japan-based plants at regular intervals. This system enabled China-based plants to benefit from incremental improvements to production techniques emerging from innovative Japanese mills.

Japanese innovations were closely connected to precise control of work practices. Leading Japanese-owned mills subjected every step of the production process to scientific experiment, using the results to standardize work motions, time rest-breaks, and even regulate

⁵⁰ Japanese women workers could be promoted from operative to foreperson, and then promoted again to a position in a Japanese-owned mill in China (Pearse 1929). Lee's (1925) report that 'squeeze' was absent in these mills suggests that Japanese supervisors succeeded in limiting forepersons' opportunities to collect bribes.

⁵¹ Kuwahara (1991) provides a brief but detailed account of training practices at a number of Japanese-owned mills in China, including Yuhon. Cochran (2000) describes training at Naigai.

the sleep habits of workers.⁵² Cost accounting by product type allowed executives to compare efficiency levels across mills, and select innovations for diffusion through the publication of company circulars and the cross-plant transfer of personnel.⁵³

Interestingly, the practices and productivity advantages of Japanese-owned firms continued when they were transferred to state ownership in 1945, even after Japanese personnel ceased to be employed. At the same time, private Chinese-owned firms were relatively unsuccessful in their attempts to copy the Japanese organizational system. Evidence in the next section indicates that foreperson resistance was the main reason for failure.

Organizational Reform under Opposition

Though the productivity gap between Japanese- and Chinese-owned mills was large on average, some Chinese-owned mills made significant advances in productivity through successful reform of the foreperson system. In other cases, attempts to modify the foreperson system produced undesirable results, including strikes and riots, which compelled would-be-reformers to leave the system in place. Successful and failed reforms had noteworthy differences in approach. Successful reform generally involved developing in-house training for Chinese engineers and technicians, redesigning employment institutions so that skilled technicians could directly control production, and offering workers a stake in enduring change. Many mills, however, adopted a more piecemeal approach, attempting only to intensify monitoring without reorganizing power structures. In these mills, forepersons used strikes and

⁵² Izumi (1980) provides an example of a questionnaire which Japanese mills used to probe the lifestyle choices of their employees, and offer them guidance on making choices which might improve their workplace performance.

⁵³ Kuwahara (2004)'s account of the Kanebo company describes the corporate structures behind these innovations.

violence to derail the reform agenda, compelling managers to repeal changes. This section considers two waves of reforms, contrasting a less successful period of piecemeal change in the mid-1920s, with a more successful phase which followed in the late 1920s and early 1930s.⁵⁴ In both periods, reforms were not evenly distributed throughout the textile sector; the largest two Chinese-owned firms, Shenxin and Yongan, took the lead, while many others, especially British-owned firms, did not participate. Despite these limitations, by the early 1930s reformers controlled a growing share of Chinese-owned capacity and their activities were generating productivity growth within the Chinese-owned sector.

The Shenxin Company, the largest Chinese-owned textile firm, provides an excellent case study with which to understand the reform process and has been the subject of a detailed examination by Sherman Cochran (2000), from which the following analysis draws heavily. Though one company alone does not comprise an industry, Shenxin was in many respects at the vanguard of the Chinese-owned sector, and changes within the firm were closely watched.

The first period of reform relied heavily on labor markets as a source of new talent. In 1924 and 1925, Shenxin assigned shop floor positions to technicians recruited from Japanese-owned firms. Reform began with an experiment: older, poorly performing American spindles were assigned to the new technicians, while forepersons retained control of newer British

⁵⁴ Lee (1925), describing reform attempts in the mid-1920s, records, "During the past few months a couple of Chinese managed mills had (sic) tried to introduce a new system, employ new technical men in charge, and the result was a wholesale walk-out till the management had promised them not to carry out the plan." Lee (1930) argues, however, that management practices in Chinese-owned mills improved during the late 1920s. Summaries of the state of the industry in 1920, when compared to plant-level investigations of benefit programs, training programs, and management practices conducted in 1932 indicate significant changes in practices between 1920 and 1932 (The Situation of the Jiangsu Textile Industry 1920, Jincheng Bank Records 1932-1934).

