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Disentangling the Effects of Technological and Organizational Changes during the Rise of the Factory: The Case of the Japanese Weaving Industry, 1905−1914

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Abstract

This paper contributes the "factory debate" by disentangling the effects of technological change and organizational change during the rise of the factory using unique data from the weaving industry in early twentieth-century Japan. In this period, a variety of production organizations coexisted, which provides us with an excellent opportunity to evaluate the implication of the factory system. Using regression analyses and observation of descriptive data, we find that production value per worker was four to seven times larger in nonpowered factories compared with weavers-out workers under the putting-out system, and that the difference reflects that in the number of work days and work intensity between factories and weavers-out workers.

Keywords: Factory, Manufactory, Putting-out system, Production organization, Industrial organization, Fabric Industry, Japan

JEL classification: L15, L23, L24, L25, N15, N5, O14

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1. Introduction

The rise of the factory has long been a topic of discussion in the economic history literature (Williamson 1985; Berg 1994; Jones 1994; Mokyr 2002; Hudson 2004). There is widespread consensus that the key characteristics of the modern factory system were "labor discipline within the shop … combined with technical specialization and co-ordination and the application of non-human power," as stated by Weber ([1923] 1961, pp.133, 224, cited in Mokyr 2002, p.122). However, with respect to the reasons for and implications of the rise of the factory, "the factory debate" continues (Hudson 2004, pp.40–42).

The factory debate dates to the nineteenth century, but an influential article by Stephen Marglin (1974) revived it in the modern context (Jones 1994, pp.32–34). The distinctive contribution of Marglin (1974) was that he separated the two features of the factory system—i.e., (a) centralization of the workforce under one roof, and (b) the application of machinery and nonhuman power—and argued that the former feature was essential. That is, he wrote, "The key to the success of the factory, as well as its inspiration, was the substitution of capitalists' for workers' control of the production process; discipline and supervision could and did reduce costs without being technologically superior" (p.84, underlined by Marglin). "Factory" here refers to an organization without motor mechanisms, namely a manufactory, and Marglin further wrote that, "The steam mill didn't give us the capitalist; the capitalist gave us the steam mill" (ibid, p.104). Williamson (1985, chapter 9) echoed Marglin (1974), interpreting supervision and discipline as devices for reducing transaction costs.

Despite numerous citations of Marglin (1974), most economic historians are critical of his arguments about the rise of the factory that separates organizational change from technological change (Landes 1986; Berg 1994; Jones 1994; Mokyr 2002; Hudson 2004). Surprisingly, however, there is little quantitative research that compares the performance of the alternative systems of organizing production that existed in the early stages of industrialization, including the putting-out system, the manufactory and the mechanized factory. Sokoloff (1984) is an important exception. Sokoloff (1984) focused on nonmechanized factories and small artisan shops in the US in the first half of the nineteenth century. Using individual data from the manufacturing censuses of 1820 and 1850, he found that, in most nonmechanized industries, factories did enjoy an efficiency advantage over the traditional artisan shop organization, but also that the scale economies in these nonmechanized industries existed only up to a modest plant size. A shortcoming of Sokoloff (1984) is that he did not directly observe different types of production organizations. That is, he made the distinction between the factory and the artisan shop based on the number of employees. Plants with more than five employees were regarded as factories, whereas those with five employees or fewer were regarded as artisan shops.

Another important exception is Clark (1994), who investigated the meaning of factory discipline by comparing disciplined factories with the "workshop system," where workers were not disciplined, in nineteenth century Britain. He found that compared with undisciplined workers, workers in disciplined

factories were paid higher weekly wages, worked with higher intensity and produced more. Clark argued that the higher wage included a wage premium for the factory discipline that workers disliked, and that the discipline forced workers to work harder than they would have without it.

The reason there is little quantitative research comparing production organizations in the early stages of industrialization is the lack of appropriate data. In this paper, I attempt to overcome this challenge by using data on the weaving industry in early twentieth-century Japan. As I show in the next section, the weaving industry was one of the major industries that led the process of early industrialization in Japan, which consisted of a variety of production organizations, including the factory, the home workshop and the putting-out system. It is remarkable that unique data that distinguish these types of production organizations are available. Moreover, factories included hand loom factories as well as those equipped power looms.

Focusing on the weaving industry is appropriate in the context of this paper because Marglin (1974) supported his argument by referring to the history of the fabric industry in Britain. That is, Marglin cited Blythell (1969), who wrote that "long before the power loom became practicable, hand loom weavers were brought together into workshops to weave by the same techniques that were employed in the cottage industry" (p.87). Clark (1994) also exploited the information from the British weaving industry. While Clark compared disciplined factories and undisciplined workshops by looking at peace rates and weekly wages, we take a different approach. That is, we estimate a production function to compare output per worker between the types of production organizations. This approach enables us to compare the magnitude of the impact of the factory system, i.e. disciplined collective works, on production with that of technological change, i.e. adoption of power looms.

Within the Japanese economic history literature, there are a number of studies on the weaving industry, and the form of the production organization has been one of the main issues. The interest of researchers in the production organization arose from the tradition of Marxian economics. Marx ([1867] 1990) identified the period from the middle of the sixteenth century to the last third of the eighteenth century in Europe as "the manufacturing period properly so called" (Marx [1867] 1990, p.455). Great efforts were made to search for the counterpart of "the manufacturing period properly so called" in the economic history of Japan and, in the same vein, many detailed studies were conducted on the putting-out system, the production organization alternative to the manufactory (Shinobu 1942; Hattori 1955; Sanbe 1961; Kandachi 1974; Ishii 1975; Kosho 1984; Ichikawa 1996).

Recently, there has been renewed interest in historical research on the Japanese fabric industry. Such studies have provided many new perspectives, examining issues such as the choice of technologies (Minami, Ishii and Makino 1982; Minami and Makino 1983; Kiyokawa 1995), the choice of production organizations (Saito 1984; Saito and Abe 1987; Hashino 1997, 2007), the emergence of large firms in industrial clusters (Abe 1989), the division of work in the industrial clusters (Abe 1989; Nakabayashi 2007; Hashino and Otsuka 2013), the relationship between the putting-out system and agricultural

household economies (Tanimoto 1998), and firm dynamics (Houri 2012). Although these studies are insightful and related to this paper, no research has compared the performance of different types of production organizations systematically and disentangled the effect of production organizations from the effect of technological change.

