CIRJE-F-1122

Transition to a Modern Regime and Change in Plant Lifecycles: A Natural Experiment from Meiji Japan

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August 2019

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Abstract

This paper examines how political, social, and economic regime changes affect the lifecycles of manufacturing plants exploiting Japan's transition from a feudal regime to a modern regime in the late nineteenth century as a natural experiment. Using plant-level data for 1902, including the foundation year of each plant, we explored how the experience-size profiles of plants differ before and after the regime change. Plants were found to grow much faster after the regime change and the acceleration of growth after the regime change was much greater for the plants in exporting industries, industries intensively using steam power, and plants adopting a corporate form. These findings suggest that access to export markets, access to modern technologies, and availability of the modern corporate form were the channels through which the regime change affected the experience-size profile of plants. The findings on the acceleration of plant growth after the regime change are supported by the analyses of more detailed data from the silk-reeling industry.

Keywords: Plant lifecycle, Market access, Trade reform, Corporate form, Natural experiment, Economic history, Japan.

JEL Classification Number: D22, L25, O14, O43, N65.

*We gratefully acknowledge Asuka Imaizumi, Kaori Ito, Yutaka Arimoto, and Kentaro Nakajima for their guidance and encouragement. We also thank comments and suggestions from numerous seminar participants. Financial support was provided by JSPS, Japan (Grant-in-Aid for Scientific Research (B) 21330064).

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1 Introduction

The size distributions of plants are heterogeneous across countries, particularly between developed and developing countries (Tybout 2000, 2014; Hsieh and Olken 2014). In recent years, the thick lower tail of plant size distributions and slower growth of plants in developing countries have been attracting interest as a source of low total factor productivity (TFP) at the macro-level (Hsieh and Klenow 2009, 2014; Jones 2016; Bento and Restuccia 2017; Restuccia and Rogerson 2017; Poschke 2018). Most studies focus on market distortions to explain differences in plant size distributions and plant growth rates. For instance, Hsieh and Klenow (2014), who compared the experience-size profiles of plants in the United States (US), Mexico, and India, suggested that plants grow more slowly as they age in the latter two countries because larger plants in India and Mexico face barriers, such as financial frictions, higher tax burdens, contractual frictions in hiring nonfamily labor, especially skilled managers, and costs of shipping to distant markets. Meanwhile, Restuccia and Rogerson (2017) classified the distortions into (a) features of statutory provisions including tax codes and regulations, (b) discretionary provisions by the government or other entities including preferential loans by banks, and (c) market imperfections including monopoly power and market frictions.

Some studies attempted to identify the distortions in developing economies empirically. Using a randomized experiment that granted money to microenterprises in Sri Lanka, de Mel, McKenzie, and Woodruff (2008) found that credit constraints reduce the growth opportunities of smaller and young firms. Jensen and Miller (2018) exploited the spread of mobile phones to fishermen in Kerala, India as a natural experiment and found that the highest-quality boat builders gained market share and grew in size, while the lowest-quality builders lost market share and exited the industry because the fishermen gained greater access to information about nonlocal builders and began buying boats nonlocally.

This paper is broadly consistent with these empirical studies, especially Jensen and Miller (2018); however, we adopt a different strategy. In particular, we identify the distortions that hinder plant growth in developing economies by exploiting the transition from a feudal regime to a modern regime in late nineteenth century Japan in a natural experiment. In 1859, under military threat from the US fleet, Japan abolished its seclusion policy that had existed for more than 200 years. Opening the country to the rest of the world was a substantial regime change in itself, but it was also the start of a broader regime change; i.e., the transition from a feudal regime under the Tokugawa government to a modern regime under the Meiji government. This transition is now generally called the 1868 Meiji Restoration, including the subsequent institutional reforms. By the end of the 1870s, the Meiji government had abolished most feudal regulations and established a set of modern institutions.

The case of late nineteenth-century Japan is important in the context of the foregoing literature because manufacturing plants that were founded before the regime change and survived the change experienced two essentially different environments, i.e., the closed economy with feudal regulations under the Tokugawa government, and the open and free economy under the Meiji government. This regime change after 1859, which was exogenous to the economy, provides a valuable natural experiment. While Bernhofen and Brown (2004) focused on the trade regime change for a direct test of the Heckscher-Ohlin theorem, we use this opportunity to identify the conditions that explain the differences in the size distributions and lifecycles of manufacturing plants. This paper first describes how plant lifecycles varied between the traditional and modern regimes. We use plant-level manufacturing census data for 1902, which provides plant-level information on foundation year, number of workers, geographic location, industry, power sources, and organizational form. The data notably includes a substantial number of plants that were built before the regime change; therefore, these plants operated in two different environments (i.e., before and after the regime change), which provides us with an opportunity to test whether one year of operation under the modern regime had a larger effect on plant growth than that under the feudal regime.

The main finding is that the experience-size profile (years of operation and size) of plants was steeper for years of operation under the modern regime than it was under the traditional regime. That is, plant growth during one year of operation was much larger than that before the regime change. Thus, plant growth accelerated after the regime change. In addition, by interacting the regime change with three attributes of plants, i.e., export industry/nonexport industry, technology intensity, and incorporated/nonincorporated, we identified the channels through which the regime changes affected plant growth. We found that the acceleration of growth after the regime change was larger for plants in exporting industries, industries using steam power intensively, and plants adopting a corporate from. These findings suggest that access to export markets, access to modern technologies, and availability of the modern corporate form, were the channels through which the regime change affected the experience-size profile of plants. To check the robustness of these results, we used detailed plant-level data from the silk-reeling industry in 1902, i.e., data on the use of production factors, use of intermediate goods, and output. The acceleration of plant growth after the regime change was confirmed by using these different scale measures.

This study relates to a broader literature in addition to the literature discussed above. That is, in general, this paper relates to the vast literature on the relationship between institutions and economic growth. The quality of institutions affects not only growth at the macro-level (for a survey, see Acemoglu, Johnson, and Robinson 2005), but also the micro-aspects of an economy, such as comparative advantage and industrial structure (Levchenko 2007; Nuun 2007; Nunn and Trefler 2014). Laeven and Woodruff (2007) showed that firm size increases with the quality of the legal system across the states of Mexico. This paper presents evidence that the characteristics of institutions affect plant growth by focusing on institutional change over time in one country.[1]

Our findings on the channels through which the regime change affected plant growth relates to the literature on the determinants of firm growth. First, Bustos (2011), and Atkin, Khandelwal and Osman (2017) found that access to foreign markets is a key driver of firm growth. Our finding that the regime change had a larger growth effect on the plants in the exporting industries is consistent with these studies. Second, for the US, Atack, Bateman, and Margo (2008) found that large establishments were more likely to use steam power than smaller ones, which suggested that the availability of steam power was a factor behind the growth of large-scale enterprises. Whereas they only showed a correlation between the adoption of steam power and plant size, we provide more persuasive evidence of this hypothesis using a natural experiment. Third, this paper relates to recent studies on the implications of incorporation (Gregg 2019; Gregg and Nafziger 2019). Using plant-level data from Imperial Russia, these researchers revealed that incorporated firms and plants owned by corporations were larger and grew faster because of the associated financial flexibility. Our findings are highly consistent with these studies.

The rest of the paper is organized as follows. Section 2 overviews the history of the regime change in the late nineteenth century in Japan and describes its impact on plant growth, focusing on the cases of two specific plants for which long-term time series data are available. Section 3 describes the data and descriptive analyses. Section 4reports the results of the econometric analyses. Section 5 examines the census data of the silk-reeling industry to check the robustness of the results. Section 6 concludes the paper.

2 Transition from a feudal regime to a modern regime

2.1 A Brief overview of the regime change

Japan experienced a drastic and swift change in its political, social, and economic regime beginning in 1859. Before that, a stable regime had existed for more than 200 years since the early seventeenth century, when the Tokugawa Shogunate (*Bakufu*) was established in 1603. This political regime (hereafter, the Tokugawa regime) was composed of the central government, *Bakufu*, and around 250 domains of feudal lords (*han*). For a feudal state, the Tokugawa regime was relatively centralized, in that the *Bakufu* totally controlled diplomatic policy and coinage. Furthermore, the *Bakufu* forced all the lords to stay in the capital city, Edo, every second year, and could change the domains of lords. However, the feudal lords also had substantial autonomy; e.g., they controlled the borders of domains by installing checking points (*sekisho*) and could issue regional paper currencies (*hansatsu*) (Sasaki 1980, pp.39–42; Shinbo 1995, pp.4–5).

[1] In a city-level analysis, Keller and Shiue (2016) showed that institutional reform in 19th century Germany was a result of French rule, which affected city-level growth.

From a socioeconomic perspective, the Tokugawa regime was a rigid class society where people were classified into one of four classes by their origin, i.e., *samurai* (warriors), farmers, craftsmen, or merchants. Each class notably corresponded to a certain occupation; i.e., people could not freely choose their occupations. In addition, they did not have freedom of movement or residence. While agriculture was the largest industry, the commerce and manufacturing industries were also fairly well developed. The merchants and craftsmen working in these industries were organized into regional trade associations, called *kabu nakama*, which were authorized by *Bakufu* or *han*. *Kabu nakama* strictly controlled new entries into each trade and thereby enjoyed monopolistic rents. At the same time, they ensured the effective functioning of markets by enforcing contracts and controlling the quality of products and services (Miyamoto 1938; Okazaki 2005).

The Tokugawa regime existed for a long period of time, partly because Japan was insulated from the outside world. Immediately after the foundation of the regime, *Bakufu* implemented a national seclusion policy. By 1639, trade and other international relationships only existed with the Netherlands, China, Korea, and Ryukyu (Okinawa), and they were strictly controlled by *Bakufu* (Tashiro 1988).

This situation finally changed in the 1850s following pressure from several Western countries. In 1853, General Matthew C. Perry of the US Navy visited Japan with his fleet and requested the *Bakufu* to establish a diplomatic relationship with the US. Threatened by Perry's fleet, the *Bakufu* concluded the Treaty of Kanagawa in 1854 with the US, which established a diplomatic relationship between Japan and the US. Similar relationships were developed with Britain, Russia, and the Netherlands in 1854, 1855, and 1856, respectively (Shinbo 1995, pp.18–19; Sugiyama 1989, pp.179–180; Fujita 2015, pp.130–134). Based on these diplomatic relationships, the *Bakufu* then concluded trade treaties with the US, Britain, Russia, the Netherlands, and France in 1858, which involved the opening of five ports (Kanagawa, Nagasaki, Hakodate, Niigata, and Hyogo) and two markets (Edo and Osaka). Later, the ports of Kanagawa, Nagasaki, and Hakodate were opened in 1859. The opening of other ports was postponed because of criticism and objections from powerful feudal lords. This obliged the *Bakufu* to make a further concession; e.g., to obtain foreign approval for this postponement, the *Bakufu* accepted a low conventional tariff rate of 5%. In this sense, for Japan, opening the country meant not only the commencement of trade but also a transition to a de facto free trade regime (Shinbo 1995, p.20; Sugiyama 1989, p.180).

The opening of the country had a substantial impact on the Japanese economy, which had been closed for more than 200 years. Relative prices changed substantially, which caused a substantial resource reallocation (Shinbo 1978; Bernhofen and Brown 2004). The impact of the opening the country was not limited to the economy. Several powerful feudal lords criticized the *Bakufu* about the procedure surrounding the decision to open the country, which resulted in civil war in 1868 between the anti-*Bakufu* lords and the *Bakufu* supported by pro-*Bakufu* lords. The former camp won the civil war and founded a new government with the Emperor as the head of the state (i.e., the Meiji Restoration). A modern state developed swiftly after the establishment of the new government. In 1871, all feudal domains were abolished and prefectures were established as local administration organizations, which was an important epoch for the transition from a feudal decentralized state to a modern centralized state.

The transition to a modern state entailed a set of essential institutional changes, which are summarized in Table 1. These reforms provided the fundamental institutional requirements for the effective functioning of markets for production factors and commodities. The feudal class system was abolished by the Family Registration Act in 1871; subsequently, people could freely choose their occupation (Kitajima ed. 1975, p.224; Takahashi 1968, pp.70-72). This reform removed barriers to the allocation of labor and human capital. The regulations relating to land, another basic production factor, were reformed following the Meiji Restoration. In 1871 and 1872, farm land utilization and land sales were liberalized. Then, land tax reform was implemented from 1873 when the Meiji government established a modern tax system. As agriculture was the major industry in Japan during this period, the land tax was central to the tax system. To reform the land tax, the government first confirmed the ownership of every piece of land in the country and decided its price based on its revenue. Then, a land tax of 3% of the land value was imposed on the land owner. The land tax reform was finally completed in 1878 (Kitajima ed. 1975, pp.220-244).

Concerning the financial system, the National Bank Act was legislated in 1872. National banks were private banks that were given the privilege of issuing bank notes. At first, only a few national banks were founded, but because the amendment of the Act in 1876 improved the profitability of national banks, more than 150 national banks had been founded by 1879, which formed a nationwide financial network (Asakura 1988, pp.34–64; Okazaki et al. 2005). Furthermore, the Tokyo and Osaka stock exchanges were established in 1878 (Hamao, Hoshi, and Okazaki 2005). For production factors to be used efficiently, an efficiently functioning corporate system is essential. Initially, the Meiji government strictly regulated the foundation of corporations; however, it entrusted this regulation to prefecture governments in 1878, which, in turn, relaxed the regulation on foundations of corporations (Shinbo 1995, p.55; Takamura 1996, pp.49-50; Toshitani and Mizubayashi 1973, pp.47–48). Finally, feudal regulations on commodity markets were also removed. Following the Meiji Restoration, border check points (*sekisho*), which the *Bakufu* and han established to control the borders of their domains, were removed (Shinbo 1995, pp.446–447). From 1872 to 1873, feudal trade associations (*kabu nakama*) were dissolved (Miyamoto 1957, pp. 8-9).

