CIRJE-F-731

Ownership Changes and Economic Efficiency: Plant-Level Evidence from the Japanese Cotton Spinning Industry, 1900-1911

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March 2010

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Abstract

This paper investigates how ownership changes affect the plant performance, focusing on the cotton spinning industry in early twentieth century Japan, where many plants experienced ownership changes. Through analyses of detailed plant-level data, it is revealed that, after ownership changes, plants tended to focus on low grade and low price products and, at the same time, total factor productivity, machine productivity and profitability of the plants significantly increased. These results indicate that the plants were managed and utilized more efficiently under the new ownership.

JEL Classifications: D12, D24, G34, L22, N65

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1. Introduction

Reallocating assets to owners who can manage and utilize them more appropriately may be an important way to enhance the efficiency of an economy (Jovanovic and Rousseau 2008). Indeed, Lichtenberg and Siegel (1990, 1992) and McGuikin and Nguyen (1995), using the large plant-level panel data for the USA in the 1970s and 1980s, found that changes in ownership of plants improved their total factor productivity (TFP). More recently, Harris et al. (2005), using large plant-level panel data for the UK in the 1980s and 1990s, showed that TFP of plants increased after they were bought out. On the other hand, Rajan et al. (2000), using plant-level panel data on the US tire industry from the 1960s to the 1990s, found that plants did not experience an increase in TFP after ownership changes. In this sense, the empirical literature has not yet reached a consensus about the productivity effect of ownership change.

This paper intends to contribute to this strand of literature by focusing on the cotton spinning industry in early twentieth century Japan. In this context, the Japanese cotton spinning industry during this period has distinctive attractive features. First, many plants underwent ownership changes. Indeed, as is shown later, of the 79 firms operating in 1899, only 21 firms survived until 1912. Second, the Japanese government collected detailed plant-level data not only on inputs and outputs but also on product quality and price. In addition, it is remarkable that the inputs and outputs of the cotton spinning industry in this period were fairly simple. Thus, we can accurately measure the productivity of each plant.

At the same time, this paper is related to another strand of literature, namely the literature on the evolution of market structure in new industries. Gort and Klepper (1982), Klepper and Graddy (1990) and Klepper and Simons (2005) established the stylized pattern of market structure evolution. That is, the number of firms in new industries follows a distinctive path such that it grows at first, then it declines sharply and finally it levels off. As we will see later, in the cotton spinning industry, a new industry in late nineteenth and early twentieth century Japan, this stylized pattern of firm dynamics is observed. The period that is the focus of this paper almost coincides with the second phase of market structure evolution, namely a phase of firm shakeout. Although this strand of literature does not pay attention to the destinations of the assets of exiting firms, at least in the Japanese cotton spinning industry, most of the assets were acquired by other firms. By looking at the implications of this asset reallocation, we can have a more realistic understanding of the evolution of new industries.

Finally, there is a strand of literature on the history of the Japanese cotton spinning industry. As it was one of the major industries that led Japan's industrialization, we have a number of studies in the field of economic history and business history, including Abe (1990), Miyamoto (1987), Saxonhouse (1974) and Takamura (1971). Although this paper benefits greatly from that research, to my knowledge, this is the first attempt to investigate the effects of plant ownership changes quantitatively from the standpoint discussed above. In this respect, this paper may add a new insight to the historical studies on the Japanese cotton spinning industry.

The remainder of this paper is organized as follows. Section 2 gives an overview of the development of the cotton spinning industry in Japan and the evolution of market structure. Section 3 describes the data. In Section 4, I examine the effects of plant ownership changes using the plant-level panel data. Section 5 concludes the paper.

2. Development of the Cotton Spinning Industry and Evolution of Market Structure

Although the cotton spinning industry was one of the major traditional industries in premodern Japan, it declined because of competition with Western rivals after Japan opened to the rest of the world in 1859. Later, new development based on adopted Western technology began in the early 1880s. After some failed attempts, Osaka Boseki

Co., founded in 1882, finally succeeded in having a profitable operation in a modern plant. Osaka Boseki Co. hired an engineer who had studied in Britain, and equipped itself with advanced spinning machines imported from there. The necessary funds were raised from the equity market. Furthermore, it introduced an operational innovation, namely, 24 hours a day operation of the plant. The resulting capital saving was important, given the relative scarcity of capital in Japan in this period.