The remainder of this paper is organized as follows. Section 2 provides an overview of the development of the Japanese fabric industry, focusing on production organizations. Section 3 describes the data. Section 4 compares labor productivity across different production organizations. Finally, Section 5 concludes the paper.

2. Development of the weaving industry in Japan: An overview

The weaving industry was one of the major industries in prewar Japan. Table 1 summarizes the position of the weaving industry in the Japanese economy. Fabric production accounted for 10−15% of total industrial production in Japan, and furthermore, along with the silk reeling industry, the weaving industry was a major export industry. The percentage of fabrics in total exports increased to around 30% in the 1920s and 1930s, whereas the proportion of raw silk in total exports declined. The major fabrics produced in prewar Japan were silk and cotton, followed by wool and hemp. In the late nineteenth century, silk fabric production increased rapidly, but cotton fabric production accelerated from the 1900s and forged ahead. The high export ratios (export/production) as well as the large amount of exports indicate that the Japanese weaving industry was highly competitive in the international market (Figure 1, Figure 2).

Table 1, Figure 1, Figure 2

It is well known that a substantial part of fabric production occurred under the putting-out system in Japan until at least the early twentieth century. From 1905, the Ministry of Agriculture and Commerce compiled unique statistics on the weaving industry, organized by type of producer. The statistics were published annually in the section on "weaving" (*orimono*) in the *Statistical Report of the Department of Agriculture and Commerce (Nōshōmu Tōkei Hyō)*. The producer types were the "factory" (*kōjō*), the "home workshop" (*kanai kōgyō*), the "weaver" (*orimoto*), and the outworker (*chin'ori*). According to the instructions of the Ministry of Agriculture and Commerce, a factory was defined as a workshop with no fewer than 10 workers, whereas a home workshop was defined as a workshop with fewer than 10 workers. For the latter, it was principally supposed that a workshop was composed of family members, but "even in case [that] the workshop has nonfamily members, if the total workers are less than 10, the workshop should be regarded as the home workshop". An outworker refers to a "producer who weaves fabric using threads of other people". Finally, a weaver refers to a "producer who makes outworkers weave fabric with the threads he prepared" (Kandachi 1974, pp.10–11; Nakajima 1997, pp.51–52). It is remarkable that

these official statistics based on the types of production organization are available, and it should be noted that these statistics are from a census that covers all producers, including very small ones.

Table 2 classifies workers by the type of production organization in which they worked. Because weavers organized outworkers under the putting-out system, I grouped them into one type, weavers and outworkers. As shown in this table, 40−50% of workers are classified into the category of weavers and outworkers. This means that the putting-out system was a major production organization in Japan during this period. In addition, about 30% of the workers worked in home workshops. Summing up these two types of employment, it can be said that around 80% of workers worked from home, as was noted by Tanimoto (1998, pp.265–266). However, in terms of the overtime change, the number of workers in the putting-out system and home workshops declined, whereas the number of factory workers increased. In this sense, a transition to the factory system occurred in this period.

Table 2

In addition to the organizational change and technological change occurred. Table 3 shows the numbers of hand and power looms. While the majority of looms were hand looms, the adoption of power looms was rising. As is well known, power looms were first adopted by large-scale fabric plants operated by cotton spinning firms in the 1890s. At first, the power looms were imported from the West, but in the late 1890s, Japanese machinery firms succeeded in producing power looms at reasonable prices. The availability of domestic power looms and an increase in real wages stimulated the diffusion of power looms to small- and medium-sized fabric producers from the 1900s (Minami, Ishii and Makino 1982; Saito and Abe 1987; Kiyokawa 1995).

Table 3

Table 4 shows the diffusion of power looms by type of production organization. During this period, power looms were adopted principally by factories. In factories, although the ratio of power looms to total looms was 19.5% in 1905, it had increased to 68.1% by 1914. The diffusion of power looms in factories was rapid, but it is notable that hand looms were still widely used in factories, as stated in the Introduction. This situation, along with the availability of detailed statistics, provides us with an excellent opportunity to disentangle the effects of organizational change, that is, to separate the effects of the introduction of the factory system from those of technological change, namely the introduction of power looms.

Table 4

3. Data and descriptive analysis

Although the census statistics on the weaving industry we used in the previous section are comprehensive, they have a shortcoming in evaluating the effects of organizational and technological changes, in that they do not contain information on production, which is essential for measuring productivity. Fortunately, there is another series of statistics on the weaving industry collected by the Ministry of Agriculture and Commerce: the Special Survey of Designated Fabrics (*Orimono Shitei Tokubetsu Chosa*). This survey, hereafter referred to as the special survey, commenced in 1905 and was published annually in the *Statistical Report of the Department of Agriculture and Commerce*. It covered the designated varieties of cotton, silk, wool and hemp fabrics that were produced in the designated prefectures. The designated fabric varieties and prefectures are reported in Appendix Table A1.

Information was collected on the amount and quantity of fabric products, in addition to the types of information contained in the census statistics, including the distinction between the types of production organizations. Fifteen varieties of fabrics were covered from 1905 to 1908, and 17 were covered from 1909 to 1914 (Ministry of Agriculture and Forestry 1932, p.446, pp.516–518, p.521, pp.561–562).[1]

Tables 5–7 based on the special survey are the counterparts of Tables 2–4 based on the census, respectively. Because the producers surveyed are limited to those producing the designated fabric varieties in the designated prefectures, the figures are different accordingly. First, the ratio of workers under the factory system in Table 5 is higher than that in Table 2, and related to this, second, the ratio of power looms is higher than that in Table 3. In other words, the producers of the designated fabric varieties in the designated prefectures were more “advanced”, both organizationally and technologically. Nevertheless, it should be noted, in the special survey, a substantial number of weavers and outworkers were surveyed, as well as many hand looms in factories. Thus, there is sufficient variation in organizations and technologies.

