RIETI Discussion Paper Series 08-E-021

Industrial Development, Firm Dynamics and Patterns of Productivity Growth:

The Case of the Cotton-spinning Industry in Prewar Japan, 1894-1924

OKAZAKI Tetsuji
RIETI

Research Institute of Economy, Trade & Industry, IAA
The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 08-E-021

Industrial Development, Firm Dynamics and Patterns of Productivity Growth: The Case of the Cotton-spinning Industry in Prewar Japan, 1894-1924

Tetsuji Okazaki*
Faculty of Economics, The University of Tokyo

Abstract

This paper explores the relationship between patterns of productivity growth and the development stage of an industry, using firm-level data on the cotton-spinning industry in Japan in the late-nineteenth century. It is found that patterns of productivity growth depend on the development stage of the industry. In the earlier stage of industrial development, the productivity growth of each firm, namely the within effect, was the sole major source of aggregate productivity growth. On the other hand, once the industry had matured, resource reallocation across firms became a major source of aggregate productivity growth, along with the within effect. This relationship between patterns of productivity growth and the development stage of an industry is considered to reflect the stage-dependent patterns of innovation and competition.

JEL classification: D21, D24, L16, L67, N65, O14

Keywords: Firm Dynamics, Productivity Growth, Industrial Development, Japan, Textile Industry

---

* E-mail: okazaki@e.u-tokyo.ac.jp. Tel: 81-3-5841-5627. Fax: 81-3-5841-5521.
The author would like to thank Professor Masahisa Fujita, Dr. Masayuki Morikawa and other participants in the June 2008 workshop at the Research Institute of Economy, Trade and Industry (RIETI), for their helpful comments and suggestions. All errors are the author's responsibility.

1 .Introduction

There is a growing body of literature which focuses on the heterogeneity of firms and establishments, and its implications for productivity change. As shown in the survey by Foster, Haltiwanger and Krizan (2001), the findings of this strand of literature include the following: (i) there is a large-scale reallocation of resources across individual producers, (ii) the pace of resource reallocation varies over time and across sectors, and (iii) much of this reallocation reflects within-sector, rather than between-sector, reallocation[1]. On the other hand, there is another strand of literature which addresses the evolution of market structure through the entry and exit of firms. Among others, Gort and Klepper (1982) established stylized facts on product market evolution, according to the net entry rate of firms. Based on Gort and Klepper (1982), Agarwal and Gort (1996) investigated the effect of the development stage of the market on the entry and exit of firms, finding that both entry and exit are profoundly affected by stage-related changes[2].

This paper aims to integrate these two strands of literature to explore the implications of the development stage of an industry for patterns of productivity growth. Given the findings of Agarwal and Gort (1996), we can infer that the pattern of productivity growth is affected by the development stage of an industry. However, in order to examine whether or not this is the case, it is essential to have detailed and comprehensive firm-level productivity data which cover the whole life cycle of the industry. This is considered to be one of the basic reasons for the lack of studies which integrate the above two strands of literature.

In this paper, we address this data availability problem by focusing on the case of prewar Japan. Japan started its industrialization based on modern technology in the late-nineteenth century. The cotton-spinning industry played a major role at this time. While it is true that a cotton-spinning industry existed in pre-modern Japan, i.e., during the Tokugawa era, the industry had declined due to the importation of cotton yarn from Western countries, after which the modern cotton-spinning industry, based on Western technology, developed from scratch in Japan in the late-nineteenth century. In this sense, the modern cotton-spinning industry in Japan is an ideal field for the study

[1] The articles in this strand include Aw, Chen and Roberts (2001); Baily, Bartlesman and Haltiwanger (2001); Baily, Hultan and Campbell (1992); Baldwin (1995); Batlesman and Doms (2000); Foster, Haltiwanger and Krizan (2006); Foster, Haltiwanger and Syverson (2008); and Griliches and Regev (1995).

[2] The articles in this strand include Agarwal and Gort (2002); Dunne, Roberts and Samelson (1989); Jovnovic (1982); Klepper (1996); Klepper and Graddy (1990); Klepper and Simons (2000); Klepper and Simons (2005); Klepper and Thompson (2006); Londregan (1990); and Manuszak (2002).

proposed above. Furthermore, one notable feature of the Japanese cotton-spinning industry is that detailed firm-level data are available from the 1890s. Using these data, we can not only identify the entry and exit of firms, but also compute firm-level productivity and market share, which allows us to observe the patterns of productivity growth. In addition, we can rely on the findings of the literature on the history of the Japanese cotton-spinning industry. The cotton-spinning industry is the one that economic historians have investigated in the most depth. This is also a great advantage of focusing on the case of the prewar Japanese cotton-spinning industry.

This paper is organized as follows. Section 2 summarizes the historical development of the cotton-spinning industry in prewar Japan. Section 3 describes the data and basic statistics. In section 4, we analyze the productivity growth pattern by stage of industrial development. Section 5 concludes the paper.

2. Development of the cotton-spinning industry in Japan: an overview

The modern cotton-spinning industry in Japan dates back to the 1870s, when the Meiji government, which assumed power from the Tokugawa Shogunate in 1868, established two state-owned cotton-spinning factories in order to promote industrialization. The government also promoted private firms by selling imported spinning machines at preferential prices. Nine private firms were founded based on these machines. However, all of these factories were unsuccessful, as they were too small in scale and made errors in choosing power sources, which in turn was due to a lack of qualified engineers and a shortage of capital (Abe 1990, Farnie and Abe 2000, Takamura 1971).