==== Table 1 here ====

2.2 Tales of two plants

The regime change described in Section 2.1 affected the growth rates of plants. To demonstrate this, we observe long-term time-series data for two individual plants that cover the periods before and after the regime change. In Japan, many companies have long histories dating back to the premodern period. We obtained long-term data on production and employment for two of those companies. The first case is a copper mining and refining plant at Besshi in Ehime Prefecture. The Besshi mine was a major pillar of Sumitomo Zaibatsu, the third largest business group in prewar Japan, whose origin dates to the sixteenth century (Sakudo 1982). Sumitomo was given a license to mine copper ore at Besshi from the *Bakufu* in 1691 (Sakudo 1982). Sumitomo mined copper ore and smelted it to crude copper at Besshi before sending this crude copper to Osaka to be refined (Sumitomo Metal Mining Co. 1991). Figure 1 shows the data for crude copper production at Besshi. Remarkably, after a decline in the early eighteenth century, the production was stable at around 500 tons for about 150 years until the 1860s, and after that, it soared to exceed 4,000 tons. In the context of this paper, until the 1860s, the Besshi mine did not grow as it aged, whereas from the 1870s, it grew rapidly as it aged.

==== Figure 1 here ====

The first reason for this distinctive pattern of plant growth at the Besshi mine was the resolution of a technological constraint. In the Tokugawa period, the Besshi mine faced transportation and drainage problems and its workers struggled to provide these services. Indeed, transportation and drainage were fundamental problems common to all mines in this period (Sumitomo Metal Mining Co. 1991). The regime change provided an opportunity to resolve these problems and Sumitomo exploited this opportunity. In 1869, directly following the Meiji Restoration, the manager of the Besshi mine, Saihei Hirose, traveled to the Ikuno mine, which was operated by the government. At Ikuno, Hirose learned about Western mining technology from a French engineer employed by the government. After returning to Besshi, Hirose invited a mining engineer, Bruno L. Larroque, from France to come and work at Besshi. Following the advice of Larroque, Sumitomo modernized the Besshi mine by introducing Western technologies, including steam engines and machine drills (Sumitomo Metal Mining Co. 1991), which resolved the problems that Besshi faced in the Tokugawa period.

The second reason was the resolution of a market constraint. In the Tokugawa period, the copper produced in Japan was mainly exported to China and the Netherlands, but it was strictly controlled by the *Bakufu* (Sakudo 1982; Imai 2015). In 1871, the Meiji government liberalized domestic trade and exports of copper. As a result, copper became a major export good in the 1870s (Takeda 1987). Sumitomo responded swiftly to this policy change and in 1871, a branch was established in Kobe to sell copper to foreign trading houses (Sakudo 1982). This indicates that access to Western technologies and Western markets enabled the Besshi mine to grow, whereas it had not been able to grow as it aged previously because of its limited access to the necessary technologies and markets.

The other case involves Yamasa, which is a major soy sauce and food company dating back to the early eighteenth century that still operates in Japan today. Yamasa's founder, Gihei Hamaguchi, moved to Choshi in Chiba Prefecture and established a soy sauce plant (Hayashi 1990). Yamasa established itself as a soy sauce producer by increasing its sales in the Edo (Tokyo) market from the late seventeenth century. However, Yamasa's sales in Edo declined in the early nineteenth century because of the effects of regulations by the soy sauce merchant guild (*kabu nakama*) in Edo. Yamasa compensated for this decline in sales in Edo through increased sales in the local market. Nevertheless, total sales stagnated from the early nineteenth century (Shinoda 1987). The change in sales is reflected in that of employment (see Figure 2).

Although the number of employees at the Yamasa plant increased steadily from around 10 to around 20 in the 1810s, employment at the plant stagnated after that. Then, in the 1870s, employment increased again to more than 40 employees in the 1880s. Yamasa's company history states:

> There was an old saying in soy sauce industry that the upper limit of plant growth was 3,500 koku (=631 kl), but under the new economic regime after the Meiji Restoration a new trend of capitalist mass production came, and our company got on the trend. Furthermore, our company shifted sales to the Tokyo market with the largest population.

Whereas the total sales were split evenly between the Tokyo and local markets until 1871, in 1887, sales to these markets reached 90% and 10%, respectively. This was indeed a drastic change (Yamasa Soy Sauce Co. 1977, p. 139). Yamasa's case clearly indicates that restricted access to the Tokyo (Edo) market curbed plant growth and the removal of this restriction enabled the plant to grow.

The cases of these two plants are encouraging; i.e., the sizes of these plants were stagnant for more than 100 years in the Tokugawa period, but grew rapidly immediately following the Meiji Restoration. The transition from stagnancy to growth was clear. Furthermore, the reasons for the change in the experience-size profile at Besshi was the introduction of steam power, which resolved the problem of drainage that limited production. At Yamasa, access to a large market was improved by the abolition of the merchant guild, which allowed an increase in soy sauce production.

==== Figure 2 here ====

3 Data and descriptive analyses

3.1 Data

The Japanese Ministry of Agriculture and Commerce conducted censuses on manufacturing plants with 10 or more workers from the 1890s and the plant-level data were published in *Kojo Tsuran (Handbook of Factories)* from 1902 (Matsuda, Sato, and Kimura 1990). The 1902 edition of *Kojo Tsuran*, which was used here, contains information for all the private manufacturing plants in Japan with 10 or more workers, such as plant name, industry, product, location, owner, year and month of foundation, number of workers, and number and horsepower of engines by power source.[2] The plants were tabulated by industry and period of foundation (Table 2). An essential feature of our data set in the context of this paper is that the observations include a substantial number of plants founded before the regime change. Of the 7,586 firms in the sample, 346 were founded before 1859, the year in which Japan opened up to the rest of the world, while 1,018 were founded before 1880, when most institutional reforms were completed. Thus, these plants were operational both before and after the regime change.

==== Table 2 here ====

The key question is how the lifecycle of plants was affected by the regime change that occurred in Japan in the late 1850s. The plant lifecycle is characterized by the relationship between plant age (i.e., years since entry) and size (i.e., the experience-size profile). Figure 3 illustrates the experience-size profiles using 1902 data. The plant size is measured in terms of the number of workers and the size of the youngest group of plants (age 0–9 years) is normalized to 1. We computed the average size by 10-year age bins to show the cross-sectional experience-size profile as a ratio of plant size to the average plant size of the youngest group, i.e., aged less than 10 years.[3]

==== Figure 3 here ====

Our dataset allows us to show the experience-size profiles of plants by subgroups of plants classified by certain criteria. First, we focused on the distinction between export and nonexport industries because trade liberalization was an essential institutional change during this period. Figures 4 shows the manufactured goods exports from Japan by commodity category. Textiles were a major export of Japan until the early twentieth century. Hence, we classified the textile industry as the exporting industry and other industries as the nonexporting industries (Table 2). Figure 5 presents the experience-size

[2]As mentioned below, some mining plants were included in the data. *Kojo Tsuran* was published after the 1902 issue, but its later issues do not include data on the number of workers or power sources.

[3]To show the experience-size profiles, this paper used the approaches of Hsieh and Klenow (2014) and Lagakos et al. (2018a, 2018b).

profiles of the exporting and nonexporting industries. First, the profile of the exporting industry shows a peak at age 10–19 years like that of all the plants, while the profile of the nonexporting industries shows a peak at 20–29 years. Second, the slope from age 0–9 to 10–19 years was much steeper for the exporting industry. The steeper slope for the exporting industry suggests that the regime change had a larger impact on this industry and we can infer that the channel through which the regime change affected the plant lifecycle was the improved access to the international market.

==== Figures 4 and 5 here ====

Next, we divided the plants by technology. The opening of the country drastically improved access to modern technologies, as the case of the Besshi mine indicates, and its impact varied across industries according to technology intensity. Here, we measure the steam intensity of each industry by the percentage of the plant with steam power in the total plants in that industry, and classify an industry as a steam power-intensive industry if the percentage was higher than the average of the all industries (Table 2). Figure 6 shows the experience-size profiles of plants by steam power intensity. Both profiles have peaks at age 10–19 years, but the slope from 0–9 to 10–19 years is much steeper for the steam power-intensive industries, which is similar to the difference between the export and nonexport industries. The access to modern technologies is a likely channel through which the regime change affected the plant lifecycle.

==== Figure 6 here ====

Finally, we divide the plants by organizational form. *Kojo Tsuran* provides information on the names of the plant owners, which enables us to determine whether a plant was owned by a corporation or by an individual. Figure 7 compares the experience-size profiles of plants owned by corporations and those owned by individuals. First, the profile of the former group peaks at age 10–19 years, while the profile of the latter group peaks at 20–29 years. Second, the slope from ages 0–9 to 10–19 years was much steeper for the plants owned by corporations. We can infer that the availability of a corporate organization is another channel through which the regime change affected the plant lifecycle.

==== Figure 7 here ====

A simple graphical observation in this section suggests that the years of operation experience of a plant had different effects on plant growth before and after the regime change. This difference depends upon the attributes of the plants, such as export intensity, steam power intensity, and organizational form. In the following section, we analyze these observations using regression analyses.

4 Regressions analyses

4.1 Empirical strategy and baseline results

Based on the observations in the previous section, we conducted regression analyses on the impact of the regime change on the experience-size profiles of plants by exploiting the regime change in the late nineteenth century as a natural experiment. For this, we need to identify the timing of the regime change. Here, we assume that the regime change was primarily completed by the end of the 1870s based on the description in Section 2 and Figure 3. We check this assumption later. This assumption implies that plants operated in a traditional environment before 1880, whereas they operated in a modern environment after 1880. Accordingly, we regressed plant size (number of workers) on the years of operation under the traditional and modern environments. That is, we estimated the following linear equation as the baseline model:

$$y_{ijp} = \beta_1(\text{Experience after entry})_{ijp} + \beta_x(\text{Other controls})_{ijp} + u_{ijp}, \tag{1}$$

$$= \beta_1 \underbrace{(\text{Experience } \textbf{before } 1880)_{ijp}}_{\text{Traditional period}} + \beta_2 \underbrace{(\text{Experience } \textbf{after } 1880)_{ijp}}_{\text{Modern period}} + \beta_x(\text{Other controls})_{ijp} + u_{ijp}, \tag{2}$$

where y_{ijp} is the log of the number of workers at plant i in industry j, located in prefecture p in 1902. The explanatory variable "Experience before 1880" is the number of years between plant foundation and 1880, while "Experience after 1880" is the number of years from 1880 to 1902. "Other controls" refers to a set of explanatory variables including: a dummy variable of entry before and after 1880, which equals one if plants entered after 1880; a steam-powered plant dummy, which equals one if plants adopted steam power; an incorporated dummy, which equals to one if the plant was owned by a corporation; a prefecture capital dummy (i.e., located in urban area dummy), which equals one if the plant was located in the prefecture capital city; and county-level population.[4]

In addition, we controlled for the following industry-level dummy variables: (1) mining; (2) ceramics; (3) food processing; (4) textiles; (5) chemicals; (6) metals and machinery;[5] and (7) miscellaneous products. We also controlled for location using the following prefecture-level dummy variables: (1) Tokyo and its neighboring prefectures (Tokyo, Kanagawa, Chiba, Saitama, and Yamanashi); Osaka and its neighboring prefectures (Osaka, Kyoto, Hyogo, Nara, and Wakayama); (3) Aichi Prefecture; and (4) the rest of Japan. We estimate equations (1) and (2) by ordinary least squares. Table 3 summarizes these statistics. As shown in Table 3, the mean of plant size in terms of the number of workers is 58.4, and

[4] The county-level population was obtained from Bureau of Statistics, Cabinet Office (1903).

[5] Some power-generation plants are included in this category.

the mean of plant age is 13.74 years. It is notable that of the 13.74 years of mean plant age, 4.50 years are experience before 1880.

==== Table 3 here ====

The baseline estimation results are shown in Table 4. Column (1) reports the results of the estimation that does not distinguish between the years before and after 1880. The coefficient on experience after entry, i.e., plant age, is positive and statistically significant at the 1% level. The estimated coefficient of 0.001 indicates that, on average, a plant grows by 0.1 percentage points each year. In this sense, the average annual growth rate was very low. Column (2) also reports the results of the estimation that controls the entry after 1880 dummy. The estimated coefficient of experience after entry is almost zero and statistically insignificant. The entry after 1880 dummy is negative and statistically significant; i.e., the regime change had a negative impact on the intercept of the experience-size profile.

Column (3) distinguishes between experience before and after 1880. The coefficient on years after 1880 is positive and statistically significant at the 1% level. Furthermore, the average annual growth rate was as high as 1.6%. Also, the coefficient on experience before 1880 is notably close to zero. Thus, from 1880, plant growth accelerated substantially. The entry after 1880 dummy is statistically insignificant.

==== Table 4 here ====

4.2 Mechanisms

In the previous subsection, we revealed that operations experience before and after the regime change had different effects on plant growth. Then, through what channels did the regime change affect plant growth? In Section 3, by comparison of the shapes of the experience-size profiles between subgroups of plants, we inferred that access to export markets, access to modern technologies, and availability of corporate structure were the possible channels. We could test this inference econometrically using the variation in these possible channels. First, the source of variation in the value of access to export markets is the extent of the comparative advantage of the industry to which each plant belonged. If an industry has a comparative advantage, opening of trade would have a direct positive impact on the plants in that industry, whereas an industry without a comparative advantage would not, or could have even a negative impact on the plants. We can identify the extent of the comparative advantage of each industry by examining the actual exports and imports of its product after trade liberalization. As we have already seen, textiles were the major export goods from Japan in the late nineteenth and early twentieth centuries (Figure 4). Hence, we can infer that the plants in the textiles industry would have experienced a larger positive impact from the regime change that included trade liberalization.

We captured this relationship using the export industry dummy, which equals one if a plant was in the textiles industry, and zero otherwise.

Columns (1) and (2) of Table 5 report the estimation results after dividing the sample into the exporting and nonexporting industries. For both industry groups, the age effect was significantly positive only for experience after 1880, but the magnitude of the age effect after 1880 was substantially larger for the exporting industries. That is, the plants in the exporting industries enjoyed a larger positive impact from the regime change.