Table 5, Table 6, Table 7

As stated above, the information on production, more specifically, production quantity and value, are recorded in the special survey. Because the units of measurement of production quantity are not uniform , we use production values hereafter. Production values are converted into 1905 prices using price fabric indices (Ohkawa et al. 1967). Figure 6 shows the change in real production value per worker (production per worker, hereafter) by type of production organization. First, total production per worker increased steadily. In the 10-year period from 1905 to 1914, production per worker increased 2.7 times, from 465 yen to 1,237 yen. Meanwhile, there are substantial differences in production per worker across types of production organizations. Production per worker in factories was 1.1−2.0 times larger than that in home workshops, while production per worker in factories was 2.6−4.9 times larger than that of weavers and outworkers. These differences in production per worker are supposed to reflect the effects of

[1] For details of the fabric varieties and prefectures surveyed, see Appendix Table A1.

technological differences as well as organizational differences. I disentangle these two components in the next section.

Figure 3

4. Measuring the effects of technological and organizational changes

The special survey provides data on 15 (1905−1908) or 16 (1909−) varieties of cotton, silk, wool, and hemp fabrics for the designated prefectures by type of production organization. We use data from 1905 to 1914, just prior to World War I. These data are unbalanced panel data with four dimensions, namely product variety, prefecture, type of production organization, and year. From the original data, I excluded the observations where any of the number of producers, the number of workers, the number of looms or the production amount is missing. As a result, 905 observations of product variety-prefecture-type of production organization-year, remained.

To identify the effects of organizational forms and technologies, we assume the following Cobb–Douglas type production function with constant returns to scale:

$$\mathrm{Y} = \mathrm{A} \times Powerloom^{\beta_1} \times Handloom^{\beta_2} \times (hL)^{1-\beta_1-\beta_2} \quad (1)$$

where Y and A represent output and total factor productivity (TFP). *Powerloom* and *Handloom* are the numbers of power looms and hand looms, respectively. L is the number of workers, while h is the parameter indicating work hours and intensity of each worker. As Clark (1994) discussed, in examining the implications of the factory system, work hours and work intensity are important, and we explicitly introduced h in equation (1). Dividing both sides by L and taking logarithms, we obtain:

$$\ln(Y/L) = \ln(A) + \beta_1 \ln(Powerloom/L) + \beta_2 \ln(Handloom/L) + (1-\beta_1-\beta_2)\ln(h) \quad (2)$$

As we cannot observe h from the data, we estimate the following equation:

$$\ln(y_{ijkt}) = \alpha + \beta_1 \ln(Percapitapowerloom_{ijkt}) + \beta_2 \ln\left(Percapitahandloom_{ijkt}\right) + Factory_j + Homeworkshop_j + \xi_i + \eta_k + \theta_t + \varepsilon_{ijkt}$$

where i, j, k, and t are indices denoting product variety, type of production organization, prefecture, and year, respectively, while y, *Percapitapowerloom* and *Percapitahandloom* are per worker measures of Y, *Powerloom* and *Handloom*, respectively. *Factory*, *Homeworkshop*, ξ, η and θ are fixed effects for factory, home workshop, product variety, prefecture and year, respectively. Finally, ε is the error term, Concerning the types of production organizations, the reference category is weavers and outworkers.

Comparing equations (2) and (3), we can see that the sum of the constant term α and the sum of the fixed effects in equation (3) equals $\ln(A) + (1-\beta_1-\beta_2)\ln(h)$ in equation (2), namely, the sum of TFP and the effect of work hours and work intensity. Thus, we can interpret the fixed effects of *Factory* and *Homeworkshop* as TFP and the effect of work hours and work intensity as being specific to factory and home workshops.

I estimate equation (3) using ordinary least squares. Y is measured as the real value of production at 1905 prices. The summary statistics are reported in Table 8, and the estimation results are reported in Table 9. Column (1) is the baseline result using the full 905 observations. The coefficient of ln(*Percapitahandloom*) is not significantly different from 0. This reflects the fact that at least one hand loom was necessary for a worker to weave fabric, and it was difficult for a worker to use more than one hand loom. The coefficient of ln(*Percapitapowerloom*) is positive and statistically significant, but the magnitude is very small. Regarding the fixed effects of the types of production organizations, both *Factory* and *Homeworkshop* are positive and statistically significant.

Table 8, Table 9

The reason the magnitude of the coefficient on ln(*Percapitapowerloom*) is small may be that the effect of power looms differed across the types of production organizations. Hence, we add the interaction terms of the loom variables and the production organization type fixed effects in column (2) in Table 9. In this case, the coefficients of the interaction terms are both significantly positive and have reasonably large values, while the individual terms, ln(*Percapitapowerloom*) and ln(*Percapitahandloom*) are insignificant. This result indicates that the effect of power looms varies across the types of production organizations and is most effective for factories. Furthermore, in column (2), the coefficients on *Factory* and *Homeworkshop* are substantially larger than those in column (1). The coefficient on *Factory* in column (2) of 1.927 means that production per worker in factories was 6.87 (= exp(1.927))-times larger than that for weavers and outworkers, other things being equal.

It is notable that the data from the special survey include those on large-scale weaving plants operated by cotton spinning firms (Abe 1989). These integrated firms concentrated on a specific product variety, white broad cloth. Taking account of the effect of those large-scale plants of integrated firms, I excluded white broad cloth from the samples in columns (3) and (4). The results are qualitatively the same as those in columns (1) and (2).

Using the estimated coefficients, we evaluate the impact of technological and organizational changes quantitatively. Table 10 reports the evaluation based on the coefficients in column (2) in Table 9. From 1905 to 1914, real production value per worker increased by 98%. Rows (f)−(k) decompose this increase into the contributions of technological change and organizational change. Rows (f)−(h) measure the impacts of technological change, i.e. the diffusion of power looms in factories and home workshops,

while rows (i)−(k) measure the impacts of organizational change, i.e. the diffusion of factories and home workshops. Around 24% (0.24/0.98) of the change in production per worker is explained by technological change, while around 32% (0.31/0.98) is explained by organizational change. The impact of organizational change, in particular the diffusion of factories, was larger than the impact of technological change.