machines.⁵⁵ By improving production methods, the technicians quickly exceeded the performance levels attained by the forepersons, convincing Shenxin's factory manager of the need for full-scale reorganization. Technicians took control of the shop floor, directly monitoring foreperson and worker activities. Managers also established maintenance and experimental departments to address core governance deficiencies in machine upkeep and optimization. Although these policies did result in an immediate performance improvement, the change was only transient.⁵⁶ Limited in number, technicians depended upon cooperation from subordinates to implement changes, but because they increased workloads and beat workers frequently, their presence was greatly resented. After several months, Shenxin's forepersons organized a workplace riot, expelling technicians from the mill. Subsequent negotiations resulted in their dismissal and the reinstatement of the prior governance system.⁵⁷ Shenxin's initial experience with reform suggests that hiring skilled technical personnel was insufficient to generate a performance improvement.

Shenxin's second period of reforms focused on educating and training technicians internally. As was characteristic of Chinese-owned firms, initial efforts to develop talent were centered on members of the company director's extended family, many of whom were sent to textile schools abroad. Simultaneously, Shenxin developed its own educational capacity through the founding of a company professional school, the Shenxin Managerial Training Institute (est. 1928). Students attending the Institute's year-long courses engaged in classroom

⁵⁵ Zhang (2003) describes the experiment, and states that reforms like these were common in Chinese-owned mills during the mid-20s, but, as at Shenxin, opposition from forepersons and gangs led to their reversal.

⁵⁶ Under the new management, each worker attended 25% more machinery; this improvement appears to have been reversed after the technicians were removed (SASS Economics Research Institute 1962).

⁵⁷ SASS Economics Research Institute (1962). The use of violence has made the Shenxin case the most well-known, but organized foreperson opposition was recorded in other prominent mills as well, see Frazier (1994).

learning under foreign-educated instructors and concurrently practiced their knowledge in the Institute's simulated factory. In developing a central educational institution to support multi-plant operations, Shenxin followed an approach that resembled the international training routines in place in Japanese-owned mills. Centralized training at Shenxin provided a framework for the introduction of managerial innovations across multiple plants, including accounting techniques which allowed inter-plant comparisons of unit costs.⁵⁸

In-house training provided the company with the capacity to reform itself. By 1933, 81 graduates had matriculated from the Institute, providing Shenxin with the nucleus of talent in middle management necessary to mount a successful reform of its Wuxi plant. This time, Shenxin's management co-opted workers through the provision of a range of benefits, including improved housing, dining, recreation, and religious facilities, and greater voice in company governance. The company's Wuxi campus, renamed 'The Community of Self-Governing Workers' because of the use of worker-elected judges to resolve labor disputes, created an autonomous social system which encouraged workers to identify their interests with those of management. Once the new system of management-labor relations had taken hold, forepersons were dismissed from the mill and replaced with technical staff. The new staff rationalized work procedures, laying off supernumerary workers and nearly doubling the machine-tending demands for those who remained. Once in place at Wuxi, reforms spread elsewhere. At the firm's Hankou mill, similar reforms were coupled with the introduction of literacy requirements for new workers, who entered an extensive classroom-based training

⁵⁸ In 1927, a similar accounting system was also introduced at Yongan, the second largest Chinese-owned firm. Here again, foreign-educated members of the directors' extended family, and the recruitment of Shenxin personnel played a key role in the improvements (Shanghai City Textile Industry Bureau 1964).

program upon employment. Achievements were more limited in Shanghai where opposition from the Green Gang made it more difficult to challenge the foreperson system.⁵⁹

Using the dates for reforms of individual Shenxin plants provided in Cochran (2000), it is possible to test whether organizational reform had a significant impact on productivity. For spinning, I use labor productivity as a performance measure because I cannot observe changes in the counts produced at each mill. Since labor productivity is less affected by changes in count than capital productivity, it provides a more reliable measure of mill performance when count is unobserved. I regress labor productivity on year dummies, plant-level fixed effects, and a reform dummy variable which is equal to one in the years following reform and equal to zero in the year of reform and all preceding years. For weaving, I regress the TFP-level of each plant on the same set of variables. Coefficient estimates, reported in Table 7, indicate that reform had a significant impact on company performance, resulting on average in a 19 percent increase in spinning labor productivity, and a 26 percent increase in weaving TFP. Reforms accounted for almost half of the growth in productivity which Shenxin experienced between 1922 and 1936.⁶⁰ Since Shenxin had acquired 20 percent of Chinese-owned capacity in both spinning and weaving by 1936, the success of these reforms had a positive impact on the competitiveness of the Chinese-owned sector.