The success of Osaka Boseki Co. stimulated new entries of cotton spinning firms, and the production of cotton yarn increased very rapidly in the 1880s and 1890s. In fact, production surpassed imports of cotton yarn in 1891, and by 1897 exports of cotton yarn surpassed imports (Figure 1). In 1899, there were as many as 79 cotton spinning firms, according to the data from *Monthly Bulletin of the Japan Cotton Spinners' Association*. However, after that, the cotton spinning industry entered a new phase. That is, production growth slowed down and the number of firms declined (Figures 1, 2).

Figures 1, 2

We can regard these growing and declining phases of the number of firms as following the general pattern of evolution of market structure (Gort and Klepper 1982; Klepper and Graddy 1990; Klepper and Simons 2005). In addition, there were some conditions specific to the Japanese cotton spinning industry in this period. The basic condition was that Japan's currency regime transited from the silver standard to the gold standard in 1897. Before the transition, the Japanese economy enjoyed export-led growth, because silver tended to depreciate relative to gold in the late nineteenth century. Stagnation of the macroeconomy after 1897 slowed down the growth of the cotton weaving industry in Japan, and thereby the growth of the domestic market for the cotton spinning industry. Furthermore, the transition to the gold standard made it difficult to export cotton yarn to China, the major overseas market for Japanese cotton yarn, because China continued to use the silver standard (Abe 1990; Miyamoto 1987).

The shakeout of cotton spinning firms from 1900 was harsh. Indeed, the number of firms declined from 79 in 1899, the peak year, to 35 in 1912, the bottom year (Figure 2). As there were some new entries from 1899 to 1912, the number of firm exits was as large as 58, 73.4% of the firms in 1899. Even if we measure the proportion of the exited firms in terms of spindles, production and workers, it was still over 50% (Table 1).

Table 1

Of the 58 firms that exited between 1899 and 1912, 46 firms were merged or acquired. To put it differently, 58.2% of the firms in 1899 were merged or acquired by 1912 (Table 1). The proportion of the merged or acquired firms was around 50% in terms of spindles, production and employees. These data indicate that a substantial part of the resource in the cotton spinning industry changed ownership in the process of the firm shakeout from 1900 to 1912. This paper explores the implications of these ownership changes.

3. Data

The data used in the previous section were compiled by Japan Cotton Spinners' Association. Japan Cotton Spinners' Association was the industrial association of the cotton spinning industry and it organized most of the cotton spinning firms in Japan. The Association was established in 1882, and shortly thereafter it began to collect monthly basic data on their operations from each member firm. The data include number of operating spindles, operating days, operating hours, production of cotton yarn, count of yarn, number of male and female workers, wage rates of male and female workers, raw cotton consumption and coal consumption (Kinugawa 1938, pp. 193–201). These data were published in *Monthly Bulletin of the Japan Cotton Spinners' Association* from 1889[1]. Hence, basic monthly input and output data are available at the firm level from the end of 1880s from this source. Because of this remarkable feature, the Japan Cotton Spinners' Association's data are frequently used in the literature on the history of the Japanese cotton spinning industry.

However, it is also remarkable that there is another data source, the *Statistical Yearbook of the Ministry of Agriculture and Commerce* (*Noshomu Tokei Nenpo*). Although the data in this source were collected from the Japan Cotton Spinners' Association until 1898, the Ministry of Agriculture and Commerce started to collect data on the cotton spinning industry from the respective local governments in 1899.

The data from the local governments have some distinctive features compared with the Japan Cotton Spinners' Association's data. First, plant-level data are available. Using these data, we can track the operation of each plant over a change of its ownership, which enables us to examine the effects of an ownership change on plant performance. Second, the data contain the average price of major yarn products of each plant. Products of the cotton spinning industry are relatively simple, but there is still quality heterogeneity. The previous literature usually adjusted for quality difference by the technological method based on count[2] information (Moriya 1973; Takamura 1971, p. 137). Meanwhile, Fujino et al. (1974) used the relationship between count and the official controlled price during the Second World War (p. 49). Compared with those methods, we can adjust for product quality more directly and accurately by using the plant-level price data from *Statistical Yearbook of the Ministry of Agriculture and Commerce*. Because of these two advantages, we use the data from *Statistical Yearbook of the Ministry of Agriculture and Commerce* in the remainder of this paper.