Table 10

5. Robustness check and discussion

The analyses in the previous sections indicate that there was a large difference in production per worker between factories and weavers-outworkers. Here we check the validity of this finding by examining the data on the habutae weaving industry in Fukui Prefecture. Habutae is a kind of silk fabric that is plain and mainly exported. Fukui was the prefecture that produced the largest amount of habutae from the mid-1890s (Ishii 1974; Kandachi 1974; Hashino 2012). The reason for focusing on habutae in Fukui is that detailed plant-level data are available for factories, including those without mechanical power.

The *Statistical Yearbook of Fukui Prefecture* (*Fukui-ken Tokei Sho*) records the data on habutae for export by type of production organization in the same format as the special survey, from 1905. Furthermore, for all factories with no fewer than 10 workers, including habutae plants, it records detailed plant-level data from 1904. These data include plant name, month and year of foundation, name of product, type of motors, horsepower of motors, number of workers, daily working hours and average daily wage of workers. In addition, the information on production value at the plant level was included from 1913.

Table 11 compares the basic features of the habutae industry in Fukui. It is known that the factory diffused early in the habutae industry in Fukui before the introduction of power looms. Ishii (1974) identified three phases in the development of in the habutae industry in Fukui and characterized these phases as follows: the phase from 1900 to 1908 was that of manufactories, and that from 1909 to 1920 was that of mechanical factories (p.652). Indeed, there were 423 factories employing 7,747 looms and 7,934 workers in this industry in 1905, of which, there were only five power looms (Fukui Prefecture, *Fukui-ken Tōkeisho*, 1905 issue, pp.157−159). In 1913 and 1914, power looms had diffused widely in factories, and the ratio of power looms was 68.7% and 79.7%, respectively (Table 11). Table 11 reports production quantity per worker and production value per worker. In 1913 and 1914, production quantity per worker in factories was 10.1- and 9.7-times larger than that in weavers-outworkers, respectively. Furthermore, production value per worker in factories was 9.1- and 9.7-times larger than that of weavers-outworkers, respectively. It is notable that the average prices of products were not substantially different across the types of production organizations, which implies that the qualities of the products

were similar, reflecting the fact that habutae is a plain and simple fabric.

Table 11

As we have just seen, there was a large difference in production quantity and value per worker between factories and weavers-outworkers in the Fukui habutae industry. It should be noted, however, that this difference reflects differences in technologies as well as differences in the organizations themselves, because Table 11 shows that the ratios of power looms were substantially different between factories and weavers-outworkers at the same time.

To separate the effect of power looms from the effect of organizational types, we exploit plant-level data of the habutae industry in Fukui Prefecture. As stated above, the *Statistical Yearbook of Fukui Prefecture* provides detailed plant-level data for all factories with no fewer than 10 workers. Of these data, we extracted those on the factories that produced habutae. Table 12 provides the summary statistics of these factories. As shown in the bottom row, 279 and 237 habutae plants are recorded for 1913 and 1914, respectively. Of the 279 plants in 1913, 151 plants were powered, while 128 plants were nonpowered. We can regard the former plants as power loom plants and the latter as hand loom plants. In 1914, the number of powered plants had increased to 198, while that of nonpowered plants had declined sharply to 39. We next compare the production values per worker of powered factories and nonpowered factories. In 1913, the mean for powered factories was 2,552 yen, while that for nonpowered factories was 866 yen. In 1914, the mean for powered factories was 2,222 yen, while that for nonpowered factories was 696 yen. Thus, the difference was 2.9 times to 3.2 times (3.0 on average). This can be interpreted as the effect of power looms. Returning to Table 10, there were 9.1 to 9.7 times (9.4 on average) difference in per worker production between factories and weavers-outworkers. On the other hand, the power loom ratio was 68.7−79.7% (74.2% on average) for factories, while it was negligible for weavers-outworkers. Given these data, we can roughly compute the difference in production value per worker between factories and weavers-outworkers attributable to the technological difference as 2.2 times (3.0×0.74). Then, the difference attributable to the organizational effect is 4.3 times (9.4/2.2).

Table 12

This result indicates that the types of production organizations had a substantial impact on the production value per worker. The difference of 4.3 times is smaller than the result from the regression in Table 9, i.e. 6.87 times, but it indicates that the regression result is reasonable. We next consider the source of this great difference in production value per worker between factories and weavers-outworkers. Here again, the plant-level data on the Fukui habutae industry provides a clue. Table 13 shows the summary statistics of daily working hours in the habutae factories. For both the powered and nonpowered factories, the mean

of daily working hours is more than 11 hours, and the standard deviations are small. Most of the workers in factories, both powered and nonpowered, worked many hours each day. The plant-level data in the *Statistical Yearbook of Fukui Prefecture* for 1913 and 1914 do not provide data about working days in each year, but that information is available for 1908. The basic statistics of work hours and work days of nonpowered habutae factories are reported in Table 13.[2] The mean numbers of work days each year and work hours per day were 307.15 and 12.49, respectively. That is, habutae factory workers had just one day off each week and several additional holidays.

Table 13

Long working days and few holidays in weaving factories are widely observed. In 1901, the Ministry of Agriculture and Commerce conducted site surveys of factories of selected industries, including the weaving industry, the results of which are reported in Ministry of Agriculture and Commerce ([1903] 1988). Based on the site survey of weaving factories around Japan, it concluded, "Daily working hours in the weaving factories range from 12 hours to sometimes as many as 17 to 18 hours, except for the carper industry in Osaka Prefecture and the Kurume Kasuri weaving industry in Fukuoka Prefecture" (p.313). The Ministry of Agriculture and Commerce ([1903] 1988) also reported the holidays for several weaving factories. Basically, holidays were the days around the new year (from December 29 to January 3), the three national holidays and every Sunday. This implies around 300 working days, which is consistent with the data on habutae factories in Fukui Prefecture.