[Insert Table 7 here]

⁵⁹ The 'reformed' personnel department in one of Shenxin's Shanghai plants was run by a prominent gangster (Frazier 2002). The Shenxin Company may have adopted a cautious reform approach in Shanghai to avoid clashing with the gang (Cochran 2000).

⁶⁰ Changes in the reform variable equal account for 43% of the change in the average weaving TFP of Shenxin plants between 1922 and 1936. Coincidentally, the analogous figure for spinning labor productivity is also 43%. Only three of the nine (six) Shenxin plants engaged in spinning (weaving) were owned by the company in 1922. For calculation purposes these plants are treated as belonging to Shenxin for the entire period.

Records of the Jincheng Bank, a Shenxin creditor, indicate that banks could play an active role in encouraging organizational change. Changes at Shenxin were closely observed by Jincheng and other banks; indeed, Jincheng participated in a consortium which took a direct role in managing some of Shenxin's underperforming Shanghai mills. Jincheng placed observers in many of its debtor mills, relying on their periodic reports to assess creditworthiness. Under the depressed market conditions of the early 1930s, continued access to credit became conditional on the acceptance of operational changes recommended by Jincheng staff.⁶¹

Research conducted by the Jincheng Bank allows testing of the hypothesis that organizational change influenced productivity. In 1932, Jincheng observers conducted an investigation of 32 Chinese- and British-owned mills in Shanghai and Jiangsu. At each mill, investigators recorded the levels of capital productivity, labor productivity, product quality, and unit costs attained in spinning 20 count yarn. Unusually, these performance measures were combined with assessments of potential explanatory factors, including machinery value, managerial quality, welfare institutions, maintenance procedures, and working conditions.⁶² Machinery value in particular is important because it provides an excellent proxy for machinery quality which could potentially influence productivity.

Treatment of this data, some of which is qualitative, merits discussion. Since the qualitative information is closely correlated, I measure organizational institutions using a single variable, termed the 'organizational quality dummy.' For organizational quality, 21 of 32 mills

⁶¹In one case, plants controlled by the Baocheng Company were even repossessed. However, Jincheng does not appear to have been successful in turning these plants around. The argument is not that Jincheng had exceptional managerial knowledge, but rather that close monitoring by creditors encouraged mill managers to undertake potentially risky productivity-enhancing reforms. (Jincheng Bank Records 1932-1934; assessment of Baocheng performance after repossession based on CCMOA data)

⁶² The evaluation forms were collected from the Shanghai Municipal Archives by the author in September 2007.

were coded as well-managed because descriptions indicated that procedures in these mills were 'orderly', 'scientific', or 'among the best'. Mills reported as 'lacking order' or as 'employing the foreperson system, and thus impossible to organize' were coded as poorly-managed. For product quality, here referring to dimensions such as the yarn's appearance and strength rather than count, simple verbal descriptions such as 'top grade' and 'middle grade' were reduced to a 4-tier numerical scale (0, 1, 2, 3). The treatment of machinery quality is also important. The bank only provides an assessment of the aggregate value of each mill's machinery. To generate mill-level estimates of spindle quality, I regressed the assessed value of production equipment on the number of spindles and looms. Based on this regression, I estimate the percentage of capital value attributable to spinning equipment at each mill, and use this to estimate the average value per spindle. As one might expect, spindles owned by newly established mills had a higher estimated value than those of older mills.

Table 8 presents the results of a series of regressions of performance measures on spindle value and an organizational quality dummy. The regressions indicate that organizational quality had a significant impact on the performance of Chinese- and British-owned mills, regardless of the performance measure used. Improvements in organization appear to have had a more dramatic effect on labor productivity (0.29 log points) than capital productivity (0.09 log points). Well-organized mills also spun significantly higher-quality yarn, suggesting that focusing only on quantity and count may miss some performance-relevant features. Although the differences are too small for statistical significance, more expensive capital equipment does appear to have been associated with slightly higher levels of capital

productivity. More expensive machines were also more heavily staffed, however, meaning that the relevance of this finding for total factor productivity is unclear.