The company which paved the way for the modern cotton-spinning industry in Japan was Osaka Boseki Co., which was established in 1880. The entrepreneur who led the foundation of Osaka Boseki Co. was Eiichi Shibusawa, the President of Daiichi Bank, and a big name in modern Japanese economic history. Indeed, he was involved in the foundation and management of almost 500 companies. Due to the leadership of Shibusawa, Osaka Boseki employed a competent engineer and manager, Kentaro Yamanobe, who had studied in Britain, while the company raised large amounts of capital from a wide range of investors thanks to Shibusawa's reputation in Japanese business circles.

One of the distinctive features of Osaka Boseki, compared with its predecessors, was the scale of its equipment. Whereas the standard number of spindles owned by its predecessor companies was 2000, Osaka Boseki had 15,000 spindles driven by steam engines. At the same time, Osaka Boseki was innovative in terms of factory operations, operating its factory throughout the day using double-shift working arrangements. This practice allowed the company to reduce its capital-labor ratio and adjust its imported technology to factor endowment conditions in nineteenth century Japan (Abe 1990, Minami 1986, Nakaoka 1986, Okazaki 1997).

Osaka Boseki achieved good financial performance on its operation in 1883, which induced many new entrants to the cotton-spinning industry. Consequently, in the late-1880s, cotton yarn production increased sharply (Figure 1). As early as 1891, cotton yarn production outstripped imports. Furthermore, in the early-1890s, two additional developments occurred. First, a new type of spinning machine, the ring frame, was introduced and soon became widely adopted, replacing the mule frame. The ring frame was not only easier to operate, but also more efficient than the mule frame (Farnie and Abe 2000, Abe 1990, Kiyokawa 1987, Ushijima 1995). It is notable that Japan was the country where the replacement of the mule frame by the ring frame proceeded the fastest and most comprehensively (Kiyokawa 1987).

The second development is that India came to be a new source of raw cotton, which contributed to a reduction in the cost of raw materials. Based on these two developments, Japan started to export cotton yarn in the early-1890s, and cotton yarn exports exceeded imports as early as the late-1890s (Abe 1990, Farnie and Abe 2000). The ratio of exports to total cotton yarn production rose sharply, reaching 45.0% in 1899. During this process of import substitution and transition to an export industry, the rate of growth in cotton yarn production was very high. Indeed, the annual average production growth rate from 1890 to 1899 was 21.8%.

(Figure 1)

In Figure 1, it is notable that production fell markedly in 1899. In addition, although not so clear as the one in 1899, there was another fall in production around 1916. The first fall coincides with the peak of the export ratio, while the second one coincides with the start of its decline. The average annual production growth rate was 5.6% from 1899 to 1916, while it was only 3.1% from 1916 to 1936.

These three phases observed in Figure 1 are basically consistent with the findings of the literature on the history of the Japanese cotton-spinning industry. In the literature, it has been stressed that the Japanese cotton-spinning industry, which had developed rapidly in the 1890s, began to face difficulties in the 1900s. The causes of these difficulties include (a) Japan's transition to the gold standard and the depreciation of silver[3], (b) the recovery of the Indian cotton-spinning industry, which had stagnated due to the plague, to compete with the Japanese cotton-spinning industry in China's domestic market, (c) increases in wages and interest rates in Japan, and (d) the rapid expansion of equipment in the 1890s (Abe 1990, Farnie and Abe 2000, Miyamoto 1986). Factors (a), (b) and (c) are related to the stagnation of exports.

Looking at the transition from the second phase to the third phase, it has been revealed that the cotton-spinning industry developed in China during the First World War, which led to a rise in the cotton yarn tariff in that country. Combined with a sharp rise in Japanese wages, the Japanese cotton-spinning industry came to be unable to compete with the Chinese cotton-spinning industry in China's domestic market in the late 1910s (Abe 2005, Takamura 1985). To cope with this situation, Japanese cotton-spinning firms started investing directly in China during the 1920s, while accelerating the diversification of their businesses into cloth-processing, silk-spinning, silk-reeling, etc.

3. The data and descriptive statistics

The basic data source for the following analyses is the *Monthly Report of the Spinner's Association*. The original title of the *Monthly Report* changed several times, but it continued to be published from May 1889 throughout the whole prewar period[4]. Of particular importance to this paper is the appendix table in the report, "Operating state of cotton-spinning firms in Japan," which contains firm-level information such as production figures, average yarn count[5], average wage rate by sex, number of workers by sex, number of operating days and average daily operating hours[6].

As the issues of the *Monthly Report* from June 1892 to April 1893 lack an appendix table, we focus on the period from 1894, when complete data became available for each year. By adding up the monthly data for each firm by year, we have prepared firm-level annual data from 1894 to 1924. This period covers the three phases of the

---

[3] The major destination country for exports of Japanese cotton yarn was China, which adopted the silver standard.

[4] The earlier titles were *Rengo Boseki Geppo* (May 1889 to June 1891), *Boshoku Geppo* (July 1891 to June 1892), *Menshi Boseki Dogyo Rengokai Hokoku* (September 1892 to December 1901), *Menshi Boseki Dogyo Rengokai Geppo* (January 1902 to November 1902) and *Menshi Boseki Rengokai Geppo* (from December 1902).

[5] Count is a unit of the diameter of cotton yarn. A larger count indicates a smaller diameter. In those days, the standard count was 20.

[6] An alternative basic data source is the *Cotton Spinning Industry Handbook* (*Menshi Boseki Jijo Sankosho*). The data from this source are more tractable in that they were totaled on a biannual basis. However, as the *Handbook* was first published in 1903, I prefer the *Monthly Report of the Spinner's Association*.

development of the cotton-spinning industry identified in section 2. Table 1 shows the number of firms covered in the data set[7]. As we will see below, the number of firms changed substantially over time. The maximum number of firms was 79 (in 1899), while the minimum was 35 (in 1912). It is notable that the proportion of industry data covered in the *Monthly Report* was very high. Indeed, the ratio of cotton yarn production included in the *Monthly Report* to cotton yarn production reported in Ministry of Agriculture and Commerce statistics was close to 100%[8].