Outworkers in the habutae industry in Fukui Prefecture, however, engaged in weaving as a subsidiary job. A report by the industrial association of the silk weaving industry in Fukushima Prefecture that examined the Fukui habutae industry wrote, "The putting-out system in the habutae weaving industry in Fukui employed many female workers, and housewives engaged in habutae weaving in addition to their main jobs. Hence, the weavers can flexibly adjust production according to industry demand" (Silk Weaving Association of Fukushima Prefecture 1904, p.4). The situation was similar for the outworkers in other weaving districts. The students of Tokyo Higher Commercial School who surveyed the weaving industry in Gunma and Tochigi Prefectures reported detailed information of a family that engaged in weaving under the putting-out system as well as in agriculture (Kawamoto, Miura and Ando 1901). In that family, two daughters worked as weavers. It is stated, "As this family engage in agriculture and sericulture as well, weaving would occur for six to seven months, namely 180 to 190 days" (pp.123−124).

Furthermore, Tanimoto (1998) studied the putting-out system in the weaving industry in Saitama Prefecture and found that outworkers were principally women in peasant households, and that they engaged in agricultural work particularly in farms' busy seasons, as well as weaving. He found that the

[2] There was just one powered habutae factory in 1908, in which work days and work hours were 300 days and 12 hours, respectively.

quantities of orders from a weaver, Takizawa, to outworkers had a clear seasonal pattern, small from May to July, the season for rice planting (pp.325−329). From the seasonal pattern of orders in 1897 in Tanimoto (1998, p.327), we can calculate the "operation rate" of outworkers. As order sizes were largest in October, he presented an index of monthly orders, setting October equal to 100. Summing the monthly orders gives 625 in total. If we assume that the operation rate in October was 100, the average operation rate was 0.52 (625/1,200). This is consistent with the information reported by Kawamoto, Miura and Ando (1901).

As the difference in production value per worker between nonpowered factories and weavers-outworkers was 4.3 times (habutae in Fukui) to 6.87 times (calculation from Table 9), the difference has not been fully accounted for, but the difference in work hours and work days can explain a substantial part of it. The remaining part may be because of work intensity. The Ministry of Agriculture and Commerce ([1903] 1988) stated that in the factories where daily work hours were long, weaving workers did not work as hard as possible, and "they try not to work behind supervisors' backs". In other words, the report pointed out that work intensity in factories was not very high. At the same time, however, the citation above indicates that supervisors monitored the behaviors of workers in factories. In adition, the report states, "Female workers doing peace works take a rest only at meal times, and most of them immediately return to work after finishing their meals. Female workers earning daily wages also cannot take a break easily because of pressure from their supervisors" (p.317). Furthermore, it is reported that most factories encouraged workers by giving additional incentive pays according to their performance in terms of quantity and quality of products, work days, etc. (pp.390−400).

On the other hand, with respect to the putting-out system, the Silk Weaving Association of Fukushima Prefecture (1904) stated that outworkers did not concentrate on weaving even during work hours. That is, if the housewives of merchant families were outworkers, they could sometimes leave their looms to take care of children, business, etc., which made products nonuniform and wasted time (p.15). Comparing the work in factories where concentration on weaving was enforced by supervisors with work in households where concentration was disturbed by other things and supervisors did not exist, we can infer that intensity was higher in the former.

6. Concluding remarks

The economic implications of the factory system have long been discussed in the literature, but there are few empirical studies. In this paper, we address this issue using data from the weaving industry in early twentieth-century Japan. In this period, the weaving industry in Japan experienced significant technological and organizational change involving the diffusion of the power loom and the spread of the factory system. It is notable that these two changes were not completely synchronized, and many manufactories with hand looms existed along with factories with power looms and outworkers organized by weavers. In other words, a variety of production organizations coexisted. In this context, the

government conducted a series of surveys organized by type of production organization. Furthermore, valuable contemporary surveys and detailed case studies are available on this topic.

These data provide us with an excellent opportunity to compare the performance and modes of operations across the different types of production organizations. Using regression analyses and descriptive statistics, we found that there is a difference in production value per worker between nonpowered factories and weavers-outworkers of approximately four to seven times. We also found that the average annual number of work days were around 300, and that the daily number of work hours were as many as 11 in factories. However, most outworkers had other businesses such as agriculture and commerce, and in the case of female workers of peasant households, they worked on weaving around 180 days a year. Thus, the difference in work days between factories and weavers-outworkers account for a substantial part of the difference in production value per worker. In addition, there is evidence that work intensity was higher in factories compared with weavers-outworkers.

This paper is the first attempt, to my knowledge, to compare the production performance of the factory and putting-out systems systematically, controlling for technologies. Large differences in production value per worker were found between them, and this reflects at least partly the difference in work days and work intensity. We can conclude that the factory system helped mobilize the workforce that was scattered in various businesses, in particular in agriculture, to manufacturing, and thereby contributed to the industrialization of the economy.