[Insert Table 8 here]

The results from analysis of the Jincheng investigation suggest that variations in organizational practice influenced productivity levels within the Chinese- and British-owned sectors. British-owned mills were among the worst managed mills included in the survey; out of four mills whose managerial conditions were described in particularly harsh terms, two were British. Though no Japanese-owned mills were included in Jincheng's investigation, other surveys conducted in 1920, 1929, and 1930, indicate that Japanese-owned mills were the best managed in China. The finding that management, and not machinery differences, were behind within-group productivity differences among Chinese-owned mills, strongly suggests that the same was true of aggregate differences between Chinese- and Japanese-owned mills. Even after nationalization following World War II, formerly Japanese-owned mills continued to be more productive than their competitors. In 1951, a Shenxin company investigation of these factories concluded that advanced training programs and management techniques, and not machinery differences, were the key factors behind their high performance.⁶³

Conclusion

The Chinese experience with the absorption of textile technology reveals several points of interest to students of technology transfer, foreign investment, and development. The organization of textile production in China was heavily influenced by the local institutional

⁶³In support of this conclusion, the survey notes that formerly Japanese-owned mills that used outdated equipment attained higher productivity levels than Chinese-owned mills that used modern equipment. (Shenxin Company Publications: A Visit to Qingdao, Tianjin, and Beijing 1951)

environment. Difficulty in negotiating local institutions caused British-owned textile firms to perform worse than Chinese-owned firms, even though they, like all firms in the industry, were operating with primarily British machines. For firms with the appropriate knowledge of how to organize Chinese labor, good results could be obtained. Japanese-owned firms, equipped with a superior understanding of the local culture, and locally-appropriate organizational techniques, were able to achieve productivity levels which approached those in Japan.

The experience of Japanese- and British-owned firms in China shows that context affects the success of technology transfer. A managerial system may be best practice in one context, but perform poorly in a different institutional and cultural environment. The implication is that many types of knowledge are only useful within a certain scope, which is defined by input characteristics. Transfers of knowledge outside of this scope may fail to improve productivity.

One interesting implication of the theory is that foreign direct investment follows a matching process; investors match differentiated firm-level knowledge stocks to differentiated input sources, and obtain a productivity level which reflects the goodness of fit. Based on this theory, one would expect countries with similar input characteristics, for instance those sharing common cultures, to have unusually strong investment relationships. Between WWI and WWII, this appears to have true of Japan and China. For example, between 1914 and 1923, Japanese-owned firms grew from 19 percent to 62 percent of the total number of foreign firms registered in Shanghai, China's premier industrial center (Reynolds 1975).

Since China's opening to foreign investment in the 1980s, investors from Hong Kong, Taiwan, and Singapore, and other Chinese communities have played a role similar to that of Japanese investors during the 1920s and 1930s. For example, Gao (2005) estimates a gravity

model of Chinese FDI and finds that Chinese ethnicity is associated with a quintupling of investment in mainland China. This quintupling accounts for 60 percent of Chinese FDI. Because of their cultural links to the mainland, investors from ethnically Chinese nations have found opportunities in China uniquely attractive. One interesting path for future work would be the identification of knowledge sources which have provided ethnically Chinese foreign investors with a competitive advantage in contemporary China.

Table 1: Average Counts in the Chinese-, Japanese-, and British-owned Sectors

Year	Chinese-owned	Japanese-owned	British-owned
1920	17.8 ^x	15.9 ^x	18.7 ^x
1924-1925	17.1 ^{''}	17.1 ^{''}	17.1 ^{''}
1927-1928	16.9 ^{''}	21.2 ^{''}	17.1 ^{''}
1929	16.7 ^o	25.3 ^o	17 ^o
1930	16.9 ^{''}	25.6 ^{''}	17.9 ^{''}
1931	16.9 ^{''}	25.9 ^{''}	18.7 ^{''}
1932	17.1 [*]	25.8* [21.6]	19.5 [*]
1933	17.3* 17.8 [']	26.3 [*]	19.5* 19.3 [']
1934	16.8 [*]	26.8 [*]	17.3 [*]
1935	17.3 [*]	27.3 [*]	23.2 [*]
1936	17.3 ^{''}	27.3 ^{''}	23.2 ^{''}
1947		24.6 [^]	