Second, the source of variation in the value of access to modern technologies was the applicability of those technologies to each industry. We regard those industries that intensively used steam power in 1902 as the industries with high applicability of modern technologies. Here we used the definition of steam power-intensive industries in Section 3. Columns (3) and (4) of Table 5 report the estimation results after separating the sample into steam power-intensive industries and nonintensive industries. For both industry groups, the age effect was significantly positive only for experience after 1880, but the magnitude of the age effect after 1880 was much larger for the steam power-intensive industries. Indeed, the industries with higher applicability of steam power experienced a larger positive impact on plant growth from the regime change.

Finally, the source of variation in the value of availability of corporate form was the applicability of the corporate form to each plant. As in Section 3, we classified plants into those owned by corporations and those owned by individuals. For both plant groups distinguished by ownership, the age effect was significantly positive only for experience after 1880, and the magnitude of the age effect after 1880 was much larger for the plants owned by corporations. Those results indicate that access to the export markets, access to modern technologies, and availability of corporate structure were the channels through which the regime change affected plant growth, and thereby changed the experience-size profile of plants.[6]

==== Table 5 here ====

4.3 Robustness checks

This subsection checks the robustness of the estimation results above. The most important issue is how to divide the sample period. In Subsection 4.2, we assumed that the regime change was completed by the end of 1870s based on historical information and Figure 3. Here we check whether this assumption is appropriate or not. To do this, we divided the whole period into four subperiods, i.e., before 1839, 1840–1859, 1860–1879, and after 1880, and estimated the age effects separately for these subperiods

[6] Appendix Table A1 also shows the results of the control variables (industry and prefecture controls) for the baseline results (Table 4) and testing channels (Table 5).

(Table 6). Column (1) reports the results for the full sample. Only the coefficient on experience after 1880 was found to be positive and significant. The coefficients on experience in the other four subperiods were insignificant or significantly negative. Columns (2) to (7) report the same results for the sample divided by plant attribute as in Subsection 4.2. The results are consistent. That is, all the coefficients on experience after 1880 were significantly positive, while all the coefficients on experience in the other periods were insignificant or significantly negative. These results indicate that the watershed between the traditional economic environment and the modern economic environment in Japan was located around 1880, and that the transition to the modern environment affected the plant lifecycle through the channels of access to the export markets, access to modern technologies, and availability of corporate structure.

==== Table 6 here ====

Tables 7 and 8 report the results of the other robustness checks. We checked whether the estimation results are driven by certain parts of the sample, i.e., the subsamples of very large or very small plants (top 5% largest, top 10% largest, bottom 5% smallest, or bottom 10% smallest samples), or very old plants (older than 300 years, 200 years or 100 years). We checked whether the baseline results are robust to dropping these largest and smallest plants (Table 7) and whether the baseline results are robust to dropping older plants (Table 8). We found that if we drop these subsamples, the results are qualitatively the same as those in Tables 4 and 5.

==== Tables 7 and 8 here ====

5 Growth of silk reeling plants before and after the regime change

By focusing on a specific industry, we can analyze the impact of the regime change on plant growth in more detail. Concerning the silk-reeling industry, *Zenkoku Seishi Kojo Chosa* (*National Census of Silk-Reeling Plants*) provided plant-level data on plant name, foundation year, location, number of employees, number of machines (pots), input of intermediate goods (cocoons), output (raw silk), and type of power source, for 1902, the same year as the *Kojo Tsuran* data used above. These data enable the measurement of labor productivity (output per worker), machine productivity (output per pot), and TFP of each plant. The total number of plants was 2,285, including machine-reeling (1,789) and hand-reeling plants (496). As these two types of plants had different technological features, we focused on machine-reeling plants, which were the major driver of the development of the silk-reeling industry (Arimoto, Nakajima, and Okazaki 2014).

The summary statistics of the key outcome variables and the explanatory variables are shown in Appendix Table A2. The average plant size (number of workers) was 56.2 and the standard deviation was 112.1. The minimum number of workers in a plant was five and the maximum number of workers is 2,234. The average number of pots was 58 with large standard deviation. However, the standard deviations of labor productivity, machine productivity, and TFP[7] were smaller, which suggests that the productivities were not closely associated with plant size. The main power sources were steam and water. Finally, the foundation years span from 1858 to 1899 (mean year, 1889). In the context of this paper, it is important to note that many plants were founded before 1880, which we identified as the year when the regime change was completed. In addition, Figure 8 shows the experience-size profile for the silk-reeling industry in terms of four different measures of plant size: (1) intermediate inputs (cocoons); (2) number of workers (labor); (3) number of pots (capital); and (4) physical output. Figure 8 shows that the growth of silk-reeling plants accelerated after the regime change in terms of all four scale measures.

Using the data, we estimate equation (2) in the previous section. In estimating the equation, we added the dummy variables representing the four prefectures where silk-reeling plants were most densely located, i.e., Aichi, Nagano, Yamanashi, and Gumma, considering that there was an agglomeration effect in the silk-reeling industry in prewar Japan (Arimoto et al. 2014).[8] Table 9 presents the estimation results, with six different dependent variables: (1) number of workers, (2) number of pots, (3) intermediate goods (cocoons), (4) physical output (raw silk), (5) physical output per worker, (6) physical output per pot, and (7) TFP. Columns (1) to (4) relate to plant scale, while columns (5) to (7) relate to productivity. The explanatory variables of interest were experience before 1880 and after 1880. Concerning plant scale, in all cases, the coefficients on experience before 1880 were positive but statistically insignificant, whereas in all cases, the coefficients on experience after 1880 were positive and strongly significant. Furthermore, it is remarkable that the magnitude of the coefficients on experience after 1880 were fairly large; i.e., with each additional year of operation, plant scale increased by around 3%. As we found in the previous section, plant growth accelerated after the regime change. For productivity, however, the coefficients for experience before 1880 and after 1880 were not statistically significant. In addition, the magnitude of the coefficients was small. This implies that years of operation did not have a positive impact on productivity on average in the silk-reeling industry in late nineteenth-century Japan.

Finally, we checked the robustness of the results by splitting the sample by power source, i.e. steam- and nonsteam-powered plants (Table 10). Figure 9 shows the average physical output for steam- and nonsteam-powered plants by experience years. Figure 9 suggests that acceleration of plant growth

[7]Appendix Table A3 shows estimation result of plant-level total factor productivity (TFP).
[8]Plant density was measured in terms of the number of plants per unit of area.

after the regime change was much larger for steam-powered plants than for nonsteam-powered plants. This observation is consistent with the regression results in Table 10. Panels A and B of Table 10 show the results for when we split the samples into steam- and nonsteam-powered plants. Panel A of Table 10 presents the results for the steam-powered plants. As shown in columns (1) to (4), experience after 1880 had a positive and significant impact on plant scale, whereas experience before 1880 had an insignificant but negative impact on plant scale. Panel B of Table 10 reports the estimation results for the plants without steam power. As in Panel B, the coefficients on experience after 1880 were positive and statistically significant, but the magnitudes of the coefficients were substantially smaller than those in Panel A. Furthermore, in columns (2) and (4), the coefficients on experience before 1880 were significantly positive and larger than the coefficients on experience before 1880. This indicates that the acceleration of plant growth after the regime change was larger for the plants using steam power, which is consistent with the findings in the previous section. With respect to productivity in all cases in panels A and B, the coefficients were not statistically significant.

This section focuses on the experience of the silk-reeling industry to check the robustness of the results in the previous section. We found that plant growth consistently accelerated after the regime change, regardless of scale measures. This pattern is the same as the findings in the previous section covering many different manufacturing industries. We also found that factor productivity measures, i.e., output per worker, output per pot, and TFP were not associated with years of operation both before and after the regime change.

==== Figures 8 and 9 here ====

==== Tables 9 and 10 here ====

6 Concluding remarks

The differences in the experience-size profiles of manufacturing plants between advanced and developing economies have attracted the interest of economists (Hsieh and Klenow 2009, 2014). In this paper, we empirically explored the mechanisms through which these differences arise using historical data from Japan. Japan experienced a drastic political, social, and economic regime change after the 1850s, i.e., the opening of the country to the rest of the world in 1859, the Meiji Restoration in 1868, and subsequent institutional reforms that were almost completed by the end of 1870s. We exploit this event as a natural experiment to investigate the implications of the traditional and modern environments before and after the regime change on the experience-size profiles of plants.

The main findings are as follows. First, plants grew much faster as they aged after the regime change than before. In other words, the experience-size profile of plants was much steeper after the regime change. Second, the acceleration of growth after the regime change was larger for plants in exporting industries, industries intensively using steam power, and plants adopting a corporate structure. These findings suggest that access to export markets, access to modern technologies and availability of the modern corporate structure were the channels through which the regime change affected the experience-size profile of plants. To check the robustness of our results, we focused on the silk-reeling industry, for which more detailed data are available. In the silk-reeling industry, the growth of plant scale consistently accelerated after the regime change, regardless of the scale measures, number of workers and machines, inputs of intermediate goods (cocoons), and output (raw silk), whereas productivity was not affected. We also showed the acceleration of plant growth from the 1870s using a long sample of time series data of plant scale from the eighteenth century for two plants. The evidence for these plants indicates that institutional changes including opening of the country and abolition of feudal regulations were the reason for this acceleration. These findings suggest that differences in institutions is an important reason for the current differences in the experience-size profiles of manufacturing plants between developed and developing countries.

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Tables and Figures

Table 1: Major changes in institutions

Classification	Year	Event
International trade	1859	Opening the international trade at three ports (Yokohama, Nagasaki and Hakodate)
	1866	Reduction of tariff rates 20% to 5%
Polity	1868	Transition of the administration from Shogun to Emperor
	1871	Substitution of prefectures for *han*
Class system	1871	Family Registration Act (Abolition of feudal class system)
	1871	Liberalization of choosing occupations
Land ownership and tax	1871	Liberalization of farm land utilization
	1872	Liberalization of land sales
	1873–1878	Establishment of the modern land ownership and the land tax system
Financial system	1872	National Bank Act
	1876	Amendment of the National Bank Act → Formation of the nationwide network of national banks
	1878	Establishment of the Tokyo Stock Exchange and the Osaka Stock Exchange
Corporation	1878	Relaxation of the regulation on founding corporations
Domestic commodity market	1869	Abolition of checking points (*sekisho*)
	1872–73	Dissolution of *kabu nakama*

Table 2: Description of sample plants by foundation year across industries

Foundation year	-1839		1840–59		1860–79		1880–		Total		Exporting	Use steam	Steam
Industry name	*N*	*Ratio*	*N*	*Ratio*	*N*	*Ratio*	*N*	*Ratio*	*N*	*Ratio*			*Ratio*
Silk reeling	2	0.9%	1	0.9%	200	29.6%	2,257	34.4%	2,460	32.4%	Yes	Yes	49.0%
Weaving	13	5.6%	10	9.1%	89	13.2%	1,473	22.4%	1,585	20.9%	Yes		3.6%
Ceramic	56	24.0%	23	20.9%	52	7.7%	285	4.3%	416	5.5%			8.9%
Tobacco	17	7.3%	21	19.1%	37	5.5%	279	4.2%	354	4.7%			13.0%
Brewing	75	32.2%	31	28.2%	79	11.7%	144	2.2%	329	4.3%			8.5%
Printing and binding	0	0.0%	0	0.0%	20	3.0%	192	2.9%	212	2.8%			8.0%
Cotton spinning	0	0.0%	0	0.0%	6	0.9%	199	3.0%	205	2.7%	Yes	Yes	53.7%
Firebomb	0	0.0%	0	0.0%	7	1.0%	198	3.0%	205	2.7%			15.6%
Mining	4	1.7%	0	0.0%	16	2.4%	170	2.6%	190	2.5%		Yes	45.8%
Wood and bamboo	4	1.7%	1	0.9%	11	1.6%	161	2.5%	177	2.3%			25.4%
Traditional flooring	0	0.0%	0	0.0%	0	0.0%	140	2.1%	140	1.8%			0.0%
Dyeing	3	1.3%	2	1.8%	14	2.1%	120	1.8%	139	1.8%			25.9%
Machinery	0	0.0%	0	0.0%	11	1.6%	122	1.9%	133	1.8%		Yes	60.2%
Paper products	1	0.4%	1	0.9%	10	1.5%	106	1.6%	118	1.6%		Yes	33.1%
Instrument	5	2.1%	6	5.5%	21	3.1%	77	1.2%	109	1.4%			27.5%
Other food products	10	4.3%	2	1.8%	31	4.6%	63	1.0%	106	1.4%			0.0%
Metal Instrument	11	4.7%	3	2.7%	13	1.9%	67	1.0%	94	1.2%			24.5%
Flour	0	0.0%	0	0.0%	2	0.3%	78	1.2%	80	1.1%		Yes	87.5%
Metal Refining	9	3.9%	6	5.5%	7	1.0%	53	0.8%	75	1.0%			18.7%
Misc	2	0.9%	1	0.9%	9	1.3%	62	0.9%	74	1.0%			21.6%
Ship and vehicle	8	3.4%	1	0.9%	11	1.6%	53	0.8%	73	1.0%		Yes	49.3%
Knitting	0	0.0%	0	0.0%	4	0.6%	53	0.8%	57	0.8%	Yes		22.8%
Pharmaceutical	2	0.9%	0	0.0%	3	0.4%	51	0.8%	56	0.7%		Yes	33.9%
Other chemical products	2	0.9%	1	0.9%	1	0.1%	19	0.3%	23	0.3%		Yes	34.8%
Oil and wax	1	0.4%	0	0.0%	1	0.1%	17	0.3%	19	0.3%		Yes	89.5%
Stone, bone, and shell	1	0.4%	0	0.0%	2	0.3%	15	0.2%	18	0.2%		Yes	33.3%
Sweets	4	1.7%	0	0.0%	4	0.6%	10	0.2%	18	0.2%			27.8%
Feather	1	0.4%	0	0.0%	0	0.0%	15	0.2%	16	0.2%			25.0%
Canned/bottled products	0	0.0%	0	0.0%	1	0.1%	14	0.2%	15	0.2%		Yes	86.7%
Electricity	0	0.0%	0	0.0%	0	0.0%	14	0.2%	14	0.2%		Yes	64.3%
Tannery	0	0.0%	0	0.0%	3	0.4%	11	0.2%	14	0.2%		Yes	35.7%
Tea	0	0.0%	0	0.0%	6	0.9%	8	0.1%	14	0.2%		Yes	50.0%
Leather	0	0.0%	0	0.0%	3	0.4%	9	0.1%	12	0.2%		Yes	33.3%
Lacquer	1	0.4%	0	0.0%	0	0.0%	9	0.1%	10	0.1%			20.0%
Soda and Ice	0	0.0%	0	0.0%	0	0.0%	8	0.1%	8	0.1%		Yes	75.0%
Fertilizer	1	0.4%	0	0.0%	0	0.0%	6	0.1%	7	0.1%		Yes	57.1%
Gas	0	0.0%	0	0.0%	0	0.0%	4	0.1%	4	0.1%			0.0%
Stitch work	0	0.0%	0	0.0%	0	0.0%	4	0.1%	4	0.1%	Yes		0.0%
Sugar	0	0.0%	0	0.0%	1	0.1%	2	0.0%	3	0.0%		Yes	66.7%
N	233	(100%)	110	(100%)	675	(100%)	6,568	(100%)	7,586	(100%)			28.1%

Source: *Handbook of Factories*s, 1902.
Notes: Steam power-intensive industries are equal to one if the steam power intensity of each industry is higher than the mean steam power intensity (28.1%).