Labor productivity for each firm is calculated by (cotton yarn production converted into 20-count yarn) / (hours worked converted into female labor). To convert cotton yarn production into 20-count yarn, we use the estimated relative price of each count of yarn to 20-count yarn, following Fujino, Fujino and Ono (1979)[9]. That is, we first estimate a log linear relationship between the relative price and the count, based on the price data in Fujino et al. 1979 (p. 49), then combine it with the average count information for each firm in the *Monthly Report* to convert each firm's yarn production into 20-count yarn. Similarly, we convert male workers into female workers by multiplying the former by the relative average wage rate for male workers to that for female workers.

The solid line in Figure 2 shows aggregate labor productivity from 1894 to 1924. Aggregate labor productivity increased substantially over this 30-year period. Indeed, it was 2.1 times higher in 1924 than in 1894. Meanwhile, variance of productivity across firms also changed over time, as the dotted line indicates. The coefficient of variation was initially relatively low and flat until the 1900s. It then went up sharply until the end of 1910s, subsequently declining in the 1920s. An increase in variance implies an increase in firm heterogeneity in terms of labor productivity, which in turn suggests the possibility that firm dynamics may affect aggregate labor productivity (Foster, Haltiwanger and Krizan 2001).

Table 1 summarizes the entry and exit of cotton-spinning firms. In the 1890s, the number of firms increased sharply, mainly due to a high entry rate after the Sino-Japanese War in 1894 and 1895. The number of firms peaked in 1899, followed by a declining trend that continued until the early-1910s. Compared with the 1890s, entry numbers declined in the 1900s, while exit numbers increased sharply. Exits represent

---

7 Some firms suspended operations for a whole year, subsequently resuming operations. In any such case, the firm is regarded as having exited and reentered the industry.

8 For example, 97.6%, 97.8% and 99.0% for 1894, 1904 and 1914, respectively. The Ministry of Agriculture and Commerce data are taken from Toyokeizai Shinposha (1927).

9 Monthly average count data for each firm is averaged for each year (arithmetic average).

closures, as well as mergers and acquisitions. The year in which the number of firms started to decline coincided with the beginning of the second phase of industrial development described in the previous section. It is suggested that the first downward movement in production growth triggered a reorganization of the industry. The number of firms then gradually increased again[10] from the early-1910s. As the production growth rate was declining during this period, we can infer that competition between firms became intense.

(Table 1)

Next, let us observe the basic statistics on firm dynamics and labor productivity (Table 2). In the subsequent analyses, we split the whole observation period into three sub-periods, namely (i) 1894-1904, (ii) 1904-1914 and (iii) 1914-1924. The whole observation period is split equally, because we will conduct a decomposition analysis of productivity growth in the next section and it is known that decomposition results depend on the length of the observation period (Foster, Haltiwanger and Krizan 2001). Compared with the three phases of industrial development described in section 2, period (i) covers part of the first and second phases, period (ii) covers part of the second phase, and period (iii) roughly corresponds to the third phase.

(Table 2)

Panel A of Table 2 indicates that there were 45 cotton-spinning firms in 1894. Of these firms, 22 survived until 1904, the remaining 23 firms having exited by then. During the same period of time, 25 firms entered the industry. With respect to 1894, the average scale of production of the firms that survived until 1904 was larger compared with the industry average, which implies that the scale of the exiting firms was smaller. On the other hand, the aggregate labor productivity of the surviving and exiting firms was not substantially different from the industry average. This fact corresponds to the low coefficient of variation shown in Figure 2, indicating that the exit of those firms did not contribute to the increase in average labor productivity of the industry, as we will confirm in the next section.

In 1904, the average scale of production of the surviving firms was about 2.4 times larger than it had been in 1894, and was much larger than the scale of the firms that

[10] The periods of pre-1899, 1899-1912 and post-1912 correspond to the stage 2, stage 4 and stage 5 periods used in both Gort and Klepper (1982) and Agarwal and Gort (1996).

entered the industry in the same year. At the same time, the aggregate labor productivity of the surviving firms increased substantially. The aggregate labor productivity of the entering firms was also higher than that for the industry as a whole in 1894, which implies that the entry of those firms positively contributed to an increase in aggregate labor productivity of the industry. Nevertheless, compared with the surviving firms in 1904, it was lower.

There were 47 firms in 1904, of which 24 survived until 1914 and 23 had exited by then, while 21 firms entered the industry (Table 2, panel B). With respect to 1904, the average scale of production of the firms that survived until 1914 was larger than the industry average. On the other hand, the aggregate labor productivity of the surviving and exiting firms was not substantially different from the industry average, and furthermore, the aggregate labor productivity of the exiting firms was slightly higher than the industry average. This implies that the exit of those firms had a negative impact on aggregate labor productivity. The average scale of production of the surviving firms became 2.55 times larger during this period, and was much larger than the scale of production of the firms that entered the industry in 1914. The aggregate labor productivity of the surviving firms increased substantially during this period. The aggregate labor productivity of the entering firms was also higher than that of the industry as a whole in 1904, but, as in the previous period, was lower when compared with the surviving firms in 1914.