Table 1 reports average counts produced by each mill group. The data indicate that Japanese-owned mills spun significantly higher counts than Chinese- and British-owned mills. Data sources are distinguished as follows:

^o Calculated from distributions of yarn counts reported in Zhao and Chen (1997).

^{*} Calculated from distributions of yarn counts reported in Yan (1965).

[] In 1932, productivity calculations for Japanese-owned mills are based only on mills outside of Shanghai. Estimates in Reynolds (1975) indicated that these mills spun lower counts than those in Shanghai. Thus I use the bracketed average count, taken from Reynolds (1975), in my productivity calculation for this year.

['] Calculated from distributions of yarn counts for 21 Chinese- and 3 British-owned mills in Wang and Wang (1935).

^x Calculated from an unweighted average of marketed yarn counts in The Situation of the Jiangsu Textile Industry (1920).

[^] Calculated from complete production statistics for 8 government- (formerly Japanese-) owned mills in Qingdao.

^{''} Estimates based on linear interpolation.

Table 2: Estimation of the Elasticity of Labor and Capital Requirements with Respect to Count, Chinese- and British-owned Mills

Independent Variable	Dependent Variable		
	Ln Pounds of Yarn Per Worker-Day	Ln Pounds of Yarn Per Worker-Day	Ln Output Per Spindle-Hour
Ln Count	-0.61* (0.25)	-0.18 (0.19)	-1.15** (0.05)
Ln Wage	0.91* (0.33)		
Range of Counts or Average Counts	9.5 to 24.3	9.5 to 24.3	10 to 42
Fixed Effects	N/A	N/A	Yes
Number of Mills	19	19	37
Number of Counts	N/A	N/A	7
Total Observations	19	19	90
R-Squared	0.36	0.02	0.9

Robust Standard Errors in Parenthesis; * 5% significance ** 1% significance

Table 2 presents estimations of the elasticity of labor and spindle productivity with respect to count based on cross-sectional production statistics from 21 British-owned mills and 3 Chinese-owned mills operating in 1932-1933 as given in Wang and Wang (1935).

Table 3: Estimation of the Elasticity of Labor and Capital Requirements with Respect to Count, Government-owned Mills (formerly Japanese) 1946-1948

Independent Variable	Dependent Variable		
	Ln (Inverse Unit Wage Cost)	Ln Pounds of Yarn Per Worker-Month	Ln Output Per Spindle-Hour
Ln Count	-0.65** (0.06)	-0.77** (0.13)	-1.15** (0.06)
Range of Counts or Average Counts	8 to 60	16.5 to 32.9	8 to 80
Fixed Effects	N/A (data averaged across 8 mills)	Yes	Yes
Time Dummies	Yes	Yes	Yes
Treatment of Std. Errors	Robust OLS	Clustered at Mill-Level	Clustered at Mill-Level
Number of Mills	8	8	8
Number of Counts	8	N/A	13
Data Type	Monthly Time-Series	Monthly Panel	Annual Panel
Dates	July 1947-Dec 1947	Aug 1946 – Dec 1948	1946-1948
Total Observations	28	232	141
R-Squared	0.92	0.27	0.96

Standard Errors in Parenthesis;* 5% significance ** 1% significance

Table 3 presents estimations of the elasticity of labor and spindle productivity with respect to count based on a monthly panel of production statistics from 8 government-owned mills operating between 1946 and 1948 as given in the Qingdao Mill Yearbooks (1948).