Table 3: Summary statistics of dependent and explanatory variables

	Whole				Entry before 1880				Entry after 1880			
Variable	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Plant size (Number of workers)	58.36	187.34	10	7224	50.61	242.51	10	7224	59.56	177.25	10	5058
Entry after 1880	0.87	0.34	0	1	0.00	0.00	0	0	1.00	0.00	1	1
Experiences	13.74	31.43	0	1016	55.57	71.72	23	1016	7.26	5.56	0	22
Experience before 1880	4.50	28.65	0	994	33.57	71.72	1	994	0.00	0.00	0	0
Experience after 1880	9.24	7.21	0	22	22.00	0.00	22	22	7.26	5.56	0	22
Plant-level dummy variables												
Producing export products	0.57	0.50	0	1	0.32	0.47	0	1	0.61	0.49	0	1
Use steam power at the plant	0.28	0.45	0	1	0.12	0.33	0	1	0.31	0.46	0	1
Use non-steam power at the plant	0.18	0.39	0	1	0.19	0.39	0	1	0.18	0.38	0	1
Steam power intensive industry	0.46	0.50	0	1	0.30	0.46	0	1	0.48	0.50	0	1
Incorporated	0.16	0.37	0	1	0.03	0.16	0	1	0.18	0.39	0	1
Located in the prefecture capital	0.23	0.42	0	1	0.26	0.44	0	1	0.23	0.42	0	1
Plant-level location variable												
County population (ln)	11.54	0.99	5.92	14.41	11.60	1.04	6.90	14.41	11.53	0.98	5.92	14.41
N	7586				1018				6568			

Source: *Handbook of Factories*, 1902.

Table 4: Results of baseline regressions– Experiences during modern regime affects lifecycles

	(1)	(2)	(3)
Experiences	0.001***	0.000	
	(0.000)	(0.000)	
Experience before 1880			-0.000
			(0.000)
Experience after 1880			0.016***
			(0.002)
Entry after 1880		-0.152***	0.039
		(0.031)	(0.037)
Use steam power at the plant	0.654***	0.659***	0.661***
	(0.023)	(0.023)	(0.023)
Use non-steam power at the plant	0.429***	0.427***	0.417***
	(0.026)	(0.025)	(0.025)
Incorporated	0.682***	0.693***	0.722***
	(0.033)	(0.033)	(0.033)
Located urban area in the county	0.059**	0.059**	0.041
	(0.028)	(0.028)	(0.028)
County population (ln)	0.065***	0.066***	0.066***
	(0.013)	(0.013)	(0.013)
Exporting products	0.392***	0.418***	0.426***
	(0.028)	(0.028)	(0.028)
Other industry controls	Yes	Yes	Yes
Regional controls	Yes	Yes	Yes
Constant	1.931***	2.040***	1.732***
	(0.148)	(0.149)	(0.152)
N	7,586	7,586	7,586
R^2	0.298	0.300	0.308

Notes: The reference for the entry period dummies is the period before 1879. Industry-level control variables are: (1) mining; (2) ceramics; (3) food processing (tobacco, brewing, flour, sweets, sugar, canned and bottled products, and tea); (4) export products (including silk-reeling, cotton spinning, and weaving industries); (5) chemical products (printing and binding, firebomb, paper products, pharmaceutical products, oil and wax, feather, tannery, leather, lacquer, fertilizer, and gas); (6) electric and metal products (machinery, instruments, metal instruments, metal refining, ships and vehicles, and electricity); (7) miscellaneous products (traditional flooring, dyeing, stone, bone, shell, and other miscellaneous products). The reference for the industry-level control variables is the food-processing industry. Prefecture-level control variables are: (1) Tokyo-neighboring prefectures (Tokyo, Kanagawa, Chiba, Saitama, and Yamanashi); (2) Osaka-neighboring prefectures (Osaka, Kyoto, Hyogo, Nara, and Wakayama); (3) Aichi Prefecture; (4) the rest of Japan. Other plant-level covariates include dummy variables of utilizing steam power at the plant, utilizing nonsteam power at the plant, whether the plant is incorporated, located in the prefecture capital, and county-level population. Robust standard errors in parentheses. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Regressions results for testing channels– Experiences during modern institutional reforms affect lifecycles, especially for plants with better market access, technology, and incorporation

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Exporting industries	Non-exporting industries	Steam power intensive	Non-steam intensive	Corporate enterprise	Non-corporate enterprise
Experience before 1880	-0.005**	0.000	-0.000	0.000	0.001	-0.000
	(0.002)	(0.000)	(0.001)	(0.000)	(0.008)	(0.000)
Experience after 1880	0.018***	0.010***	0.020***	0.009***	0.043***	0.010***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880	-0.103*	0.131**	-0.142**	0.149***	0.491*	-0.013
	(0.059)	(0.051)	(0.068)	(0.043)	(0.254)	(0.036)
Exporting products			1.071***	0.201***	0.938***	0.300***
			(0.076)	(0.033)	(0.090)	(0.027)
Use steam power at the plant	0.810***	0.400***	0.746***	0.589***	0.711***	0.628***
	(0.026)	(0.043)	(0.031)	(0.054)	(0.065)	(0.023)
Use non-steam power at the plant	0.445***	0.355***	0.497***	0.247***	0.554***	0.396***
	(0.030)	(0.048)	(0.037)	(0.041)	(0.088)	(0.026)
Incorporated	0.930***	0.514***	0.912***	0.532***		
	(0.046)	(0.044)	(0.048)	(0.042)		
Located urban area in the county	0.077**	0.055	0.020	0.079**	0.064	0.027
	(0.038)	(0.040)	(0.058)	(0.031)	(0.087)	(0.027)
County population (ln)	0.131***	0.013	0.087***	0.048***	-0.025	0.080***
	(0.023)	(0.017)	(0.026)	(0.015)	(0.041)	(0.013)
Other industry controls	Yes	Yes	Yes	Yes	Yes	Yes
Regional controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.462***	2.384***	0.923***	2.079***	2.442***	1.788***
	(0.271)	(0.189)	(0.305)	(0.169)	(0.518)	(0.147)
N	4,311	3,275	3,462	4,124	1,223	6,363
R^2	0.388	0.253	0.346	0.218	0.281	0.225

Notes: The reference for the entry period dummies is the period before 1879. Industry-level control variables are: (1) mining; (2) ceramics; (3) food processing (tobacco, brewing, flour, sweets, sugar, canned and bottled products, and tea); (4) export products (including silk-reeling, cotton spinning, and weaving industries); (5) chemical products (printing and binding, firebomb, paper products, pharmaceutical products, oil and wax, feather, tannery, leather, lacquer, fertilizer, and gas); (6) electric and metal products (machinery, instruments, metal instruments, metal refining, ships and vehicles, and electricity); (7) miscellaneous products (traditional flooring, dyeing, stone, bone, shell, and other miscellaneous products). The reference for the industry-level control variables is the food-processing industry. Prefecture-level control variables are: (1) Tokyo-neighboring prefectures (Tokyo, Kanagawa, Chiba, Saitama, and Yamanashi); (2) Osaka-neighboring prefectures (Osaka, Kyoto, Hyogo, Nara, and Wakayama); (3) Aichi Prefecture; (4) the rest of Japan. Other plant-level covariates include dummy variables of utilizing steam power at the plant, utilizing nonsteam power at the plant, whether the plant is incorporated, located in the prefecture capital, and county-level population. Robust standard errors in parentheses. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Detecting the period of the regime change

Sample	(1) Whole	(2) Exporting industries	(3) Non-Exporting industries	(4) Steam power intensive	(5) Non-steam intensive	(6) Corporate enterprise	(7) Non-corporate enterprise
Experience before 1839	-0.000	-0.000	-0.000	0.003	-0.000	0.086	-0.000
	(0.000)	(0.001)	(0.000)	(0.003)	(0.000)	(0.107)	(0.000)
Experience between 1840-1859	-0.009	-0.032*	-0.008	-0.064	-0.011		-0.010
	(0.012)	(0.019)	(0.012)	(0.049)	(0.011)		(0.011)
Experience between 1860-1879	-0.023***	-0.029***	-0.012*	-0.015	-0.015**	-0.065	-0.025***
	(0.006)	(0.009)	(0.007)	(0.013)	(0.007)	(0.043)	(0.006)
Experience after 1880	0.016***	0.019***	0.010***	0.020***	0.009***	0.043***	0.010***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry between 1840-1859	-0.167	-0.664**	-0.127	-1.002*	-0.171		-0.200
	(0.150)	(0.271)	(0.158)	(0.605)	(0.146)		(0.146)
Entry between 1860-1879	-0.496**	-0.783*	-0.394	-1.226	-0.492**	0.890	-0.523**
	(0.249)	(0.448)	(0.266)	(1.052)	(0.245)	(2.664)	(0.245)
Entry after 1880	-0.574**	-0.948**	-0.335	-1.365	-0.447*	1.121	-0.681***
	(0.263)	(0.465)	(0.292)	(1.062)	(0.270)	(2.724)	(0.259)
Exporting products	0.410***			1.070***	0.200***	0.938***	0.276***
	(0.029)			(0.076)	(0.033)	(0.090)	(0.028)
Use steam power at the plant	0.658***	0.806***	0.401***	0.745***	0.591***	0.709***	0.624***
	(0.023)	(0.026)	(0.043)	(0.031)	(0.054)	(0.065)	(0.023)
Use non-steam power at the plant	0.410***	0.438***	0.353***	0.498***	0.244***	0.549***	0.387***
	(0.025)	(0.030)	(0.048)	(0.037)	(0.041)	(0.088)	(0.026)
Incorporated	0.721***	0.928***	0.513***	0.911***	0.532***		
	(0.033)	(0.046)	(0.044)	(0.048)	(0.042)		
Located urban area in the county	0.039	0.078**	0.055	0.021	0.080***	0.062	0.026
	(0.028)	(0.038)	(0.040)	(0.058)	(0.031)	(0.087)	(0.027)
County population (ln)	0.066***	0.132***	0.013	0.086***	0.048***	-0.026	0.080***
	(0.013)	(0.023)	(0.017)	(0.026)	(0.015)	(0.042)	(0.013)
Other industry controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	2.366***	2.303***	2.858***	2.148**	2.685***	1.826	2.484***
	(0.301)	(0.525)	(0.341)	(1.085)	(0.313)	(2.777)	(0.294)
N	7,586	4,311	3,275	3,462	4,124	1,223	6,363
R^2	0.309	0.390	0.254	0.347	0.219	0.282	0.227

Notes: The reference for the entry period dummies is the period before 1879. Industry-level control variables are: (1) mining; (2) ceramics; (3) food processing (tobacco, brewing, flour, sweets, sugar, canned and bottled products, and tea); (4) export products (including silk-reeling, cotton spinning, and weaving industries); (5) chemical products (printing and binding, firebomb, paper products, pharmaceutical products, oil and wax, feather, tannery, leather, lacquer, fertilizer, and gas); (6) electric and metal products (machinery, instruments, metal instruments, metal refining, ship and vehicle, and electricity); (7) miscellaneous products (traditional flooring, dyeing, stone, bone, shell, and other miscellaneous products). The reference for the industry-level control variables is the food-processing industry. Prefecture-level control variables are: (1) Tokyo-neighboring prefectures (Tokyo, Kanagawa, Chiba, Saitama, and Yamanashi); (2) Osaka-neighboring prefectures (Osaka, Kyoto, Hyogo, Nara, and Wakayama); (3) Aichi Prefecture; (4) the rest of Japan. Other plant-level covariates include dummy variables of utilizing steam power at the plant, utilizing nonsteam power at the plant, whether the plant is incorporated, located in the prefecture capital, and county-level population. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Robustness checks– The main results are not driven by largest and smallest plants