Looking at the final period, there were 45 firms in 1914, of which 24 survived until 1924 and 21 had exited by then, while 31 firms entered the industry (Table 2, panel C). With respect to 1914, the average scale of production of the firms that survived until 1924 was larger than the industry average, but the difference was much smaller compared with the previous two periods. This reflects the fact that some large firms exited through mergers during this period[11]. On the other hand, a substantial difference in labor productivity across the firm categories appeared for the first time during this period, whereby the aggregate labor productivity of the exiting firms was substantially lower than the industry average in 1914, which implies that the exit of those firms positively contributed to the increase in aggregate labor productivity. The average scale of production of the surviving firms also increased during this period, but

[11] Osaka Boseki Co. and Mie Boseki Co. were merged into a new company, Tokyo Boseki Co., in 1914, while Amagasaki Boseki Co. acquired Settsu Boseki Co. to become Dainihon Boseki Co. in 1918. Tokyo Boseki and Dainihon Boseki became two of the three largest cotton-spinning companies in Japan, along with Kanegafuchi Boseki Co. These large-scale mergers substantially contributed to the positive covariance effect in this period. In particular, the covariance effect attributable to the merger of Amagasaki Boseki and Settsu Boseki is 53% of the total covariance effect in this period.

the growth rate declined. The aggregate labor productivity of the surviving firms increased, as in previous periods. The aggregate labor productivity of the entering firms was also higher than the industry average in 1914. Furthermore, it was almost equivalent to that of the surviving firms in 1924. This is also a phenomenon that was observed for the first time during this period.

4. Firm dynamics and productivity growth

Based on our observation of the basic statistics in Table 2, we can infer the trends in the effects of firm dynamics on aggregate labor productivity. However, in order to assess the magnitude of these effects, we need to decompose the change in aggregate labor productivity. Here, we employ a standard formula for productivity change decomposition (Foster, Haltiwanger and Krizan 2001, 2006). The average labor productivity of an industry in year t ,P_t is given by

$$P_t = \Sigma_i \theta_{i,t} \times P_{i,t}$$

where $\theta_{i,t}$ and $P_{i,t}$ denote the weight of firm i in year t in terms of labor input and the labor productivity of firm i in year t, respectively. Weight is measured in terms of labor input. $\Delta P_t = P_t - P_{t-1}$ can be decomposed into the following five factors:

within effect: $\Sigma_{i \in S} \theta_{i,t-1} \times \Delta P_{i,t}$
between effect: $\Sigma_{i \in S} \Delta \theta_{i,t} \times (P_{i,t-1} - P_{t-1})$
covariance effect: $\Sigma_{i \in S} \Delta \theta_{i,t} \times \Delta P_{i,t}$
exit effect: $\Sigma_{i \in X} \theta_{i,t-1} \times (P_{t-1} - P_{i,t-1})$
entry effect: $\Sigma_{i \in N} \theta_{i,t} \times (P_{i,t} - P_{t-1})$

where S, X and N denote the set of firms that survive from year t-1 to t, firms that exit during this period and firms that enter during this period, respectively. The within effect captures the fraction of aggregate labor productivity change which can be attributed to each firm's productivity change. The between effect and the within effect capture the effect of a reallocation of resources across surviving firms. If firms more efficient than the industry average increase their shares, the between effect is positive, and vice versa. If firms whose productivity goes up increase their shares, or if firms whose productivity goes down decrease their shares, the covariance effect is positive, and vice versa. The exit effect and the entry effect capture the productivity implication of firm replacement. If the productivity of exiting firms is lower than the industry average in year t-1, or if the productivity of entering firms is higher than the industry average in year t, these effects are positive, and vice versa. The four effects other than the within effect capture the labor productivity change due to general resource reallocation.

The results of decomposition using the above formula are reported in Table 3. Firstly, the fraction of productivity growth due to the within effect differs between the pre-1914 period and the 1914-1924 period. Whereas almost all the productivity growth in the former period can be attributed to the within effect, the contribution of the within effect declined to 50.2% in the 1914-1924 period. This finding indicates that the patterns of labor productivity growth changed substantially over time. That is, whereas in the former period, productivity growth of each firm was the basic source of aggregate productivity growth, in the 1914-1924 period the general reallocation of resources across firms became a major source of aggregate productivity growth, along with productivity growth, of each firm.

This was partly due to the decline in the magnitude of the within effect, but was also because of the increase in the magnitude of the other four effects. The sum of the between and covariance effects indicates the effect of resource reallocation across the surviving firms. In the pre-1914 period, the contribution of this factor was negative, but subsequently became positive. Finally, the sum of the exit and entry effects, namely the effect of firm replacement, was largest in the 1914-1924 period. In particular, the exit effect was much larger in that period when compared with the previous two periods.

(Table 3)

Overall, the particularity of the 1914-1924 period stands out. In this period, while the magnitude of the within effect declined, the effect of general resource reallocation increased. Next, we will reexamine this feature using regression analysis, following Foster et al. (2006) by estimating the following equation for each of the three periods, namely 1894-1904, 1904-1914 and 1914-1924.

.

$$P_{it} = \beta_0 + \beta_1 ENTER_{it} + \beta_2 EXIT_{it} + \beta_3 ENDYEAR_t + e_{it}$$

$ENTER_{it}$ is a dummy variable which equals 1 if firm i entered the industry during the period, and 0 otherwise. $EXIT_{it}$ is a dummy variable which equals 1 if firm i exited from the industry during the period, and 0 otherwise. $ENDYEAR_t$ is a dummy variable which equals 1 if the year is the end of the period, and 0 otherwise. e_{it} is the error term. The results of the OLS estimation are reported in Table 4.