Table 4: Estimation of Elasticity of Labor Requirements with respect to Count, British Data

Independent Variable	Dependent Variable		
	Ln Output Per Worker-Hour (Preparatory 41% of Labor Requirements)	Ln Output Per Worker-Hour (Final Stages 59% of Labor Requirements)	Ln Output Per Worker-Hour
Ln count	-0.53** (0.14)	-0.73** (0.18)	-1.08** (0.10)
Range of Counts or Average Counts*	16-40*	16-40*	8-43
Location and Time	England 1947	England 1947	England 1912
Fixed Effects	N/A	N/A	N/A
Time Dummies	N/A	N/A	N/A
Number of Mills	43	19	1
Number of Counts	N/A	N/A	17
Data Type	Cross-Section	Cross-Section	Cross-Section
Dates	1947	1947	1912
Total Observations	43	19	20
R-Squared	0.3	0.54	0.87
Source of Data	Tippet and Vincent (1953)	Tippet and Vincent (1953)	Leonig (2003)

Robust Standard Errors in Parenthesis;* 5% significance ** 1% significance

Table 4 presents estimations of the elasticity of labor productivity with respect to count based data from British firms operating in 1912 and in 1947. Data from Britain in 1912 imply a larger elasticity of labor requirements with respect to count, -1.08, than Chinese data sources, -0.65. Data from Britain in 1947 are separate the spinning process into two processes, pre- and post-spinning. A weighted average of the estimated coefficients in pre- and post-spinning, yield an overall elasticity of -0.65, which is identical to that estimated using Chinese data.

Table 5: Capital and Labor Productivity in Chinese-, Japanese-, and British-owned Mills, and in Japan

Location	Pounds Per Worker Hour					Pounds Per Spindle Hour			
	In China			In Japan		In China			In Japan
Ownership→ Year↓	Ratio of <i>Chinese</i> <i>Japanese</i>	Chinese	British	Japanese	Japanese	Chinese	British	Japanese	Japanese
1924-1925	0.79 (0.78)	1.03	0.89	1.31	1.88'	0.029	0.023	0.035	0.042'
1927-1928	0.67	1.11	0.86	1.67	2.56'	0.033	0.025	0.037	0.042'
1929	0.57 <0.55- 0.7>	1.04	0.86	1.82	2.56'	0.032 (0.038) <0.025- 0.033>	0.026	0.044 (0.046) <0.037- 0.046>	0.042' (0.045) <0.045>
1930	0.51	1.05	1.05	2.07	3.54'	0.031	0.027	0.046	0.048'
1931	0.44	1.07	1.08	2.46	3.54'	0.029	0.028	0.045	0.048'
1932	0.52	1.24	1.09	2.36	3.54'	0.030 (0.034)	0.027	0.043	0.048'
1933	0.54	1.34	0.97	2.47	3.54'	0.031	0.024	0.041	0.048'
1934	0.58	1.45	0.67	2.50	3.54'	0.029 (0.032)	0.017	0.043	0.048'
1935	0.52	1.47	1.06	2.80	3.99'	0.029	0.020	0.045	0.045'
1936	0.48 (0.46)	1.33	0.91	2.77	3.99'	0.032	0.023	0.048	0.045'
1947				[2.73]				[0.045]	

Table 5 shows that my estimates of labor and capital productivity based on CCMOA data are consistent with anecdotal reports based on investigations of small groups of mills; all figures refer to either 20 counts or 20 count equivalents. My estimates based on CCMOA data are bolded, and the other figures are distinguished as follows:

[] My estimate of labor and spindle productivity for government-owned Qingdao mills based on the conversion of Qingdao yearbook data into 20 count equivalents.

' Wolcott and Clark (1999), statistics are for 20 count equivalents

() Zhao and Chen (1997), Ratios of labor productivity in the Chinese- and Japanese-owned sectors: based on reports of relative unit costs (1924) and unit wage costs (1936) for 20 count yarn. I convert these to labor productivity ratios by adjusting for a 10% wage premium in the Japanese-owned sector in 1924-1925, and a 21% wage premium in 1936. The premiums are from Lee (1925) and Duus (1989), respectively.

<> Duus (1989), citing Takamura (1982): statistics are for 20 count yarn.