Sample	(1) Whole	(2) Exporting industries	(3) Non-Exporting industries	(4) Steam power intensive	(5) Non-steam intensive	(6) Corporate enterprise	(7) Non-corporate enterprise
Panel A: Drop top 5% largest							
Experience before 1880	-0.000	-0.006**	0.000	0.000	0.000	0.005	-0.000
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.007)	(0.000)
Experience after 1880	0.010***	0.013***	0.004*	0.013***	0.005***	0.023***	0.008***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.001)
Entry after 1880 (dummy)	0.012	-0.114**	0.075*	-0.129**	0.081**	0.249	-0.006
	(0.030)	(0.052)	(0.040)	(0.054)	(0.037)	(0.170)	(0.031)
Constant	1.946***	1.896***	2.590***	1.466***	2.208***	2.949***	1.891***
	(0.122)	(0.193)	(0.158)	(0.223)	(0.146)	(0.376)	(0.129)
N	7,203	4,097	3,106	3,202	4,001	1,010	6,193
R^2	0.251	0.341	0.180	0.289	0.173	0.185	0.217
Panel B: Drop top 10% largest							
Experience before 1880	-0.000	-0.004**	0.000	0.001	-0.000	-0.004	-0.000
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.007)	(0.000)
Experience after 1880	0.008***	0.011***	0.002	0.010***	0.004**	0.018***	0.007***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.001)
Entry after 1880 (dummy)	0.015	-0.034	0.025	-0.091*	0.059*	0.005	0.003
	(0.027)	(0.045)	(0.037)	(0.050)	(0.034)	(0.148)	(0.028)
Constant	2.068***	1.903***	2.726***	1.420***	2.357***	3.345***	2.005***
	(0.114)	(0.183)	(0.147)	(0.201)	(0.138)	(0.345)	(0.122)
N	6,824	3,867	2,957	2,956	3,868	845	5,979
R^2	0.211	0.308	0.127	0.264	0.121	0.175	0.200
Panel C: Drop bottom 5% smallest							
Experience before 1880	-0.000	-0.005**	0.000	0.001	0.000	0.007	-0.000
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.006)	(0.000)
Experience after 1880	0.015***	0.017***	0.009***	0.019***	0.008***	0.041***	0.009***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880 (dummy)	0.008	-0.127**	0.103*	-0.150**	0.112**	0.478*	-0.043
	(0.037)	(0.059)	(0.053)	(0.069)	(0.044)	(0.257)	(0.037)
Constant	1.824***	1.639***	2.315***	1.163***	2.133***	2.202***	1.950***
	(0.156)	(0.281)	(0.192)	(0.312)	(0.174)	(0.515)	(0.149)
N	7,088	4,092	2,996	3,315	3,773	1,183	5,905
R^2	0.308	0.376	0.266	0.336	0.232	0.273	0.221
Panel D: Drop bottom 10% smallest							
Experience before 1880	-0.000	-0.004**	0.000	0.001	0.000	0.007	-0.000*
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.006)	(0.000)
Experience after 1880	0.014***	0.016***	0.009***	0.019***	0.007***	0.041***	0.009***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880 (dummy)	-0.007	-0.125**	0.088	-0.145**	0.091**	0.498*	-0.060
	(0.038)	(0.059)	(0.055)	(0.070)	(0.045)	(0.257)	(0.038)
Constant	2.039***	1.911***	2.390***	1.378***	2.311***	2.201***	2.195***
	(0.160)	(0.286)	(0.197)	(0.319)	(0.178)	(0.517)	(0.153)
N	6,756	3,938	2,818	3,216	3,540	1,166	5,590
R^2	0.299	0.368	0.258	0.323	0.232	0.273	0.210

Notes: see Table 8.

Table 8: Robustness checks (continued)– The main results are not driven by older plants

Sample	(1) Whole	(2) Exporting industries	(3) Non-Exporting industries	(4) Steam power intensive	(5) Non-steam intensive	(6) Corporate enterprise	(7) Non-corporate enterprise
Panel E: Drop age>=300 sample							
Experience before 1880	0.000	-0.009**	0.001	-0.000	0.001	0.001	-0.000
	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)	(0.008)	(0.001)
Experience after 1880	0.016***	0.018***	0.010***	0.020***	0.010***	0.043***	0.010***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880 (dummy)	0.046	-0.133**	0.153***	-0.142**	0.163***	0.491*	-0.010
	(0.039)	(0.064)	(0.054)	(0.068)	(0.045)	(0.254)	(0.039)
Constant	1.725***	1.498***	2.366***	0.923***	2.063***	2.442***	1.784***
	(0.153)	(0.273)	(0.190)	(0.305)	(0.170)	(0.518)	(0.148)
N	7,578	4,310	3,268	3,462	4,116	1,223	6,355
R^2	0.308	0.388	0.254	0.346	0.218	0.281	0.224
Panel F: Drop age>=200 sample							
Experience before 1880	-0.001	-0.009**	0.001	-0.005**	0.001	0.001	-0.001
	(0.001)	(0.004)	(0.001)	(0.002)	(0.001)	(0.008)	(0.001)
Experience after 1880	0.016***	0.018***	0.010***	0.020***	0.010***	0.043***	0.010***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880 (dummy)	0.035	-0.133**	0.154***	-0.176**	0.174***	0.491*	-0.026
	(0.041)	(0.064)	(0.057)	(0.069)	(0.048)	(0.254)	(0.040)
Constant	1.747***	1.498***	2.384***	0.992***	2.041***	2.442***	1.814***
	(0.153)	(0.273)	(0.191)	(0.305)	(0.171)	(0.518)	(0.148)
N	7,548	4,310	3,238	3,454	4,094	1,223	6,325
R^2	0.308	0.388	0.253	0.347	0.218	0.281	0.224
Panel G: Drop age>=100 sample							
Experience before 1880	-0.001	-0.010*	0.002	-0.008	0.002*	0.001	-0.002
	(0.001)	(0.005)	(0.001)	(0.005)	(0.001)	(0.008)	(0.001)
Experience after 1880	0.016***	0.018***	0.010***	0.020***	0.010***	0.043***	0.010***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880 (dummy)	0.024	-0.142**	0.175***	-0.194**	0.196***	0.491*	-0.040
	(0.043)	(0.069)	(0.061)	(0.076)	(0.051)	(0.254)	(0.043)
Constant	1.739***	1.503***	2.349***	1.003***	2.005***	2.442***	1.804***
	(0.156)	(0.273)	(0.194)	(0.306)	(0.174)	(0.518)	(0.151)
N	7,462	4,309	3,153	3,447	4,015	1,223	6,239
R^2	0.309	0.388	0.255	0.347	0.221	0.281	0.226

Notes: The reference for the entry period dummies is the period before 1879. Industry-level control variables are: (1) mining; (2) ceramics; (3) food processing (tobacco, brewing, flour, sweets, sugar, canned and bottled products, and tea); (4) export products (including silk-reeling, cotton spinning, and weaving industries); (5) chemical products (printing and binding, firebomb, paper products, pharmaceutical products, oil and wax, feather, tannery, leather, lacquer, fertilizer, and gas); (6) electric and metal products (machinery, instruments, metal instruments, metal refining, ship and vehicle, and electricity); (7) miscellaneous products (traditional flooring, dyeing, stone, bone, shell, and other miscellaneous products). The reference for the industry-level control variables is the food-processing industry. Prefecture-level control variables are: (1) Tokyo-neighboring prefectures (Tokyo, Kanagawa, Chiba, Saitama, and Yamanashi); (2) Osaka-neighboring prefectures (Osaka, Kyoto, Hyogo, Nara, and Wakayama); (3) Aichi Prefecture; (4) the rest of Japan. Other plant-level covariates include dummy variables of utilizing steam power at the plant, utilizing nonsteam power at the plant, whether the plant is incorporated, located in the prefecture capital, and county-level population. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Results of the machine-reeling plants in the silk-reeling industry

	Physical inputs and output				Productivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Unit: ln	Worker	Pot	Input	Output	Output per worker	Output per pot	TFP
Experience before 1880	0.012	0.022	0.013	0.020	0.008	-0.002	0.006
	(0.020)	(0.019)	(0.024)	(0.024)	(0.011)	(0.014)	(0.008)
Experience after 1880	0.027***	0.025***	0.030***	0.030***	0.003	0.004	-0.001
	(0.004)	(0.004)	(0.006)	(0.006)	(0.003)	(0.003)	(0.001)
Entry after 1880	0.175	0.225**	0.165	0.226	0.051	0.002	0.055
	(0.120)	(0.114)	(0.146)	(0.142)	(0.072)	(0.078)	(0.043)
Water power	0.430***	0.527***	0.343***	0.390***	-0.039	-0.137***	
	(0.054)	(0.055)	(0.075)	(0.074)	(0.042)	(0.044)	
Steam power	0.976***	1.024***	1.286***	1.362***	0.386***	0.339***	
	(0.045)	(0.045)	(0.064)	(0.062)	(0.036)	(0.038)	
Aichi	-0.079	-0.039	0.051	0.066	0.145***	0.105**	0.040
	(0.057)	(0.057)	(0.078)	(0.078)	(0.049)	(0.050)	(0.026)
Nagano	0.443***	0.460***	1.039***	1.092***	0.649***	0.632***	0.089***
	(0.069)	(0.068)	(0.085)	(0.085)	(0.040)	(0.044)	(0.018)
Yamanashi	0.679***	0.596***	0.752***	0.814***	0.134*	0.218***	0.039
	(0.131)	(0.128)	(0.152)	(0.151)	(0.082)	(0.072)	(0.038)
Gumma	0.081	0.003	0.661***	0.784***	0.703***	0.780***	0.177***
	(0.086)	(0.095)	(0.100)	(0.105)	(0.112)	(0.121)	(0.038)
Constant	2.365***	2.319***	3.994***	5.603***	3.238***	3.284***	-0.066
	(0.143)	(0.140)	(0.183)	(0.180)	(0.097)	(0.105)	(0.051)
N	1,979	1,979	1,979	1,979	1,979	1,979	1,979
R^2	0.219	0.221	0.247	0.267	0.177	0.154	0.024

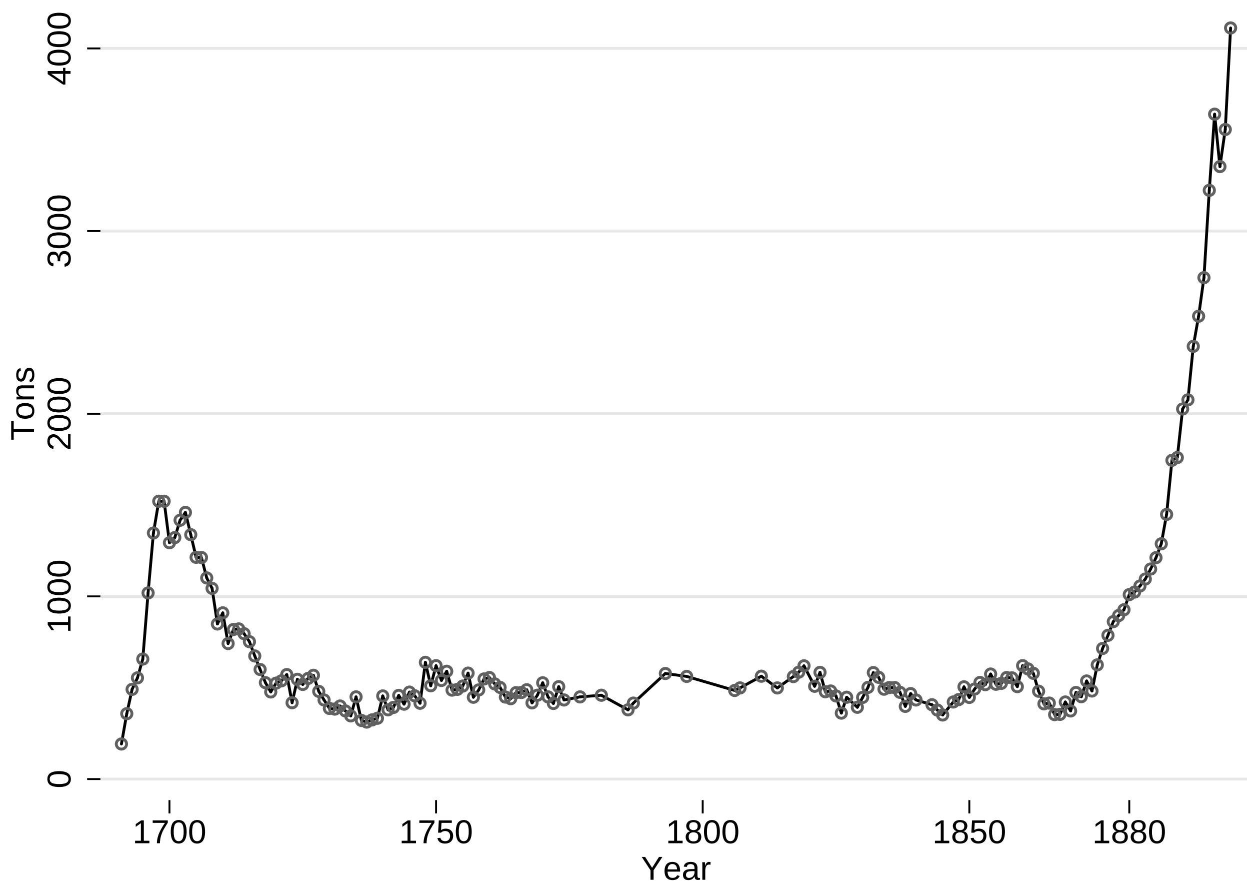
Notes: The reference for the entry period dummies is the period before 1879. The reference for the prefecture control is other than Aichi, Nagano, Yamanashi, and Gumma, which were the four most-dense prefectures for silk-reeling plants. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 10: Robustness checks for the machine-reeling plants in the silk-reeling industry

	Physical inputs and output				Productivity		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Unit: ln	Worker	Pot	Input	Output	Output per worker	Output per pot	TFP
Panel A: Steam powered plants							
Experience before 1880	-0.026	-0.023	-0.038	-0.038	-0.012	-0.014	-0.000
	(0.046)	(0.042)	(0.057)	(0.057)	(0.023)	(0.026)	(0.013)
Experience after 1880	0.033***	0.031***	0.038***	0.037***	0.004	0.006	-0.001
	(0.005)	(0.006)	(0.008)	(0.008)	(0.004)	(0.004)	(0.002)
Entry after 1880	0.014	0.070	0.023	0.033	0.019	-0.037	0.008
	(0.244)	(0.224)	(0.292)	(0.291)	(0.122)	(0.136)	(0.069)
Constant	3.402***	3.407***	5.337***	7.079***	3.677***	3.672***	0.023
	(0.263)	(0.246)	(0.322)	(0.321)	(0.143)	(0.159)	(0.079)
N	931	931	931	931	931	931	931
R^2	0.119	0.116	0.090	0.092	0.023	0.017	0.003
Panel B: No steam powered plants							
Experience before 1880	0.036	0.050**	0.035	0.045*	0.009	-0.006	0.007
	(0.023)	(0.023)	(0.025)	(0.025)	(0.013)	(0.016)	(0.010)
Experience after 1880	0.018***	0.016***	0.021***	0.021***	0.003	0.004	-0.001
	(0.006)	(0.006)	(0.008)	(0.008)	(0.004)	(0.004)	(0.002)
Entry after 1880	0.180	0.211	0.146	0.229	0.049	0.018	0.070
	(0.137)	(0.139)	(0.173)	(0.165)	(0.088)	(0.097)	(0.057)
Constant	2.750***	2.781***	4.315***	5.931***	3.180***	3.149***	-0.121*
	(0.176)	(0.180)	(0.229)	(0.223)	(0.120)	(0.130)	(0.070)
N	1,048	1,048	1,048	1,048	1,048	1,048	1,048
R^2	0.108	0.106	0.197	0.218	0.234	0.205	0.050