(Table 4)

First, the EXIT coefficient is negative and statistically significant only for 1914-1924. This is consistent with the results shown in Table 3, in which the exit effect was small in 1894-1904 and negative in 1904-1914, but became positive and large in 1914-1924. Second, the ENTER coefficient is not statistically significant. This implies that after controlling for the overall productivity growth of the industry using $ENDYEAR_t$, the labor productivity of the entering firms was not significantly different from the other firms, including the exiting firms. In other words, the positive entry effect shown in Table 3 basically reflects the overall productivity growth of the industry. On the other hand, the $ENDYEAR_t$ coefficient has a declining trend. This is interpreted as a reflection of the maturity of the industry.

Integrating these results with the observations made in the previous sections, we have a consistent picture of industrial development, firm dynamics and productivity growth patterns. In the first period (1894-1904), when the cotton-spinning industry was establishing its international competitiveness and the number of firms rose and fell sharply, productivity across firms generally grew, and hence the implication of resource reallocation across firms was small. To put it differently, the within effect explained almost all of the aggregate productivity growth. In the second period (1904-1914), when the industry was on a stable growth path, the shakeout of firms continued. Meanwhile, as in the first period, productivity across firms generally grew, and hence the implication of resource reallocation across firms was small. Finally, in the third period (1914-1924), when the industry was losing its international competitiveness, the number of firms ceased to decline, but exits continued and came to be associated with a firm's productivity. While overall productivity growth declined, resource reallocation across firms came to be a major source of aggregate productivity growth.

5. Concluding remarks

In this paper, we have explored the relationship between patterns of productivity growth and the development stage of an industry, using firm-level data on the cotton-spinning industry in Japan in the late-nineteenth century. We have found that patterns of productivity growth depend on the development stage of the industry. In the earlier stage of industrial development, productivity growth of each firm, namely the within effect, was the sole major source of aggregate productivity growth. This is because overall productivity growth was high, and exits were not associated with productivity. On the other hand, once the industry had matured, resource reallocation across firms became a major source of aggregate productivity growth, along with the within effect. This is because overall productivity growth declined, while exits came to be associated with a firm's productivity.

This relationship between patterns of productivity growth and the development stage of an industry is considered to reflect the stage-dependent patterns of innovation and competition. Agarwahl and Gort (2002) reveal that in the early years of an industry, technological opportunities for innovation are high, while as the industry matures, technological opportunities decline and innovations increasingly shift to product refinement and cost reduction, which intensifies competition. The change over time in overall productivity growth and the exit patterns we found in this paper are consistent with the conclusion reached by Agarwahl and Gort (2002). This paper has clarified the implications of this stage-dependent pattern of innovation and competition for patterns of productivity growth, integrating the framework and findings in the literature on the productivity growth analysis.

References

Abe, Takeshi. 1990. *Men Kogyo* (The cotton industry in Meiji Japan). In *Sangyoka no Jidai* (*Era of industrialization*) 1, eds. Shunsaku Nishikawa and Takeshi Abe, 164-212. Tokyo: Iwanami Shoten

Abe, Takeshi. 2005. The Chinese market for Japanese cotton textile goods, 1914-30. In *Japan, China, and the growth of the Asian international economy*, 1850-1949, ed. Kaoru Sugihara, 73-100. New York: Oxford University Press

Agarwal, Rajshee and Michel Gort. 1996. The evolution of markets and entry, exit and survival of firms. *The Review of Economics and Statistics* 78(3): 489-498

Agarwal, Rajshee and Michel Gort. 2002. Firm and product life cycles and firm survival. *The American Economic Review* 92(2): 184-190

Aw, Bee Yan, Xiaomin Chen and Mark Roberts. 2001. Firm-level evidence on productivity differentials in Taiwanese manufacturing. *Journal of Development Economics* 66: 51-86

Baily, Martin Neil, Eric J. Bartelsman and John Haltiwanger, 2001. Labor productivity: Structural change and cyclical dynamics. *The Review of Economics and Statistics* 83(3): 420-433

Baily, Martin Neil, Charles Hulten and David Campbell. 1992. Productivity Dynamics in Manufacturing Plants. *Brookings Papers on Economic Activity* (*Microeconomics*): 187-249.

Baldwin, John R. 1995. Turnover and productivity growth. In *The dynamics of industrial competition*, ed. John R. Baldwin, 208-238. Cambridge: Cambridge University Press

Batlesman, Eric J. and Mark Doms. 2000. Understanding productivity: Lessons from longitudinal microdata. *Journal of Economic Literature* 38: 569-594

Dunne, Timothy, Mark Roberts and Larry Samuelson. 1989. The growth and failure of U.S. manufacturing plant. *The Quarterly Journal of Economics* 104(4): 671-698

Farnie, Douglas A. and Takeshi Abe. 2000. *Region and strategy in Britain and Japan: Business in Lancashire and Kansai, 1890-1990*, eds. Douglas A. Farnie, Tetsuro Nakaoka, David J. Jeremy, John F. Wilson and Takeshi Abe. 115-157. London: Routledge

Foster, Lucia, John Haltiwanger and C. J. Krizan. 2001. Aggregate Productivity Growth: Lessons from micro economic evidence. In *New development in productivity analysis*, eds. Charles R. Hulten, Edwin R. Dean and Michel J. Harper, 303-363. Chicago: The University of Chicago Press

Foster, Lucia, John Haltiwanger and C. J. Krizan. 2006. Market selection, reallocation and restructuring in the U.S. retail trade sector in the 1990s. *The Review of Economics and Statistics* 88(4): 748-758

Foster, Lucia, John Haltiwanger and Chad Syverson. 2008. Reallocation, firm turnover, and efficiency: Selection on productivity or profitability? *The American Economic Review* 98(1): 394-425

Fujino, Shozaburo, Shiro Fujino and Akira Ono. 1979. *Seni kogyo* (*Textile industry*), Tokyo: Toyo Keizai Shinposha