Although *Statistical Yearbook of the Ministry of Agriculture and Commerce* started to publish data from the local government in 1899 as stated above, the data for 1899 do not seem to be continuous to the data for 1900 and after. Meanwhile, the *Statistical Yearbook* gives plant-level data until 1911. Hence, we use the data for the period from 1900 to 1911 (12 years). In these data, we can identify 116 plants. Of them, first we exclude the plants on which the data for the full 12 years are not available. Then, we exclude the plants whose ownership changed more than once in this period. Finally, we exclude the plants whose ownership changed in either of the two-year periods at the beginning or end of the study period (*i.e.*, 1900–1901 or 1910–1911) to capture clearly the effects of ownership change. Consequently, 52 plants were left as the sample, of which 25 plants experienced ownership changes. Table 2 lists these 25 plants. It is notable that the acquiring firms were relatively few, and that there were some firms that acquired multiple plants in this period. For example, six plants in the samples were acquired by Mie Boseki Co., while five plants were acquired by Kanegafuchi Boseki Co.

Table 2

Table 3 summarizes the basic characteristics of the sample plants in the initial year, *i.e.*, 1900. Value of production is the value of products that include waste yarn and waste cotton as well as cotton yarn. The value of cotton yarn is given by the average

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[1] The original titles in Japanese changed a few times. The titles were *Rengo Boseki Geppo* (1889–1891), *Boshoku Geppo* (1891–1892) and *Dainihon Boseki Rengokai Geppo* (1892–1942).

[2] "Count" is a measure of the heaviness of cotton yarn. The smaller the count, the heavier the yarn, and the larger the count, the lower the price per weight. In this sense, we can say that yarn of smaller count is yarn of lower grade.

price of cotton yarn. Production of waste yarn and waste cotton is available in the *Statistical Yearbook of the Ministry of Agriculture and Commerce*, and the prices of them are taken from Fujino et al. (1979). Value added is given by subtracting the value of materials (raw cotton and coal) from the value of production. The prices of raw cotton and coal are taken from Fujino et al. (1979). The number of workers is the sum of the numbers of female and male workers, where the latter is adjusted by the ratio of the male wage rate to the female wage rate[3]. Total hours worked are the number of workers times operation days times operation hours divided by two. The reason why we divide it by two is that most of the plants in this period adopted two shift operations; however, we did not apply this adjustment to the plants whose operating hours were less than 14 hours per day. Profit is given by value added minus wages.

Comparing the plants that experienced ownership changes with those that did not, we find that the former plants were generally smaller than the latter. That is, in terms of output as well as input, the scale of the plants that experienced ownership changes was significantly smaller than those that did not. In addition, machine productivity of the former plants was significantly lower than that of the latter. However, in other respects, the differences were not substantial. Quality of products (price and count), labor productivity and profitability were not significantly different between the two groups of plants (Table 3).

Table 3

4. Impact of Ownership Changes on Plant Performance

We now examine the effects of ownership changes on plant performance. For that purpose we use panel data of the above 52 plants from 1900 to 1911 (624 plant-years). The variables and basic statistics are shown in Table 4[4]. The values are evaluated at 1900 constant price[5]. To identify the effects of ownership changes, we estimate the following equation,

$$X_{it} = \alpha + \beta_1 EVENT_i + \beta_2 AFTER_{it} + \Sigma \gamma_t YEAR_t + \varepsilon_{it}, \qquad (1)$$

where X_{it} represents a certain performance measure of plant i in year t. $EVENT_i$ is a dummy variable that equals 1 if plant i experienced an ownership change from 1902 to 1909, and 0 otherwise. $AFTER_{it}$ is a dummy variable that equals 1 if plant i had experienced an ownership change before year t, and 0 otherwise. $YEAR_t$ represents year dummies and ε_{it} is the error term. The sign of the coefficient of AFTER is of special interest in the context of this paper.