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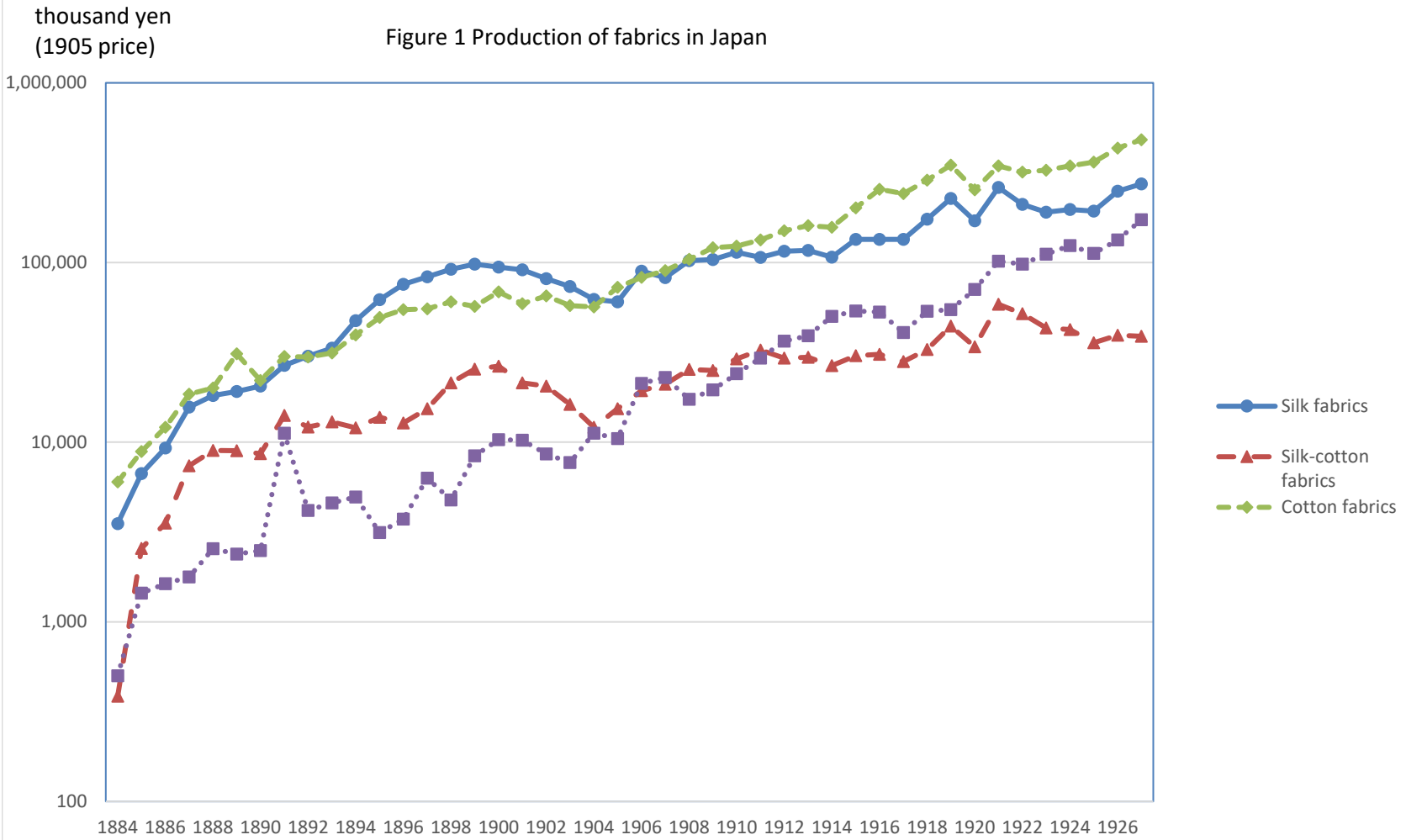
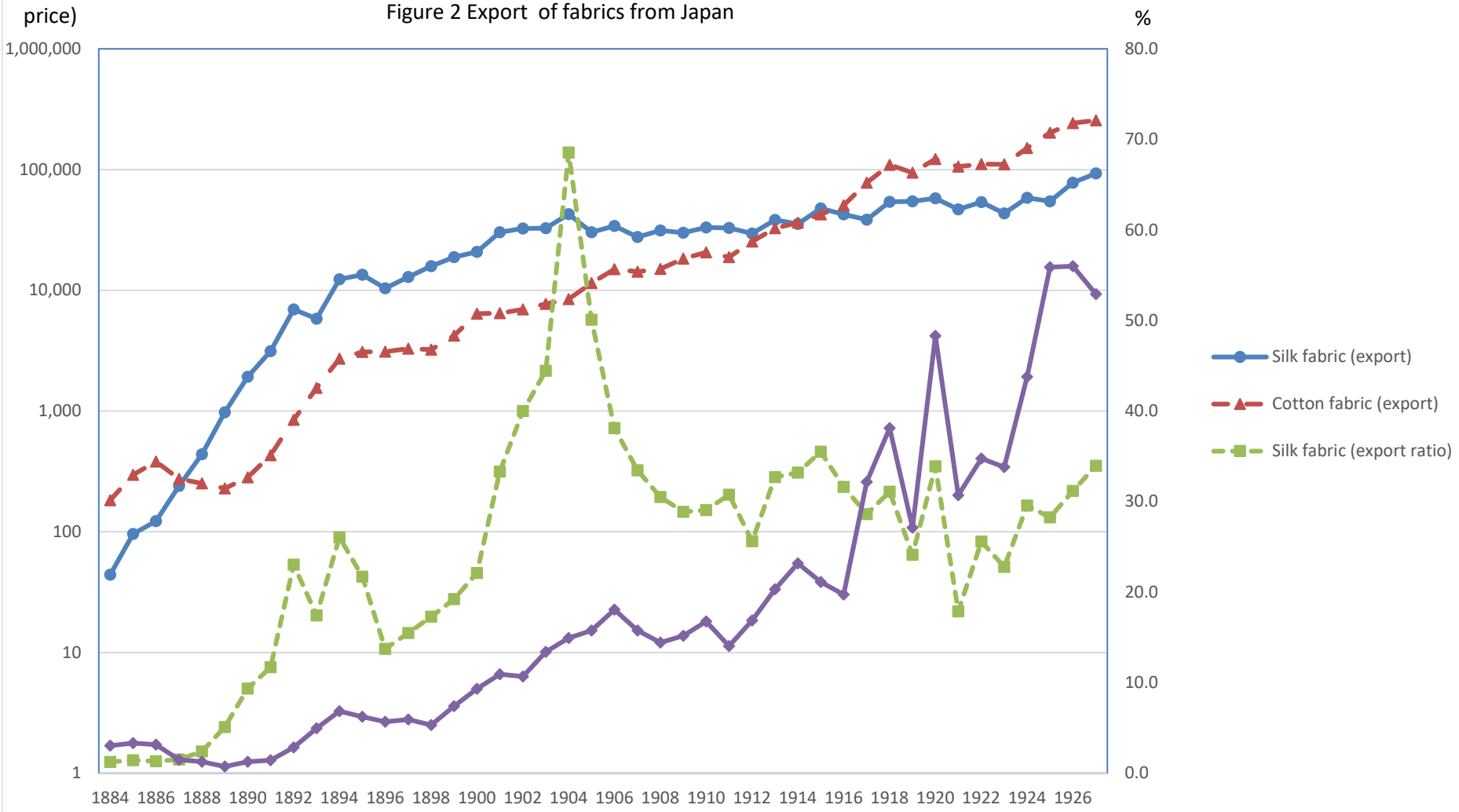
Figure 1 Production of fabrics in Japan