Gort, Michel and Steven Klepper. 1982. Time paths in the diffusion of product innovations, *The Economic Journal* 92: 630-653

Griliches, Zvi and Haim Regev. 1995. Productivity and firm turnover in Israeli industry: 1979-1988. *Journal of Econometrics* 65(1): 175-203

Javanovic, Boyan. 1982. Selection and the evolution of industry. *Econometrica*. 50(3): 649-670

Kiyokawa, Yukihiko. 1987. *Men bosekigyo ni okeru gijjutsu sentaku: Myuru boki kara Ring boki he* (Technological choice in the cotton-spinning industry: From the Mule frame to the Ring frame). In *Nihon no kogyoka to gijutsu hatten* (J*apanese industrialization and technological development*), eds. Ryoshin Minami and Yukihiko Kiyokawa, 83-107, Tokyo: Toyo Keizai Shinposha

Klepper, Steven. 1996. Entry, exit, and innovation over the product life cycle. *The American Economic Review* 86(3): 562-583

Klepper, Steven and Elizabeth Graddy. 1990. The evolution of new industries and the determinants of market structure. *The Rand Journal of Economics*. 21(1): 27-44

Klepper, Steven and Kenneth L. Simons. 2000. The making of an oligopoly: Firm survival and technological change in the evolution od the U.S. tire industry. *The Journal of Political Economy* 108(4): 728-760

Klepper, Steven and Kenneth L. Simons. 2005. Industry shake out and technological change. *International Journal of Industrial Organization*, 23:23-43

Klepper, Steven and Peter Thompson. 2006. Submarkets and the evolution of market structure. *The Rand Journal of Economics*. 37(4): 861-886

Londregan, John. 1990. Entry and exit over the industry life cycle. *The Rand Journal of Economics*. 21(3): 446-458.

Manuszak, Mark D. 2002. Endogenous market structure and competition in the 19th century American brewing industry. *International Journal of Industrial Organization* 20: 673-692

Minami, Ryoshin. 1986. *The economic development of Japan: A quantitative study*. Basingstoke: Macmillan

Miyamoto, Matao. 1986. *Meijiki Bosekigyo no Seisansei ni tsuite* (Productivity of cotton-spinning industry in Meiji period), Osaka Daigaku Keizaigaku 35(4): 132-157

Nakaoka, Tetsuro, ed. 1990. *Gijutsu keisei no kokusai hikaku: Kogoka no shakaiteki noryoku* (*International comparison of technology formation: Social capability for industrialization*). Tokyo: Chikuma Shobo

Okazaki, Tetsuji. 1997. *Kogyoka no kiseki* (*The track of Japanese industrialization*). Tokyo: Yomiuri Shinbunsha

Shindo, Takejiro. 1958. *Nihon mengyo rodo ron* (*On the industrial relationship of the Japanese cotton-spinning industry*). Tokyo: The University of Tokyo Press

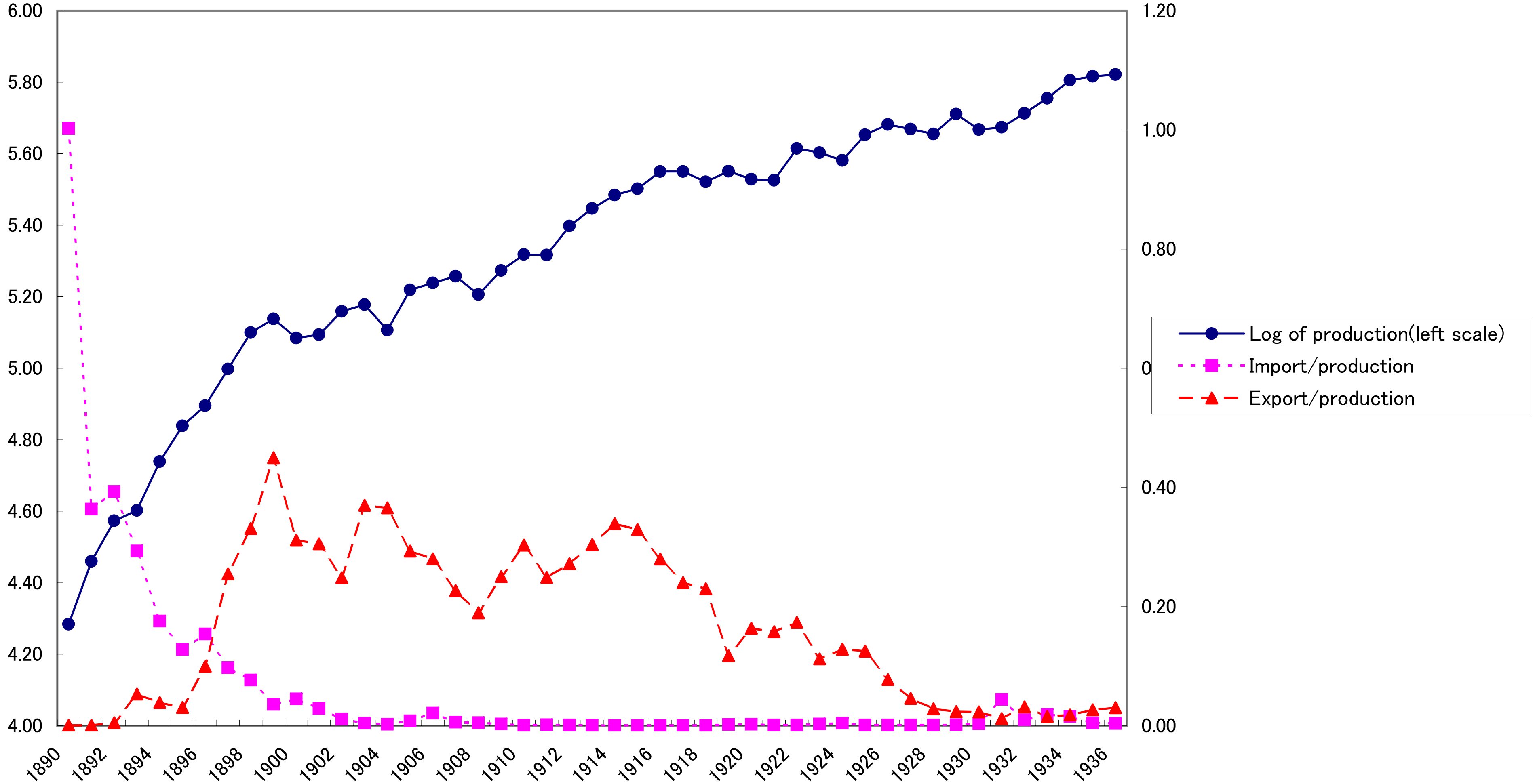
Takamura, Naosuke. 1971. *Nihon bosekigyo-shi bunseki josetsu* (*Toward an analysis of the Japanese cotton-spinning industry*). Tokyo: Hanawa Shobo