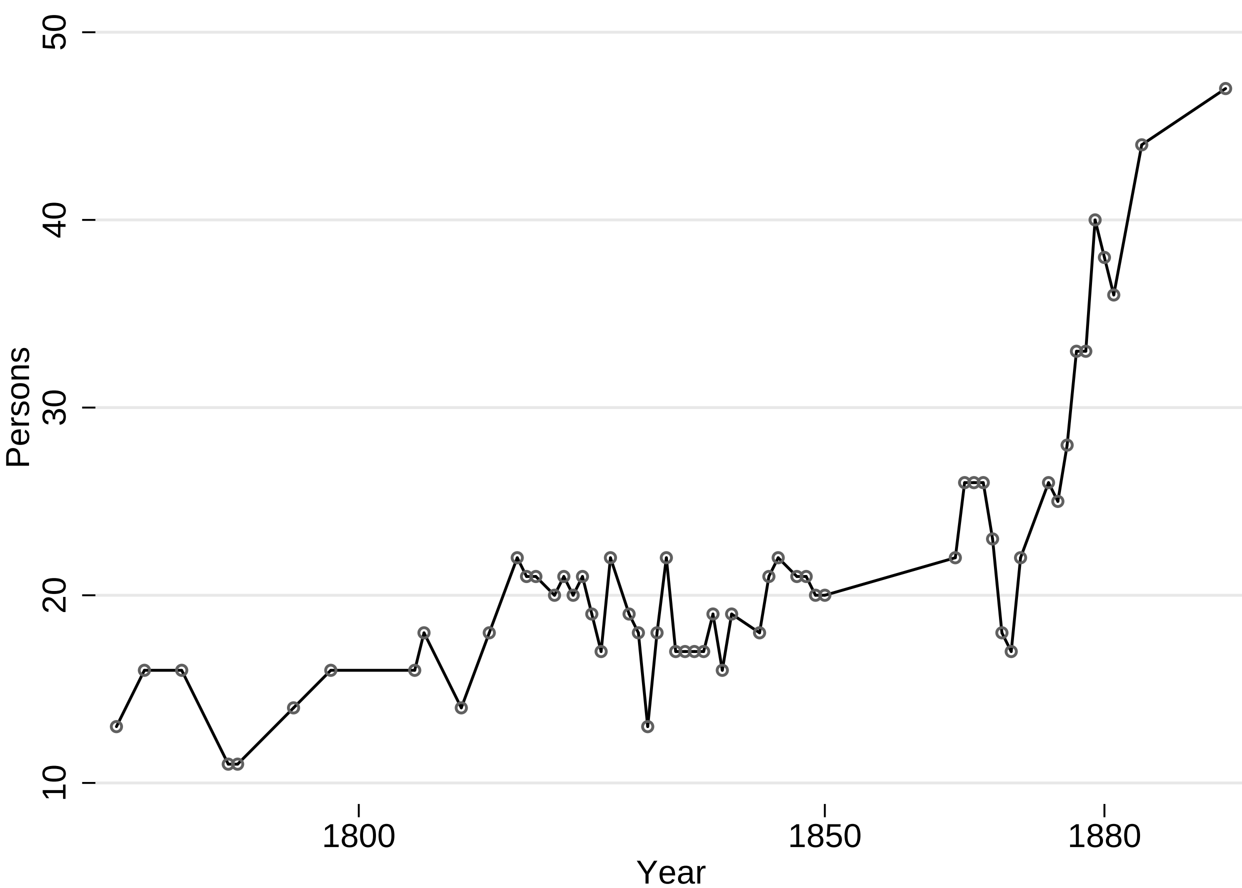
Notes: The reference for the entry period dummies is the period before 1879. We used control dummy variables of water-power use and steam-power use at the plant level. The reference for the prefecture control is other than Aichi, Nagano, Yamanashi, and Gumma, which were the four most-dense prefectures for silk-reeling plants. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Production of copper at Sumitomo Besshi Mine (Unit: Tons), 1691–1899



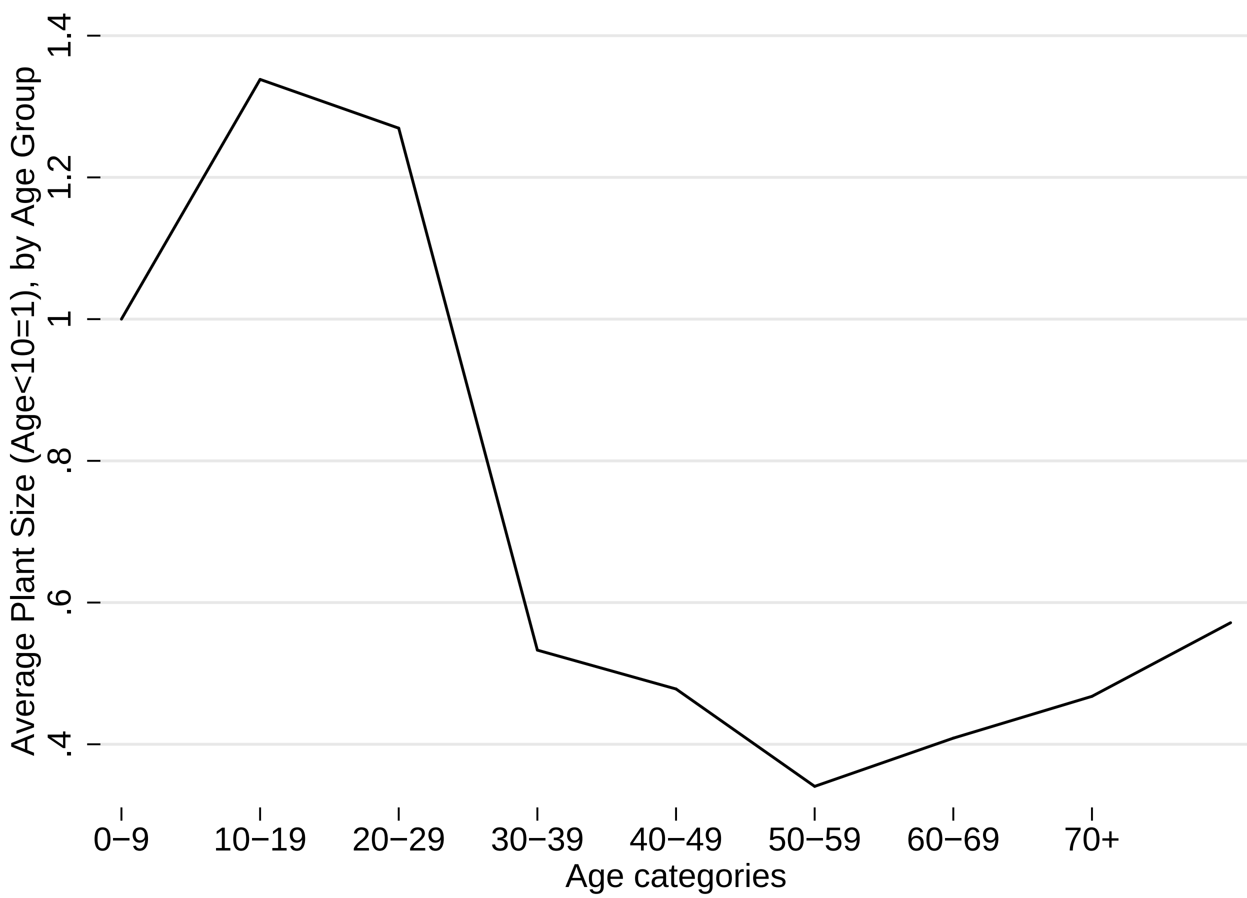
Source: Sumitomo Metal Mining Co. ed. *Sumitomo Besshi Kozan-shi*, appendix volume, 1991.

Figure 2: Number of employees at Yamasa Soy Sauce (Unit: Persons), 1774–1893



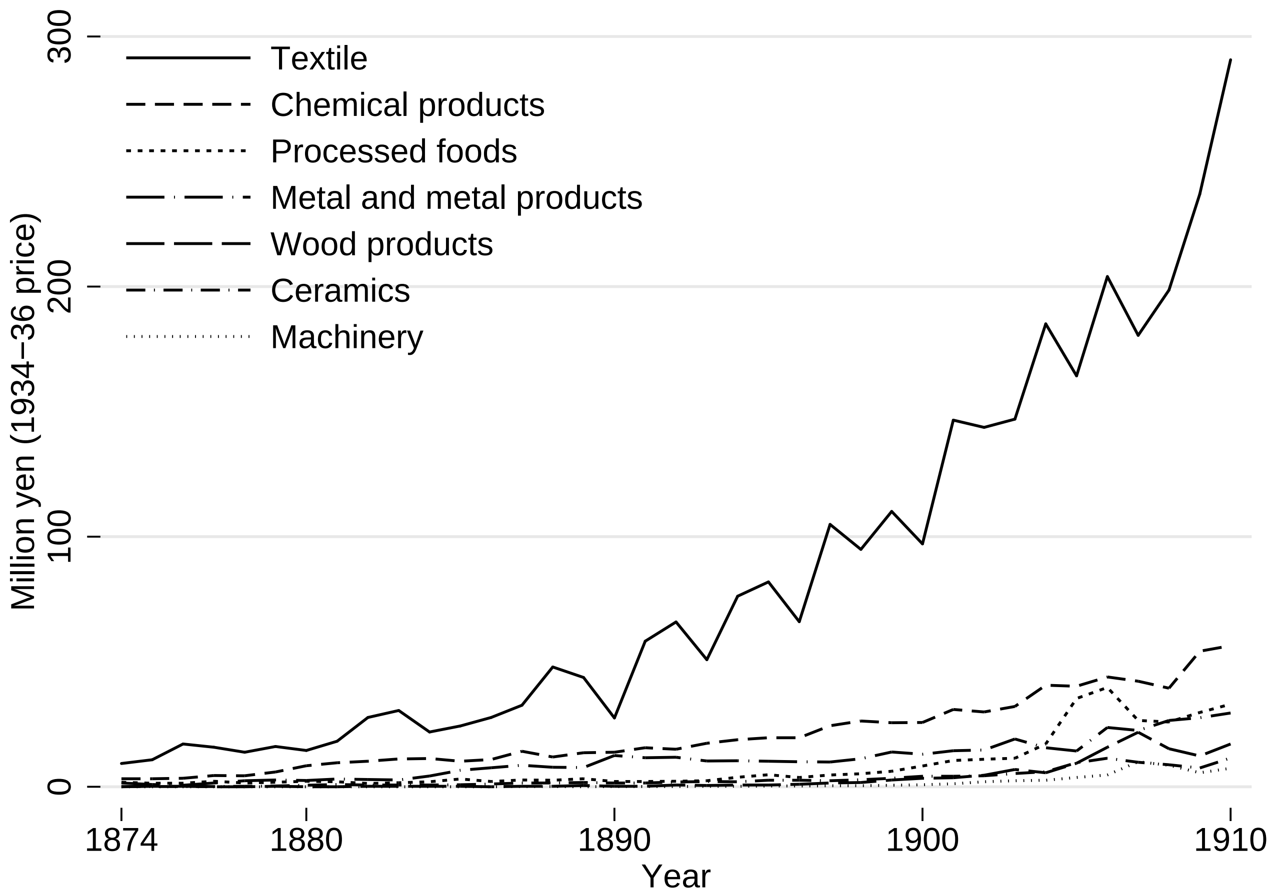
Source: Suzuki (1990), pp.146-7.
Notes: Those workers who were not employed for a full year were converted into workers employed for a full year by multiplying their length of employment by (days of employment/360).