Table 4

Panel A of Table 5 reports the estimation results of equation (1) by pooled OLS. The coefficients of AFTER are positive and statistically significant in the cases where we use machine productivity (MP) and profit per spindle (PROFIT), whereas they are

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[3] With respect to Table 1, we did not conduct this adjustment for simplicity.

[4] As there are 10 observations whose value added were negative, we lost them with respect to the log of value added.

[5] The deflators are as follows. The price of cotton yarn, waste yarn and waste cotton (Fujino et al. 1979) for value of production, the value added deflator for the cotton spinning sector (Fujino et al. 1979) for value added and the general expenditure deflator (Ohkawa et al. 1967) for profit.

negative and statistically significant for average count of products (COUNT) and average price of products (PRICE). For the other performance measures, the coefficients of AFTER are not statistically significant. The negative coefficients on COUNT and PRICE indicate that, after the ownership change, those plants concentrated on relatively low grade and low price products[6]. Related to this, it is notable that, concerning COUNT and PRICE, the coefficients of EVENT are positive and statistically significant, which indicates that those plants had produced relatively high grade and high price products before the ownership changes. These results imply that those plants shifted product strategy and that, through this shift, they raised their machine productivity and profitability.

Table 5

I check the results by adding plant fixed effects to equation (1). Namely,

$$X_{it} = \beta_1 AFTER_{it} + \Sigma \gamma_t YEAR_t + \Sigma \delta_i PLANT_i + \varepsilon_{it}, \quad (2)$$

where $PLANT_i$ represent plant dummies. The estimation results are reported in Panel B of Table 5. The coefficients of AFTER for MP and PROFIT are still positive and statistically significant, and statistical significance is stronger than in Panel A. In addition, the coefficients of AFTER are positive and statistically significant for LNVA and LNHOUR as well. Although the coefficient of AFTER for PRICE becomes insignificant, it is still negative and statistically significant for COUNT. Integrating the results in Panel B with those in Panel A, we can conclude that, after the ownership change, those plants shifted their strategy to mass production of low grade and low price products and thereby raised machine productivity and profitability.

Finally, I will examine the effect of ownership changes on the TFP of a plant. For this purpose, the following Cobb–Douglas type production functions are estimated,

$$LNVA_{it} = \alpha + \beta_1 LNMACHINE_{it} + \beta_2 LNHOUR_{it} + \beta_3 EVENT_i + \beta_4 AFTER_{it} + \Sigma \gamma_t YEAR_t + \varepsilon_{it} \quad (3)$$

$$LNVA_{it} = \beta_1 LNMACHINE_{it} + \beta_2 LNHOUR_{it} + \beta_3 AFTER_{it} + \Sigma \gamma_t YEAR_t + \Sigma \delta_i PLANT_i + \varepsilon_{it}. \quad (4)$$

Equation (3) is for pooled OLS estimation, while equation (4) is a fixed effect model. The term of AFTER is intended to capture the effect of ownership change on plant TFP. The estimation results are reported in Table 6. The coefficient of AFTER is positive and statistically significant in both equations (3) and (4). In addition, the coefficients of LNMACHINE and LNHOUR have the expected signs. Comparing the coefficient of AFTER with the mean of LNVA in Table 4, we find that ownership change raised TFP of a plant by 1.2%–1.3%.

Table 6

5. Concluding Remarks

Focusing on the cotton spinning industry in early twentieth century Japan, this paper investigated how ownership changes affected plant performance. In the 1900s, the Japanese cotton spinning industry was just in the shakeout phase, and many plants

[6] See note 2.

experienced ownership changes. The plant-data collected by the Ministry of Agriculture and Commerce allow us to track the performance of plants before and after ownership changes and to compare their performance with those of the plants that did not experience ownership changes.

It was revealed that plant ownership changes were associated with product strategy. That is, after ownership changes, the plants tended to focus on low grade and low price products. Moreover, at the same time, TFP, machine productivity and profitability of the plants increased significantly after ownership changes. These results indicate that, under new ownership, plants came to be managed and utilized more efficiently. Given that the cotton spinning industry was in the shakeout phase, the results shed some light on the evolution of new industries. In the initial growing phase, plants are not always founded by appropriate owners. That may be one of the reasons why sharp shakeouts follow and, from these shakeouts, plants come under new owners who can manage and utilize them more efficiently.