Takamura, Naosuke. 1985. Shihon Chikuseki 1: Kei kogyo (Capital accumulation 1: The light industry). In *Nihon teikokushugi shi* 1 (*History of Japanese imperialism* 1) ed. Kaichiro Oishi, 153-197. Tokyo: The University of Tokyo Press

Toyo Keizai Shinposha ed. 1927. *Meiji taisho kokusei soran* (*Statistical handbook of Meiji Taisho Japan*). Tokyo: Tokyo Keizai Shinposha

Ushijima, Toshiaki. 1995. *Meijiki menshi bossekigyo ni okeru Ringu bosesekiki no* *donyu to seisansei no josho: Yunyu giojyutsu no teichaku wo meguru yobiteki kosatsu* (Introduction of the Ring frame and productivity growth in the cotton-spinning industry in Meiji Japan: A preliminary investigation into the introduction and diffusion of the imported technology), *Mita Shogaku Kenkyu* 38(4): 63-80

Figure 1 Development of the cotton-spinning industry in Japan



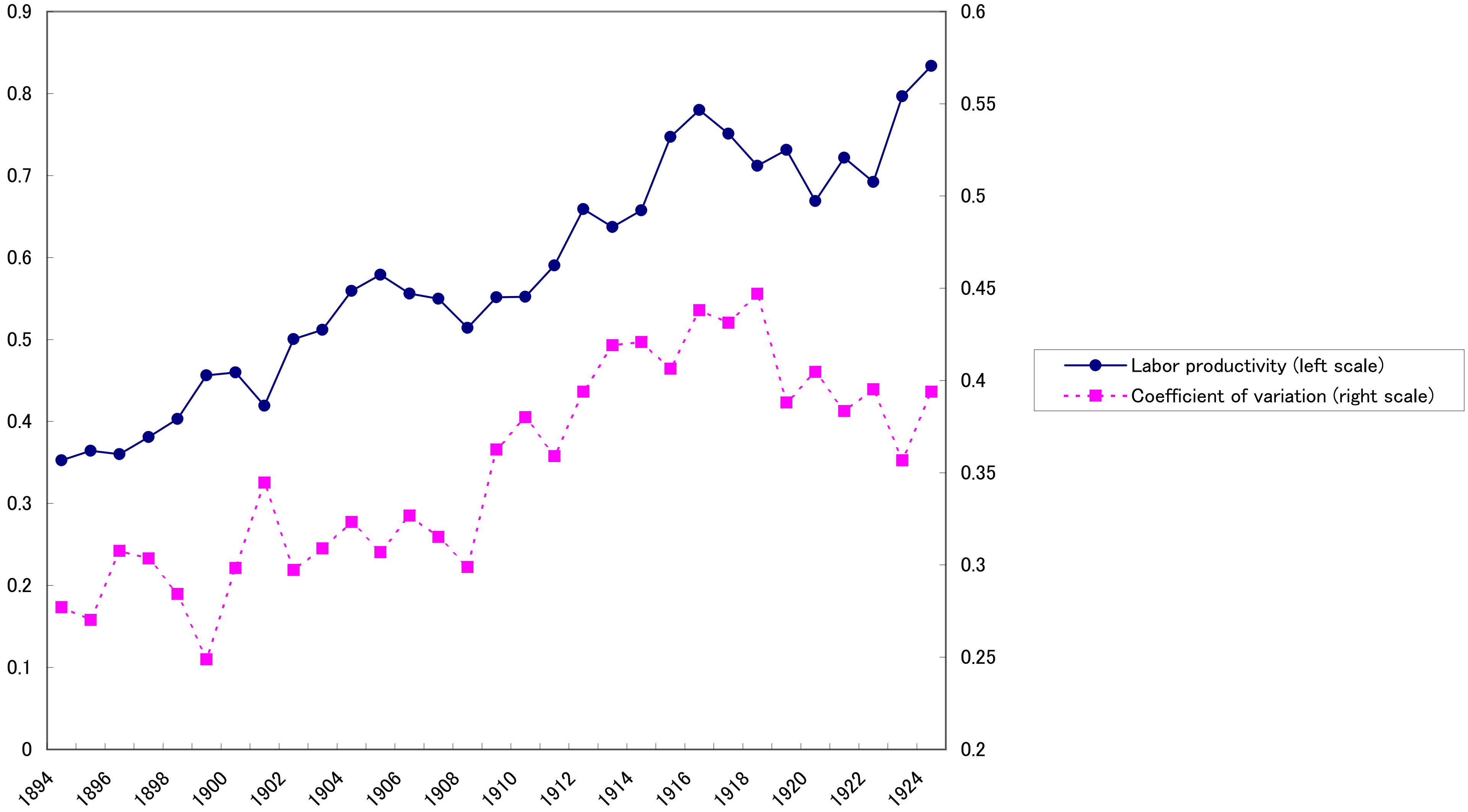
Source: Toyo Keizai Shinposha (1927); Shindo (1958).