Figure 1: Productivity Levels in Spinning

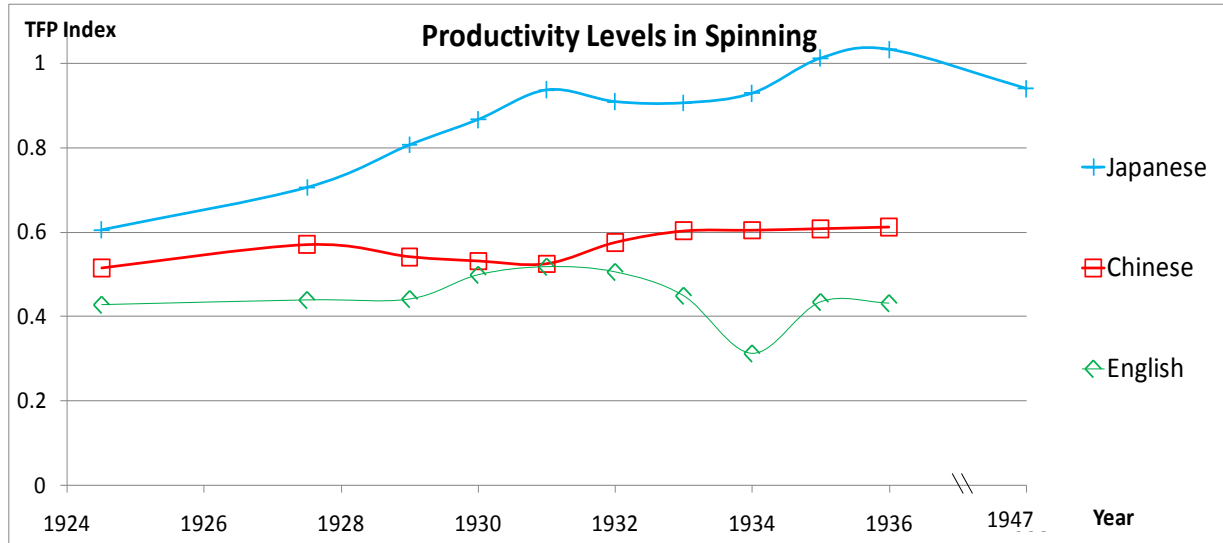


Figure 1 displays TFP indexes for the Japanese-, Chinese-, and British-owned sectors. TFP levels are reported as a percentage of the estimated average TFP in spinning in Japan in 1930-1934. The indexes are quality adjusted, based on differences in factor requirements as a function of count. With the exception of 1932 and 1947, the aggregated indexes include all mills for which output data is available in CCMOA statistics. In 1932, the Shanghai Incident forced Japanese-owned mills in Shanghai to close temporarily, and thus the 1932 Japanese series includes only mills in Qingdao and Wuhan. The 1947 “Japanese” datapoint refers to 8 state-owned mills in Qingdao, which had previously been Japanese-owned. This datapoint is based on monthly production statistics for 1947 in the Qingdao Mill Yearbooks (1948).

Table 6: Estimation of Cobb-Douglas Production Function for Weaving

Dependent Variable	Independent Variables			
Change in \ln Cloth per Loom	Constant	Change in \ln Workers Per Loom		
	0.091*(0.039)	0.49*(0.22)	n=270	R ² =0.03

Robust standard errors are reported in parentheses. * 5% significance ** 1% significance

Table 6 reports the estimation of a Cobb-Douglas constant returns-to-scale production function for weaving in terms of first differences. Statistics on cloth production are taken from the CCMOA data as described in the text.