Figure 3: First look at how transition to modern regime affects age-size profile in 1902 using average plant size, by experience group



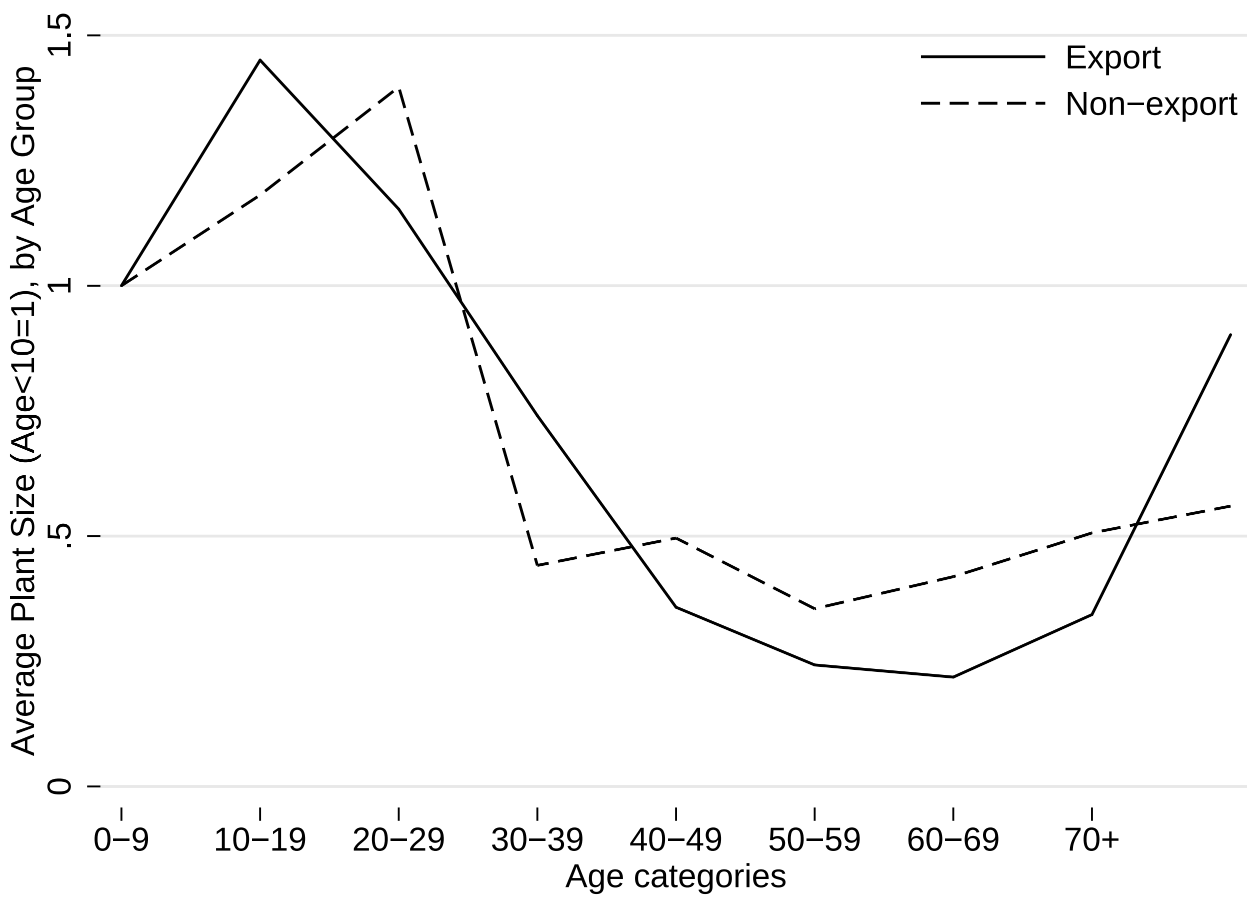
Notes: The figure compares plant size and plant experience (age) in 1902, i.e., experience-size profile. The plant size is measured in terms of the number of workers within each experience group. The size of the youngest group (ages 0–9) is normalized to 1. We compute the average plant size by 10-year experience bin to show the cross-sectional experience-size profile as a ratio of plant size relative to the average plant size of the youngest group, i.e., age less than 10 years (ages 0–9).

Figure 4: Export values of manufactured goods from Japan (Unit: Million yen)



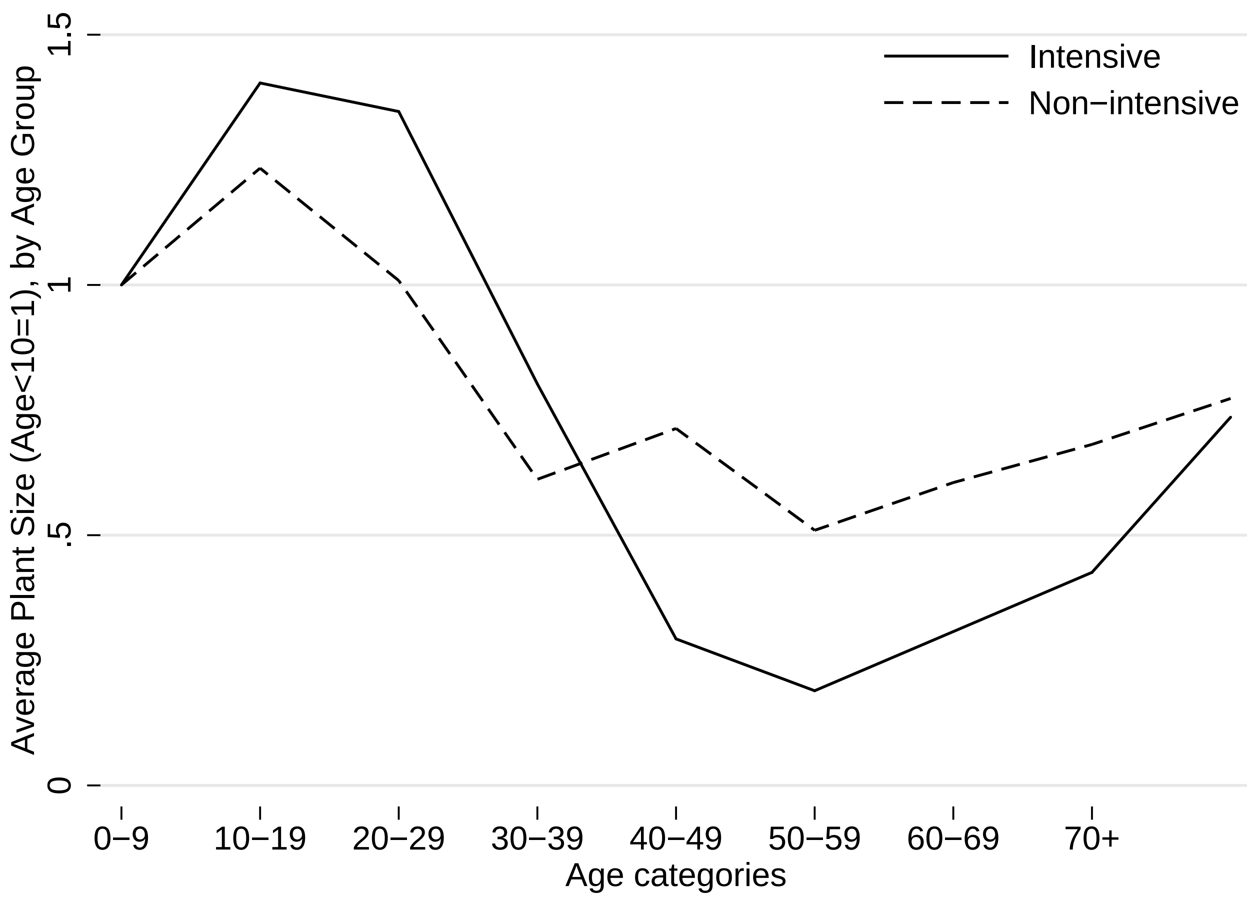
Source: Source: Yamamoto and Yamazawa (1979), pp.184–185.
Notes: The figure gives export values of several manufactured goods from Japan in each year between 1874 and 1910. Manufactured goods include the following products: Textiles (solid line); Chemical products (dashed line); Processed foods; Metal and metal products; Wood products; Ceramics; Machinery for ordering export values in 1910. The export values of manufactured goods are normalized by the prices of 1934–36 and are measured in million Japanese yen.

Figure 5: Plants producing export goods were more likely to grow as they age after the period of institutional changes compared with plants producing nonexport goods



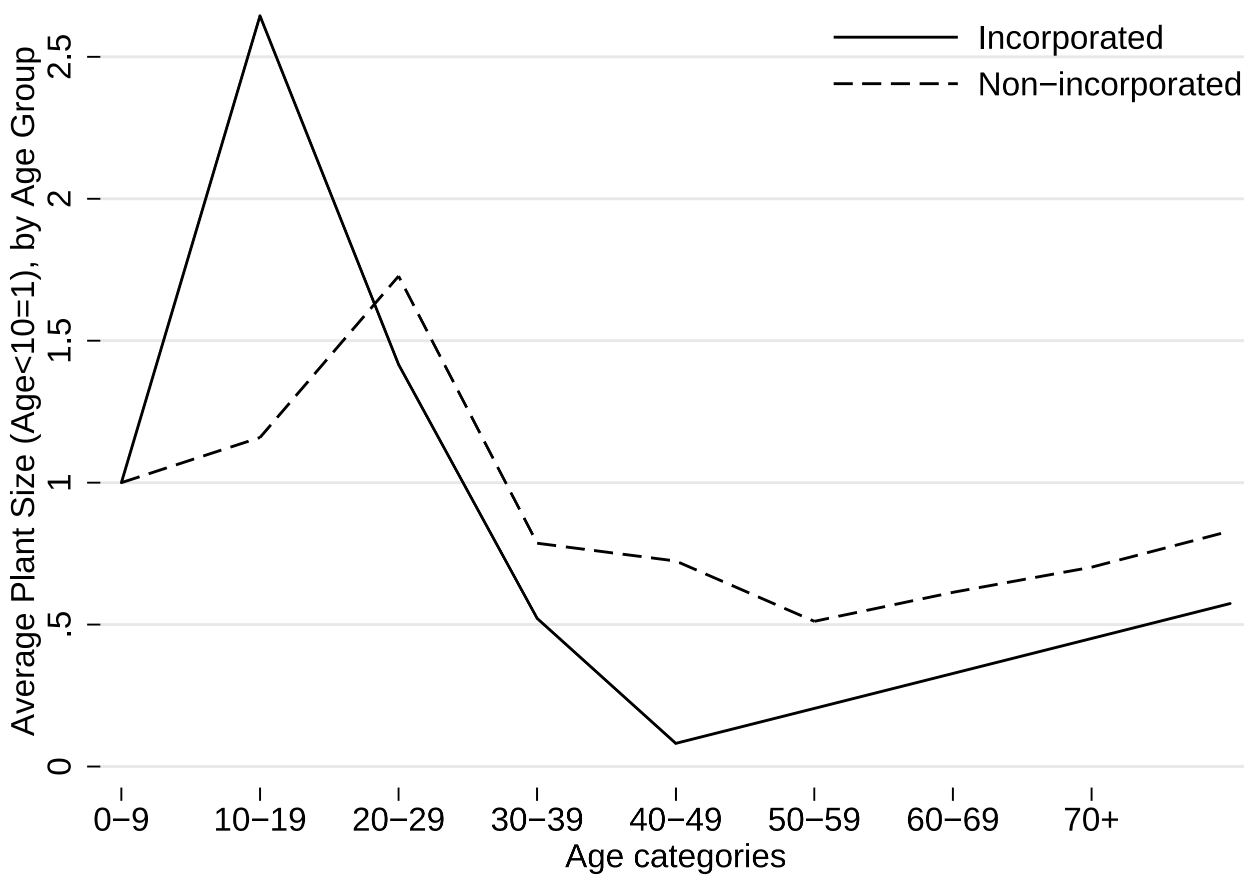
Notes: The figure gives experience-size profiles for exporting and nonexporting industries. The figure shows average plant size for both exporting (solid line) and nonexporting (dashed line) industries, by experience group in 1902. The measurement of average plant size for exporting and nonexporting industries is the same as in Figure 3. The plant sizes of exporting and nonexporting industries are measured in terms of the number of workers within each experience group for plants belonging to exporting and nonexporting industries, respectively. The size of the youngest group (ages 0–9) is normalized to 1. We compute the average plant size by 10-year experience bin to show the cross-sectional experience-size profile as a ratio of plant size relative to the average plant size of the youngest group, i.e., age less than 10 years (ages 0–9).

Figure 6: Plants utilizing steam power intensively were more likely to grow as they age after the period of institutional changes compared to plants belonging nonintensive industries



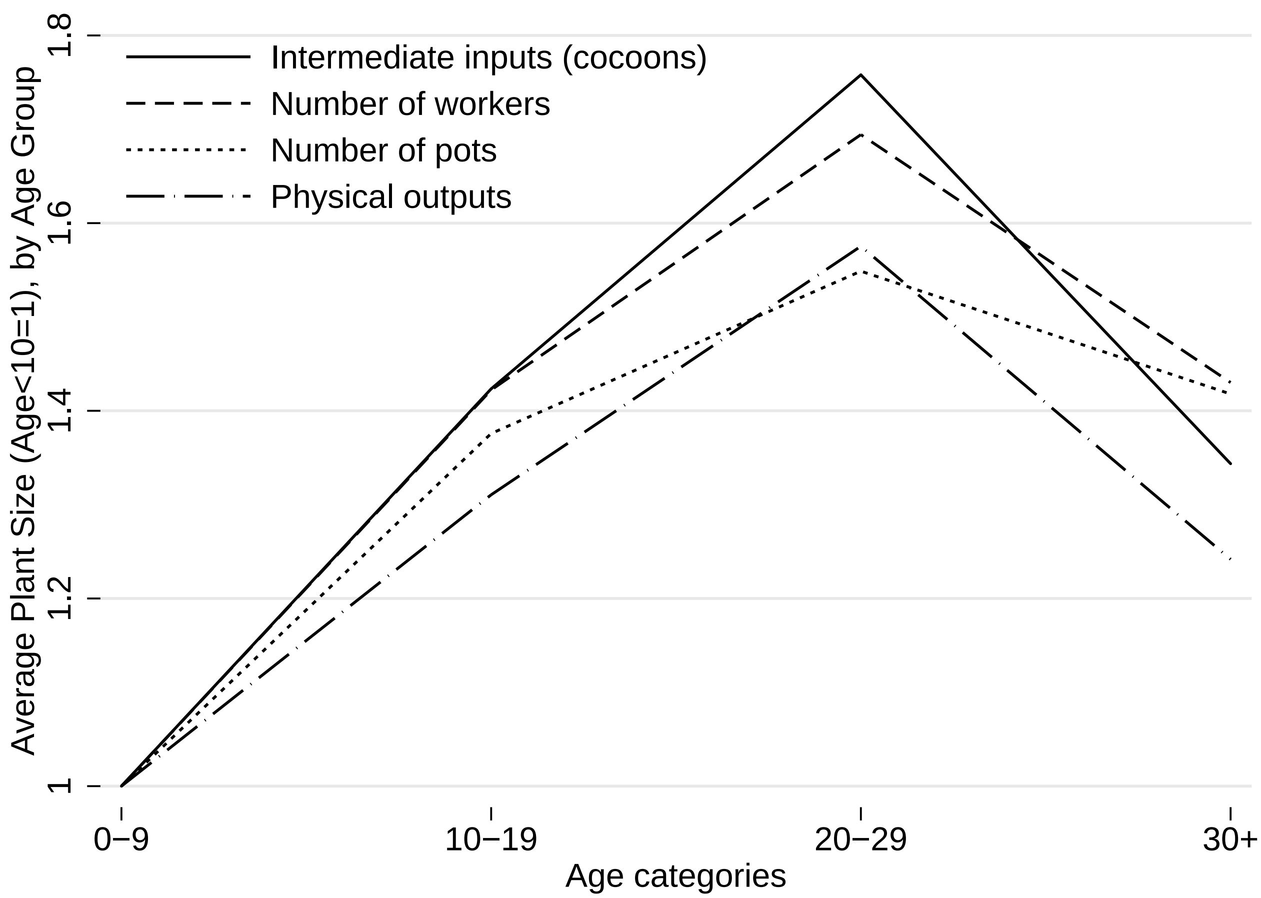
Notes: The figure gives experience-size profiles for steam power intensive and nonintensive industries. The figure shows the average plant size for both steam power-intensive (solid line) and nonintensive (dashed line) industries, by experience group in 1902. The measurement of average plant size for steam power-intensive and nonintensive industries is the same as in Figure 3. The plant sizes of steam power-intensive and nonintensive industries are measured in terms of the number of workers within each experience group for plants belonging to steam power-intensive and nonintensive industries, respectively. The size of the youngest group (ages 0–9) is normalized to 1. We compute the average plant size by 10-year experience bin to show the cross-sectional experience-size profile as a ratio of plant size relative to the average plant size of the youngest group, i.e., age less than 10 years (ages 0–9).