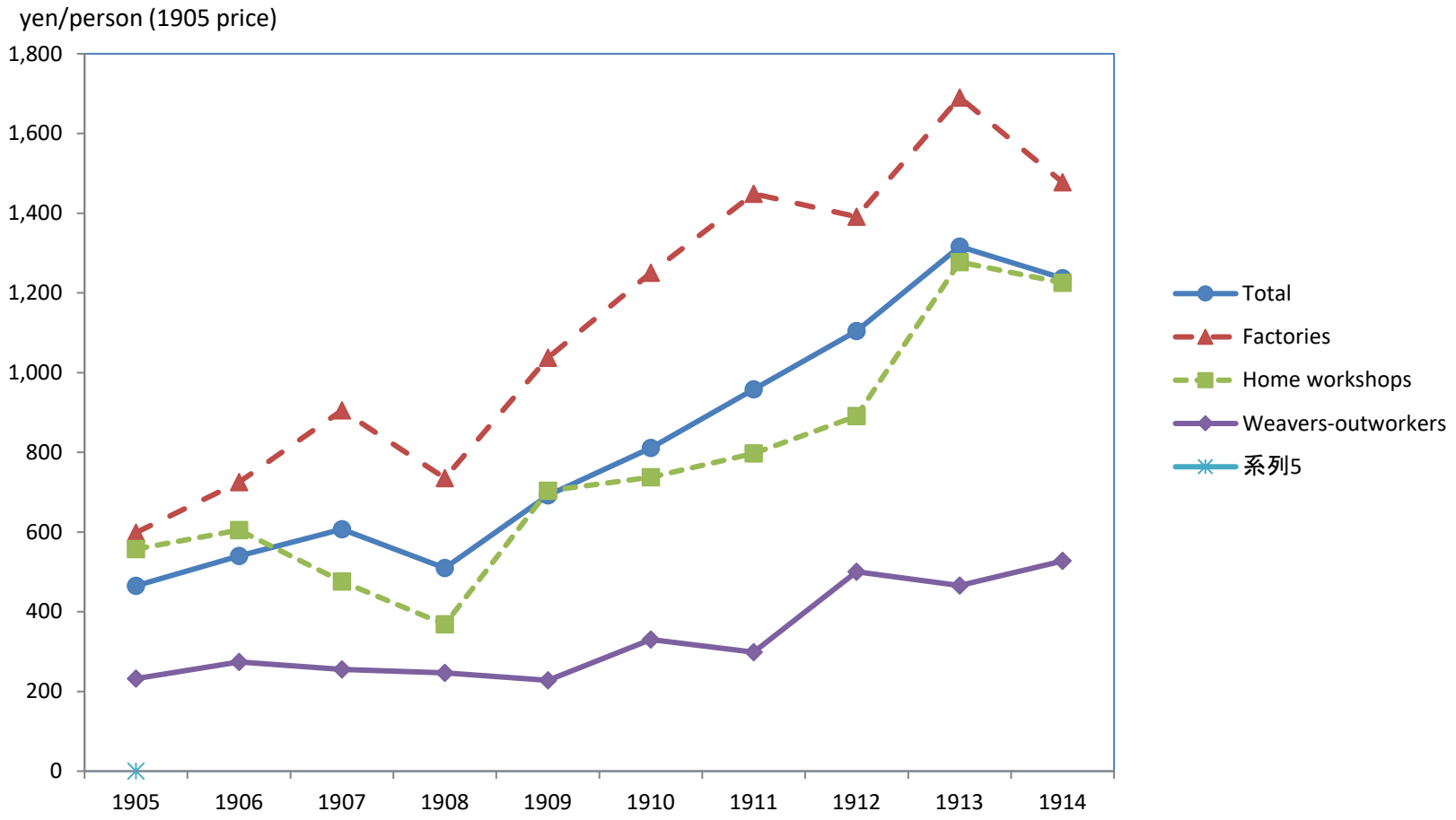
Source: Asahi Shinbunsha (1930), p.744.

Figure 2 Export of fabrics from Japan



Note: Export ratio = export/production.
Source: Asahi Shinbunsha (1930), pp.248-249, p.744.

Figure 3 Production per worker by type of production organization



Source: Made from "Special Survey of the Weaving Industry" in Ministry of Agriculture and Commerce, *Nōshōmu Tōkei Hyō (Statistical Report of the Department of Agriculture and Commerce)* various issues (see the text).

Table 1 Weaving industry in the Japanese economy

thousand yen, %

	Production	Export				
	A. Manufacturing total	B. Fabrics	C. B/A (%)	D. Total	E. Fabrics	F. D/E (%)
1890	433,846	46,341	10.7	56,604	3,521	6.2
1900	1,181,185	178,235	15.1	204,430	31,362	15.3
1910	2,072,902	287,580	13.9	458,429	66,109	14.4
1920	9,579,237	1,447,609	15.1	1,948,395	552,549	28.4
1930	8,837,872	1,102,367	12.5	1,469,852	410,342	27.9

Source:

A: Shinohara (1972), pp.140-143.

B.: Asahi Shinbunsha (1930), p.744; Ministry of Commerce and Industry (1932), pp.2-34

D. Tōyō Keizai Shinpōsha (1935), p.2.

E. Tōyō Keizai Shinpōsha (1935), p.86.

Table 2 Production organizations in the weaving industry (census)

	Factories		Home woorkshops		Weavers and outworkers	
	Person	%	Person	%	Person	%
1905	94,964	(12.3)	230,864	(29.9)	447,030	(57.8)
1906	106,582	(13.3)	275,705	(34.3)	421,075	(52.4)
1907	107,268	(13.9)	239,551	(31.0)	424,995	(55.1)
1908	116,080	(15.0)	245,824	(31.8)	411,733	(53.2)
1909	127,974	(16.0)	241,268	(30.1)	432,487	(53.9)
1910	132,872	(17.1)	230,441	(29.6)	414,174	(53.3)
1911	137,705	(18.4)	241,003	(32.2)	370,173	(49.4)
1912	168,994	(23.5)	217,185	(30.2)	333,800	(46.4)
1913	164,971	(23.9)	199,888	(29.0)	324,951	(47.1)
1914	168,653	(26.7)	178,487	(28.3)	283,535	(45.0)

Source: Ministry of Agriculture and Commerce, *Nōshōmu Tōkei Hyō* (*Statistical Report of the Department of Agriculture and Commerce*), various issues.