Table 1 Entry and exit of cotton-spinning firms

	Number of firms (year end)	Entry	Exit		
				Closure	Merger
1894	45				
1895	47	4	2	2	0
1896	60	14	1	1	0
1897	63	7	4	4	0
1898	75	14	2	1	1
1899	79	8	4	3	1
1900	67	3	15	7	8
1901	64	3	6	4	2
1902	64	3	3	3	0
1903	55	4	13	9	4
1904	47	1	9	4	5
1905	50	6	3	1	2
1906	51	5	4	3	1
1907	49	3	5	0	5
1908	39	0	10	0	10
1909	37	2	4	2	2
1910	37	1	1	1	0
1911	36	1	2	2	0
1912	35	2	3	0	3
1913	41	9	3	2	1
1914	45	4	0	0	0
1915	41	3	7	4	3
1916	39	2	4	1	3
1917	42	5	2	0	2
1918	47	7	2	0	2
1919	47	6	6	1	5
1920	54	9	2	0	2
1921	58	5	1	1	0
1922	67	13	4	1	3
1923	59	1	9	5	4
1924	55	1	5	3	2

Source: Various issues of the *Monthly Report of the Japan Spinner's Association* .
Note: See the text.

Figure 2 Growth of labor productivity



Note: See Table 1.

Table 2 Basic statistics by firm category

A.1894-1904

				1894	1904
Total	Production	Total	ton	56,679	126,609
(N=45, 47)		Average	ton	1,260	2,694
	Labor productivity	Weighted average	kg/manhour	0.409	0.525
Surviving firms	Production	Total	ton	38,789	92,854
(N=22)		Average	ton	1,763	4,221
	Labor productivity	Weighted average	kg/manhour	0.414	0.547
Exiting firms	Production	Total	ton	17,890	—
(N=23)		Average	ton	778	—
	Labor productivity	Weighted average	kg/manhour	0.399	—
Entering firms	Production	Total	ton	—	33,755
(N=25)		Average	ton	—	1,350
	Labor productivity	Weighted average	kg/manhour	—	0.473

B.1904-1914

				1904	1914
Total	Production	Total	ton	126,609	307,265
(N=47, 45)		Average	ton	2,694	6,828
	Labor productivity	Weighted average	kg/manhour	0.525	0.664
Surviving firms	Production	Total	ton	95,420	243,729
(N=24)		Average	ton	3,976	10,155
	Labor productivity	Weighted average	kg/manhour	0.516	0.681
Exiting firms	Production	Total	ton	31,189	—
(N=23)		Average	ton	1,356	—
	Labor productivity	Weighted average	kg/manhour	0.554	—
Entering firms	Production	Total	ton	—	63,535
(N=21)		Average	ton	—	3,025
	Labor productivity	Weighted average	kg/manhour	—	0.607

C.1914-1924

				1914	1924
Total	Production	Total	ton	307,265	405,237
(N=45, 55)		Average	ton	6,828	7,368
	Labor productivity	Weighted average	kg/manhour	0.664	0.784
Surviving firms	Production	Total	ton	214,643	345,701
(N=24)		Average	ton	8,943	14,404
	Labor productivity	Weighted average	kg/manhour	0.684	0.784
Exiting firms	Production	Total	ton	92,622	—
(N=21)		Average	ton	4,411	—
	Labor productivity		kg/manhour	0.623	—
Entering firms	Production	Total	ton	—	59,536
(N=31)		Average	ton	—	1,921
	Labor productivity	Weighted average	kg/manhour	—	0.781

Note: See Table 1

Table 3 Decomposition of labor productivity growth

		1894–1904	1904–1914	1914–1924
Productivity change	Total	0.116	0.139	0.119
(kg/manhour)	Within	0.130	0.132	0.060
	Subtotal	−0.037	−0.004	0.029
	Between	−0.007	0.028	−0.005
	Covariance	−0.030	−0.032	0.034
	Subtotal	0.022	0.012	0.031
	Exit	0.003	−0.007	0.013
	Entry	0.019	0.019	0.017
Percentage	Total	100.0	100.0	100.0
	Within	112.5	94.5	50.2
	Subtotal	−31.6	−2.9	24.2
	Between	−5.9	20.0	−4.3
	Covariance	−25.7	−22.9	28.5
	Subtotal	19.1	8.4	25.6
	Exit	2.9	−4.9	11.2
	Entry	16.2	13.3	14.4

Note: See Table 1

Table 4 Labor productivity decomposition by regression

	1894–1904		1904–1914		1914–1924	
EXIT	−0.004		0.042		−0.255	***
	(−0.15)		(0.79)		(−3.63)	
ENTER	−0.051		0.052		0.050	
	(−0.97)		(0.60)		(0.60)	
ENDYEAR	0.232	***	0.095		0.029	
	(6.15)		(1.60)		(0.38)	
Constant	0.355	***	0.539	***	0.776	***
	(24.99)		(15.18)		(11.86)	
R^2	0.348		0.053		0.154	
Obs.	92		92		100	

Note: White heteroschedasticity robust t values in parenthethes.
*** statistically significant at 1% level.