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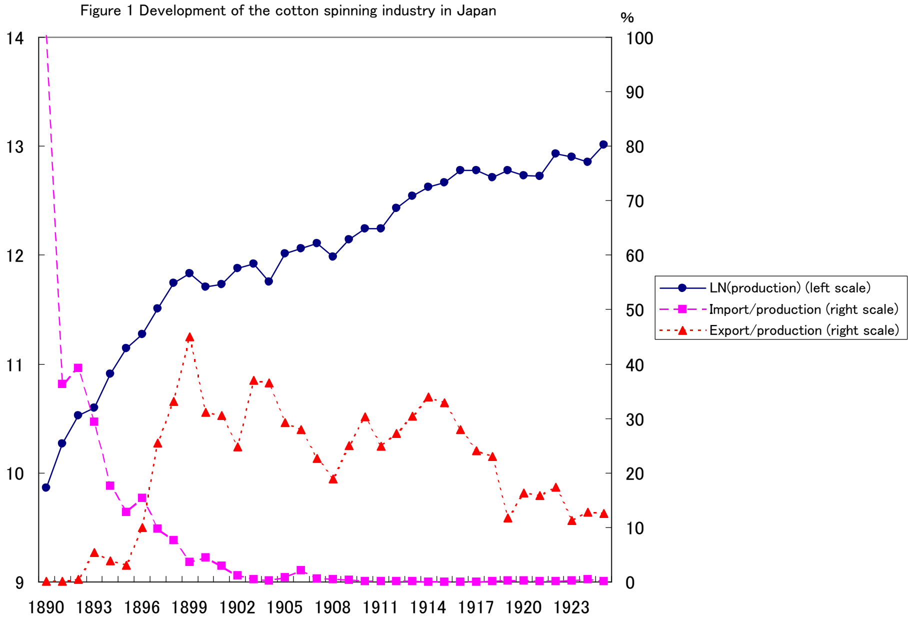
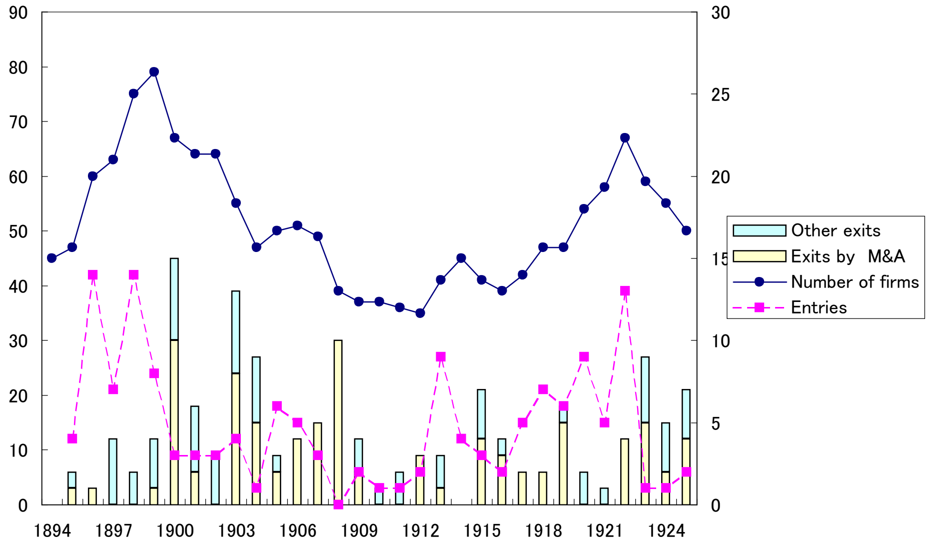
Figure 1 Development of the cotton spinning industry in Japan



Source: Tokyo Keizai Shinposha

Figure 2 Firm dynamics in the cotton spinning industry



Source: *Monthly Bulletin of Japan Cotton Spinners' Association*, various issues.