Figure 7: Incorporated plants were more likely to grow as they age after the period of institutional changes compared to nonincorporated plants



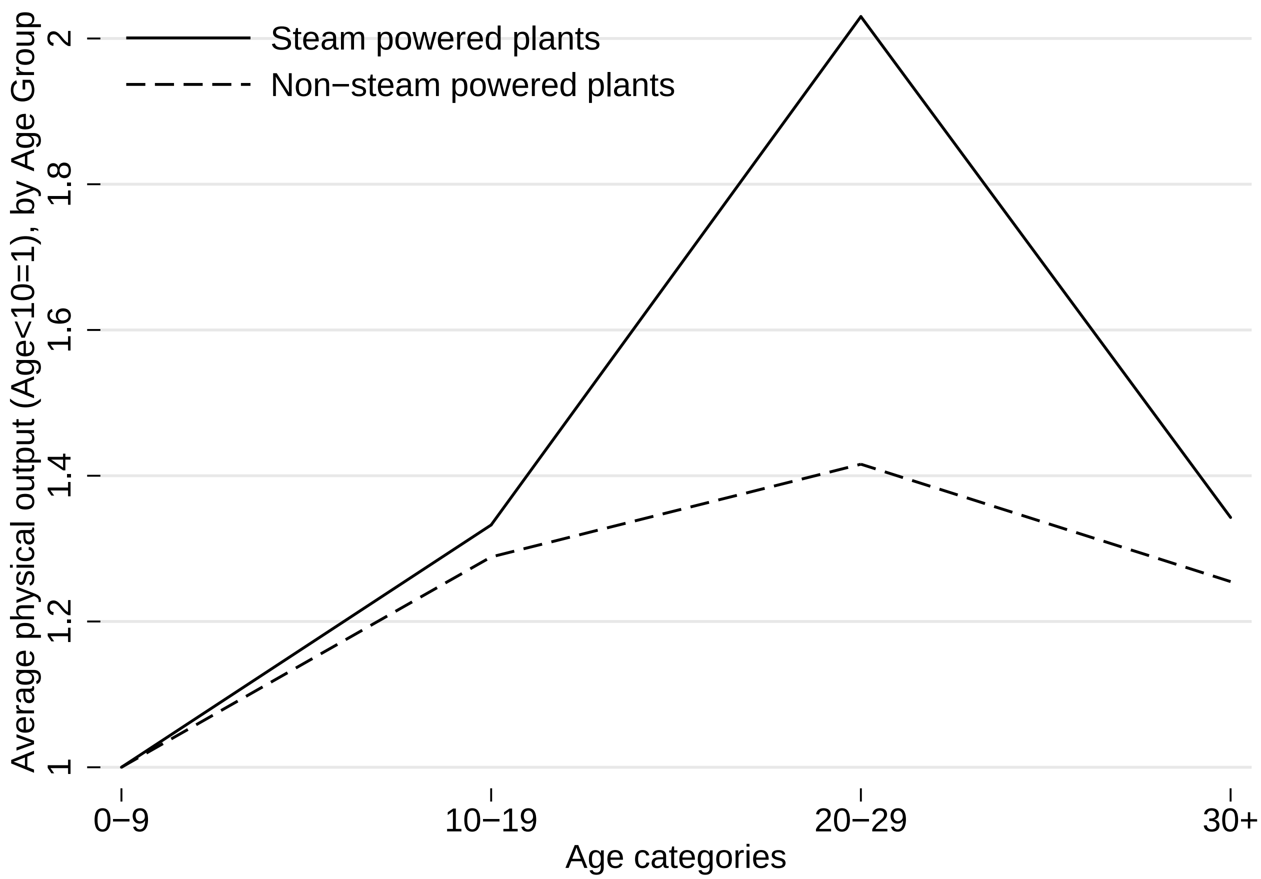
Notes: The figure gives experience-size profiles for incorporated and nonincorporated plants. The figure shows both of average plant size for incorporated (solid line) and nonincorporated plants (dashed line), by experience group in 1902. The measurement of average plant size for incorporated and nonincorporated plants is the same as in Figure 3. The plant sizes of incorporated (solid line) and nonincorporated plants are measured in terms of the number of workers within each experience group for incorporated (solid line) and nonincorporated plants, respectively. The size of the youngest group (ages 0–9) is normalized to 1. We compute the average plant size by 10-year experience bin to show the cross-sectional experience-size profile as a ratio of plant size relative to the average plant size of the youngest group, i.e., age less than 10 years (ages 0–9).

Figure 8: Silk-reeling plants were more likely to grow as they age after the period of institutional changes



Notes: The figure gives plant sizes versus plant age (experience) for 1902, i.e., experience-size profile among machine-reeling plants in the silk-reeling industry based on the 1902 census of the silk-reeling industry. This figure has four different measures of plant size: (1) intermediate inputs (cocoons); (2) number of workers (labor); (3) number of pots (capital); (4) physical outputs. The size of the youngest group (age 0–9 years) is normalized to 1. We compute the average plant size by 10-year experience bin to show the cross-sectional experience-size profile as a ratio of plant size relative to the average plant size of the youngest group, i.e., age less than 10 years (age 0–9 years).

Figure 9: Steam-powered plants were more likely to produce more as they age after the period of institutional changes compared to nonsteam-powered plants among silk-reeling plants



Notes: The figure gives physical outputs versus plant age (experience) for steam-powered and nonsteam-powered plants for 1902, i.e., experience-size profile among machine-reeling plants in silk-reeling industry based on the 1902 census of the silk-reeling industry. The physical output size of the youngest group (age 0–9 years) is normalized to 1. We compute the average physical output size by 10-year experience bin to show the cross-sectional experience-size profile as a ratio of physical output size relative to the average physical output size of the youngest group, i.e., age less than 10 years (age 0–9 years).

Table A1: Baseline results showing full of industry and prefecture controls

Sample	(1) Whole	(2) Exporting industries	(3) Non-Exporting industries	(4) Steam power intensive	(5) Non-steam intensive	(6) Corporate enterprise	(7) Non-corporate enterprise
Experience before 1880	-0.000	-0.005**	0.000	-0.000	0.000	0.001	-0.000
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.008)	(0.000)
Experience after 1880	0.016***	0.018***	0.010***	0.020***	0.009***	0.043***	0.010***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Entry after 1880	0.039	-0.103*	0.131**	-0.142**	0.149***	0.491*	-0.013
	(0.037)	(0.059)	(0.051)	(0.068)	(0.043)	(0.254)	(0.036)
Use steam power at the plant	1.062***		1.142***	1.676***		1.220***	0.998***
	(0.092)		(0.093)	(0.116)		(0.234)	(0.099)
Use non-steam power at the plant	0.170***		0.136***		0.062	0.259**	0.122***
	(0.040)		(0.040)		(0.040)	(0.127)	(0.040)
Incorporated	0.426***			1.071***	0.201***	0.938***	0.300***
	(0.028)			(0.076)	(0.033)	(0.090)	(0.027)
Located urban area in the county	0.405***		0.412***	0.678***	0.421***	0.354***	0.467***
	(0.045)		(0.045)	(0.091)	(0.053)	(0.107)	(0.048)
County population (ln)	0.104**		0.181***	0.714***	-0.013	0.409***	0.040
	(0.048)		(0.049)	(0.095)	(0.054)	(0.149)	(0.046)
Industry controls (reference: Resource-based products)	0.166***		0.121***	0.612***	0.015	0.069	0.152***
Food processing	(0.039)		(0.038)	(0.188)	(0.040)	(0.123)	(0.039)
	0.661***	0.810***	0.400***	0.746***	0.589***	0.711***	0.628***
Export products	(0.023)	(0.026)	(0.043)	(0.031)	(0.054)	(0.065)	(0.023)
	0.417***	0.445***	0.355***	0.497***	0.247***	0.554***	0.396***
Chemical products	(0.025)	(0.030)	(0.048)	(0.037)	(0.041)	(0.088)	(0.026)
	0.722***	0.930***	0.514***	0.912***	0.532***		
Electrical and metal products	(0.033)	(0.046)	(0.044)	(0.048)	(0.042)		
	0.041	0.077**	0.055	0.020	0.079**	0.064	0.027
Miscellaneous products	(0.028)	(0.038)	(0.040)	(0.058)	(0.031)	(0.087)	(0.027)
	0.066***	0.131***	0.013	0.087***	0.048***	-0.025	0.080***
Regional controls (reference: Rest of Japan)	(0.013)	(0.023)	(0.017)	(0.026)	(0.015)	(0.041)	(0.013)
Tokyo prefecture	-0.104**	-0.209**	0.083	-0.061	-0.035	0.346***	-0.208***
	(0.051)	(0.092)	(0.061)	(0.097)	(0.058)	(0.131)	(0.049)
Kanagawa prefecture	-0.112*	-0.198***	0.027	-0.043	-0.192**	0.506*	-0.203***
	(0.063)	(0.070)	(0.118)	(0.089)	(0.077)	(0.281)	(0.052)
Chiba prefecture	0.233***	-0.010	0.414***	0.057	0.330***	-0.438	0.224***
	(0.079)	(0.075)	(0.113)	(0.076)	(0.116)	(0.446)	(0.075)
Saitama prefecture	0.003	0.037	-0.239	0.457***	-0.219***	0.033	0.026
	(0.078)	(0.076)	(0.237)	(0.151)	(0.062)	(0.264)	(0.073)
Yamanashi prefecture	0.321***	0.356***	-0.031	0.332***	-0.118	0.513	0.355***
	(0.066)	(0.067)	(0.177)	(0.069)	(0.169)	(0.356)	(0.068)
Aichi prefecture	-0.145***	-0.177***	-0.059	-0.151***	-0.122***	-0.071	-0.159***
	(0.025)	(0.031)	(0.040)	(0.045)	(0.029)	(0.097)	(0.024)
Osaka prefecture	0.001	0.006	0.058	0.264**	-0.055	0.643***	-0.154***
	(0.039)	(0.073)	(0.046)	(0.116)	(0.039)	(0.130)	(0.035)
Kyoto prefecture	-0.090*	-0.118**	0.035	-0.127**	0.054	0.209	-0.169***
	(0.050)	(0.051)	(0.128)	(0.064)	(0.089)	(0.166f)	(0.040)
Hyogo prefecture	0.161***	-0.083	0.307***	-0.051	0.324***	0.402**	0.085
	(0.053)	(0.074)	(0.070)	(0.083)	(0.062)	(0.156)	(0.052)
Nara prefecture	-0.154	0.125	-0.460***	-0.126	-0.016	0.502	-0.305***
	(0.175)	(0.288)	(0.169)	(0.214)	(0.202)	(0.764)	(0.113)
Wakayama prefecture	0.007	0.126	-0.231	0.064	-0.023	-0.162	0.100
	(0.172)	(0.275)	(0.176)	(0.221)	(0.232)	(0.316)	(0.203)
Constant	1.732***	1.462***	2.384***	0.923***	2.079***	2.442***	1.788***
	-0.152	-0.271	-0.189	-0.305	-0.169	-0.518	-0.147
N	7586	4311	3275	3462	4124	1223	6363
R^2	0.308	0.388	0.253	0.346	0.218	0.281	0.225

Notes: The reference for the entry-period dummies, industry dummies, and prefecture dummies is the period before 1879, resource-based products, and the rest of Japan, respectively. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Summary statistics of plants in silk-reeling industry (N=1789)

Variable	Mean	Std. Dev.	Min	Max
Plant size (Number of workers)	56.240	112.139	5	2234
Capital (Number of pots)	58.358	107.019	10	2134
Intermediate goods (Raw cotton)	509.695	1206.809	4	21125
Output (kg)	2941.770	7409.815	20	128118
Output per worker	45.971	67.294	1.73913	2713.333
Output per pot	44.702	59.663	0.610	2348.077
Water power plant (dummy)	0.370	0.483	0	1
Steam powered plant (dummy)	0.470	0.499	0	1
Year of entry	1889.453	6.202	1858	1899
Experiences	12.547	6.202	3	44
Experience before 1880	0.396	1.521	0	22
Experience after 1880	12.151	5.324	3	22
Entry after 1880 (dummy)	0.911	0.285	0	1

Source: *National Census of Silk-Reeling Plants*, 1902.

Table A3: Estimation result of plant-level total factor productivity (TFP)

Variable	(1) ln Output	(2) ln Output
ln capital	0.043**	0.034
	(0.022)	(0.021)
ln labor	0.117***	0.117***
	(0.028)	(0.028)
ln intermediate inputs	0.882***	0.880***
	(0.027)	(0.027)
Water power dummy		0.054**
		(0.023)
Steam power dummy		0.076***
		(0.025)
Constant	1.802***	1.794***
	(0.037)	(0.040)
N	1,979	1,979
R^2	0.941	0.942

Notes: The dependent variable is the log of physical quantity of outputs measured by weight. Capital is the number of pots at the plants, labor is the number of workers, and intermediate inputs is the physical quantity of cocoons used measured in volume. Water power dummy is a dummy variable that equals one if the plants use water power at the plants. Steam power dummy is a dummy variable that equals one if the plants use steam power at the plants. Robust standard errors in parentheses. Asterisks indicate statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1.