Figure 2: Productivity Levels in Weaving

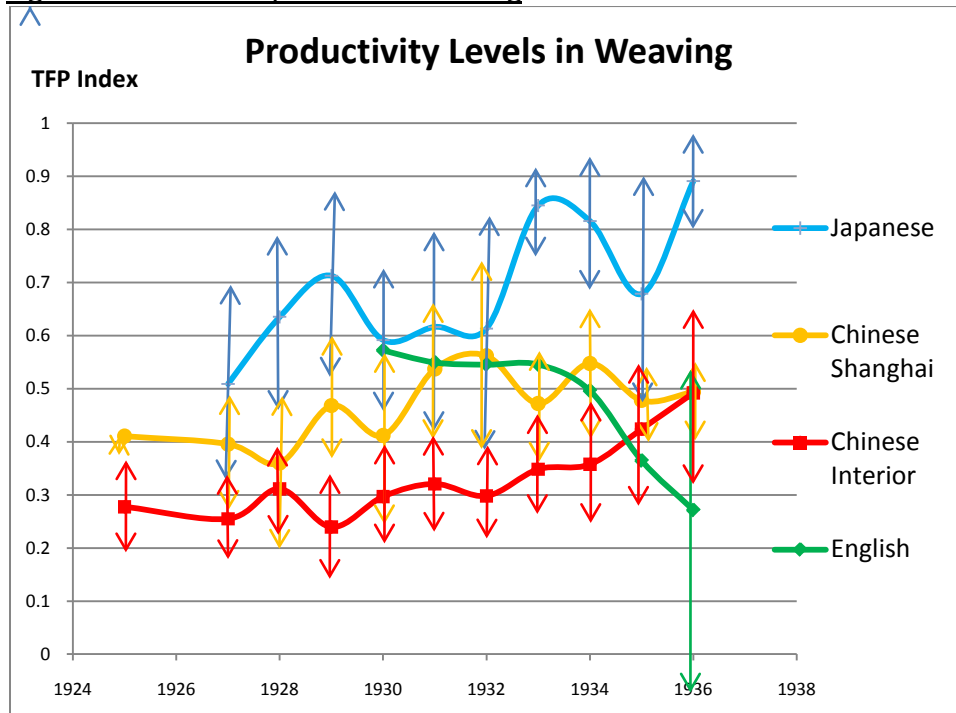


Figure 2 displays the mean residuals of a CRS Cobb-Douglas production function described in Table 5. The arrows indicate heteroscedasticity-robust 95% confidence intervals for the mean TFP level of the four groups of mills listed in the legend. Since British data is only available at an aggregate level for most years, a confidence interval is only available for 1936. In 1932, the Shanghai Incident forced Japanese-owned mills in Shanghai to close temporarily, and thus the Japanese data for 1932 excludes these mills.

Table 7: Analysis of the Productivity Effects of Organizational Reforms at the Shenxin Company

Independent Variables	Dependent Variable					
	Log Spinning Labor Productivity			Weaving TFP Index (1930s Average TFP Level=1)		
Reform Dummy	0.19** (0.07)	0.39** (0.05)	0.25** (0.05)	0.26* (0.12)	0.43** (0.11)	0.32** (0.09)
Year Dummies	Yes (x 13)	No	Yes (x 13)	Yes (x 11)	No	Yes (x 11)
Mill Fixed Effects	Yes (x 76)	Yes (x 76)	No	Yes (x 32)	Yes (x 32)	No
Number of Observations	689	689	689	219	219	219
R ²	0.14	0.04	0.14	0.65	0.32	0.11

Robust standard errors are reported in parentheses. * 5% significance ** 1% significance

Table 7 presents a series of OLS regressions demonstrating that organizational reforms at Shenxin were associated with significant productivity improvements. Production statistics are taken from the CCMOA data and organizational reforms are dated according to Cochran (2000). I use labor productivity to measure performance in spinning because a plant-level TFP measure is unavailable. Since labor productivity is less sensitive to changes in count, it is a better measure of performance than capital productivity when count is unobserved. In weaving, plant-level TFP measures are available, and I use them accordingly.

Table 8: The Impact of Organizational Quality on the Productivity of Chinese- and British-owned Mills

Independent Variable	Dependent Variable				
	Log Output Per Worker	Log Output Per Spindle	Log Unit Cost	Product Quality	
Organizational Quality Dummy	0.09 (0.03)**	0.27 (0.09)**	0.07 (0.03)**	-0.08 (0.03)*	0.8 (0.35)*
Log Capital Value Per Spindle	0.07 (0.04)	-0.07 (0.10)	0.04 (0.03)	0.06 (0.05)	0.2 (0.70)
Log Spindles Per Worker	0.97 (0.06)**				
R squared	0.91	0.29	0.27	0.18	0.18
Number of Observations	32	32	32	26	31

Robust standard errors are reported in parentheses. * 5% significance ** 1% significance

Table 8 presents a series of OLS regressions demonstrating that well-organized mills performed better. The data is taken from the Jincheng Bank Records (1932-1934).

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