Table 1 Firm survival and exits from 1899 to 1912

	Number of firms		Number of spindles (1,000 units)		Cotton yarn producton (ton)		Employees	
Total	79	(100.0)	12,672	(100.0)	141,557	(100.0)	809,396	(100.0)
Survived from 1899 to 1912	21	(26.6)	5,734	(45.3)	67,639	(47.8)	383,872	(47.4)
Exited between 1899 and 1912	58	(73.4)	6,937	(54.7)	73,918	(52.2)	425,524	(52.6)
Merged or acqured	46	(58.2)	6,477	(51.1)	69,017	(48.8)	392,640	(48.5)
Other exits	12	(15.2)	460	(3.6)	4,901	(3.5)	32,884	(4.1)

Note: Percentage in parentheses.
Source: *Monthly Bulletin of Japan Cotton Spinners' Association*, various issues.

Table 2 The plants that experienced ownership change between 1902 and 1909

Plant no.	Owner in 1900	Owner in 1911	Year of ownership turnover	Production in 1900	Number of workers in 1900
1	Chugoku Boseki	Osaka Godo Boseki	1902	591,818	560
2	Daiwa Boseki	Settsu Boseki	1902	593,890	399
3	Hakata Kenmen Boseki	Kanegafuchi Boseki	1902	582,939	249
4	Hirano Boseki	Settsu Boseki	1902	2,196,600	1,561
5	Hirano Boseki	Settsu Boseki	1902	720,033	847
6	Kyushu Boseki	Kanegafuchi Boseki	1902	1,562,215	1,032
7	Kyushu Boseki	Kanegafuchi Boseki	1902	719,079	571
8	Kyushu Boseki	Kanegafuchi Boseki	1902	534,178	443
9	Nakatsu Boseki	Kanegafuchi Boseki	1902	775,153	413
10	Fukuyama Boseki	Fukushima Boseki	1903	838,059	550
11	Konakigawa Menpu	Fuji Gasu Boseki	1903	235,439	238
12	Meiji Boseki	Osaka Godo Boseki	1903	865,775	1,114
13	Nihon Hosoito Boseki	Ozu Hosoito Boseki	1903	655,443	1,122
14	Osaka Nenshi	Naigai Wata	1903	278,503	240
15	Senshu Boseki	Kishiwada Boseki	1903	1,034,736	547
16	Nagoya Boseki	Mie Boseki	1905	859,662	775
17	Owari Boseki	Mie Boseki	1905	1,491,767	1,125
18	Tokyo Gasu Boseki	Fuji Gasu Boseki	1906	1,018,132	1,187
19	Yasuda Shoji	Mie Boseki	1906	717,831	295
20	Chita Boseki	Mie Boseki	1907	619,970	436
21	Ichinomiya Boseki	Nihon Boseki	1907	259,834	550
22	Koriyama Boseki	Settsu Boseki	1907	1,248,513	860
23	Kuwana Boseki	Mie Boseki	1907	792,145	437
24	Tsuhima Boseki	Mie Boseki	1907	759,177	510
25	Kasaoka Boseki	Fukushima Boseki	1908	809,050	564

Source: Ministry of Agriculture and Commerce, *Statistical Yearbook of Agriculture and Commerce*, various issues.

Table 3 Characteristics of the sample plants in the initial year (1900)

		(1)All plants		(2)Plants experienceing ownership change		(3)Plants not experienceing ownership change		Mean difference, (3)-(2)
		Mean	Stdev.	Mean	Stdev.	Mean	Stdev.	
Value of production	yen	1,153,413	944,535	830,398	431,160	1,452,501	1,176,928	622,103 ***
Value added	yen	296,671	314,583	201,229	150,501	385,043	395,400	183,814 **
Number of workers	person	863	698	665	351	1,046	877	381 **
Number of spinndles	unit	17,302	11,846	14,028	5,870	20,334	14,953	6,306 **
Total hours worked	man-hour	3,339,394	2,445,629	2,656,603	1,430,060	3,971,607	2,996,842	1,315,004 **
Average price of products	yen	111.69	46.38	109.08	41.58	114	51	5.03
Average count of products	count	24.00	16.35	24.32	15.29	23.70	17.56	-0.62
Labor productivity	yen/man-hour	0.36	0.15	0.36	0.16	0.37	0.13	0.01
Machine productivity	yen/spindle	65.97	19.25	60.37	17.45	71.16	19.69	10.79 **
Profit per spindle	yen/spindle	12.01	7.11	10.84	5.71	13.09	8.15	2.25
Number of obs.		52		25		27		

Note: *** statistically significant at 1% level
** statistically significant at 5% level

Table 4 Basic statistics of the observations (1900–1912)

	Variable name	Obs.	Mean	Stdev.	Max.	Min.
LN(value added)	LNVA	614	12.43	1.08	7.01	14.85
LN(number of spinndles)	LNMACHINE	624	9.70	0.78	11.69	6.91
LN(total hours worked)	LNHOUR	624	15.02	0.81	16.77	11.71
LN(input of raw cotton)	LNCOTTON	624	13.24	0.88	15.43	9.53
Average count of products	COUNT	624	23.01	14.50	86.52	11.00
Average price of products	PRICE	624	132.79	50.30	420.00	79.00
Labor productivity	LP	624	0.51	0.25	2.43	0.09
Machine productivity	MP	624	74.00	32.70	690.94	2.80
Profit per spindle	PROFIT	624	14.98	11.55	84.00	−18.33

Note: Production, value added, price and profit are at 1900 price. See the text for details.

Table 5 Effects of ownership change on plant performance

A. Pooled OLS

Dependent variable	LNVA		LP		MP		PROFIT	
Independent variables								
EVENT	−0.148	−1.40	−0.016	−2.56 **	−2.292	−1.62	−1.290	−1.43
AFTER	0.069	0.53	0.013	1.46	3.379	2.01 **	2.025	1.78 *
Const.	12.243	82.77 ***	0.093	13.02 ***	19.213	10.89 ***	12.628	11.32 ***
Year dummies	Yes		Yes		Yes		Yes	
Plant fixed effect	No		No		No		No	
R−squared	0.066		0.113		0.162		0.186	
Obs.	614		624		624		624	
Dependent variavle	LNMACHINE		LNHOUR		PRICE		COUNT	
Independent variables								
EVENT	−0.071	−0.92	−0.020	−0.23	4.450	1.65 *	3.548	1.76 *
AFTER	−0.073	−0.85	−0.005	−0.06	−5.099	−1.68 *	−5.261	−2.32 **
Const.	9.568	83.99 ***	14.780	121.31	48.611	14.66 ***	22.294	8.83 ***
Year dummies	Yes		Yes		Yes		Yes	
Plant fixed effect	No		No		No		No	
R−squared	0.021		0.019		0.013		0.016	
Obs.	624		624		624		624	

B. Fixed effect model

Dependent variable	LNVA		LP		MP		PROFIT	
Independent variables								
AFTER	0.194	2.33 **	0.013	1.60	3.872	2.44 **	2.172	2.18 **
Const.	12.188	160.78 ***	0.085	13.31 ***	15.706	15.16 ***	12.008	13.49 ***
Year dummies	Yes		Yes		Yes		Yes	
Plant fixed effect	Yes		Yes		Yes		Yes	
R−squared	0.055		0.099		0.145		0.180	
Obs.	614		624		624		624	
Dependent variavle	LNMACHINE		LNHOUR		PRICE		COUNT	
Independent variables								
AFTER	0.010	0.31	0.088	1.69 *	−0.338	−0.33	−1.771	−2.08 **
Const.	9.534	308.18 ***	14.771	278.19 ***	50.751	29.57 ***	24.000	22.7 ***
Year dummies	Yes		Yes		Yes		Yes	
Plant fixed effect	Yes		Yes		Yes		Yes	
R−squared	0.014		0.0159		0.005		0.008	
Obs.	624		624		624		624	

Table 6 Effect of ownership change on plant TFP

Dependent variable: LNVA						
Independent variables						
EVENT	−0.733	−1.37				
AFTER	0.163	2.23	**	0.152	1.99	**
LNMACHINE	0.863	8.09	***	0.457	2.85	***
LNHOUR	0.299	3.09	***	0.420	4.35	***
Const.	−0.430	−0.74		1.622	0.34	
Year dummies	Yes			Yes		
Plant fixed effect	No			Yes		
R−squared	0.748			0.733		
Obs.	614			614		