Table 3 Technologies in the weaving industry (census)

	Power looms		Hand looms	
	Unit	%	Unit	%
1905	19,422	(2.6)	717,164	(97.4)
1906	22,635	(3.1)	718,380	(96.9)
1907	31,548	(4.0)	757,158	(96.0)
1908	40,350	(5.1)	748,386	(94.9)
1909	54,811	(7.0)	723,097	(93.0)
1910	72,511	(9.5)	687,223	(90.5)
1911	89,003	(12.2)	638,412	(87.8)
1912	118,653	(15.9)	626,017	(84.1)
1913	120,013	(17.6)	563,289	(82.4)
1914	129,823	(20.5)	502,909	(79.5)

Source: See Table2.

Table 4 Power loom ratio by type of production organization (census)

%

	Factories	Home woorkshops	Weavers and outworkers
1905	19.5	1.0	0.5
1906	23.1	0.5	0.2
1907	28.4	0.7	0.5
1908	33.0	1.3	0.3
1909	39.6	1.4	0.4
1910	49.2	1.6	0.8
1911	55.0	3.1	0.9
1912	62.6	2.3	1.8
1913	64.7	2.2	2.4
1914	68.1	3.1	2.7

Source: See Table2.

Table 5 Production organizations in the weaving industry (special survey)

	Factories		Home woorkshops		Weavers and outworkers	Ratio of factories
	Person		Person		Person	%
1905	71,210	(48.2)	25,604	(17.3)	50,893	(34.5)
1906	67,791	(46.3)	25,372	(17.3)	53,275	(36.4)
1907	54,766	(47.1)	24,754	(21.3)	36,714	(31.6)
1908	62,952	(49.7)	23,192	(18.3)	40,460	(32.0)
1909	56,528	(47.5)	20,085	(16.9)	42,406	(35.6)
1910	52,742	(46.0)	16,352	(14.3)	45,645	(39.8)
1911	54,345	(52.1)	12,867	(12.3)	37,047	(35.5)
1912	64,723	(64.0)	8,699	(8.6)	27,692	(27.4)
1913	63,413	(64.2)	7,838	(7.9)	27,538	(27.9)
1914	69,893	(70.6)	5,574	(5.6)	23,517	(23.8)

Source: Made from "Special Survey of the Weaving Industry" in Ministry of Agriculture and Commerce, *Nōshōmu Tōkei Hyō (Statistical Report of the Department of Agriculture and Commerce)* various issues.

Table 6 Technologies in the weaving industry (special survey)

	Power looms		Hand looms	
	Unit		Unit	%
1905	12,561	(9.9)	113,708	(90.1)
1906	13,267	(10.6)	111,954	(89.4)
1907	13,262	(10.4)	113,896	(89.6)
1908	20,530	(15.7)	110,053	(84.3)
1909	19,819	(18.0)	90,104	(82.0)
1910	26,066	(23.9)	82,803	(76.1)
1911	34,074	(34.4)	64,896	(65.6)
1912	46,383	(48.5)	49,343	(51.5)
1913	47,414	(50.6)	46,238	(49.4)
1914	53,329	(60.2)	35,287	(39.8)

Source: See Table 5.

Table 7 Power loom ratio by type of production organization (special survey)

	Power loom ratio		
	Factories	Home woorkshops	Weavers and outworkers
1905	22.8	2.1	0.0
1906	26.4	0.7	0.0
1907	31.3	0.0	0.0
1908	38.7	0.4	1.0
1909	40.3	2.4	0.3
1910	52.2	8.5	0.3
1911	64.2	10.7	0.3
1912	75.2	26.3	0.5
1913	78.6	12.9	0.2
1914	84.3	31.2	0.9

Source: See Table 5.

Table 8 Basic statistics

	Obs.	Mean	Std. Dev.	Min	Max
Production per worker	905	6.124	1.439	−0.025	10.984
ln(percapitapowerloom)	905	−3.167	2.581	−10.166	3.922
ln(percapitahandloom)	905	−1.456	2.281	−9.219	3.091
ln(percapitapowerloom) × Factory	905	−0.813	1.503	−8.979	0.573
ln(percapitapowerloom) × Homeworkshop	905	−1.039	2.007	−9.237	3.922
ln(percapitahandloom) × Factory	905	−1.366	2.283	−9.219	0.438
ln(percapitahandloom) × Homeworkshop	905	−0.055	0.267	−2.996	1.852
Factory	905	0.490	0.500	0.000	1.000
Small factory	905	0.275	0.447	0.000	1.000

Source: see the text.

Table 9 Estimation of production function

Dependent variable: Production per worker (1905 price)	(1)Full samples		(2)Full samples		(3)Excluding wide white cotton fabrics		(4)Excluding wide white cotton fabrics	
ln(powerloom)	0.068 (0.024)	***	−0.060 (0.051)		0.073 (0.025)	**	−0.056 (0.052)	
ln(handloom)	−0.047 (0.030)		−0.011 (0.154)		−0.039 (0.035)		−0.045 (0.156)	
Factory	0.900 (0.138)	***	1.927 (0.364)	***	0.859 (0.139)	***	1.919 (0.368)	***
Homeworkshop	0.363 (0.124)	***	1.008 (0.359)	***	0.328 (0.125)	***	0.965 (0.367)	***
ln(powerloom)×Factory			0.251 (0.066)	***			0.248 (0.067)	***
ln(powerloom)×Homeworkshop			0.125 (0.059)	***			0.119 (0.060)	**
ln(handloom)×Factory			0.021 (0.159)				0.070 (0.163)	
ln(handloom)×Homeworkshop			−0.233 (0.222)				−0.221 (0.229)	
Constant	4.770 (0.329)	***	4.245 (0.412)	***	4.217 (0.583)		3.597 (0.647)	***
Product FE	Yes		Yes		Yes		Yes	
Prefecture FE	Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes	
Number of obs.	905		905		840		840	
R^2	0.484		0.500		0.478		0.494	

Source: see the text.

Table 10 Evaluation of the impacts of the technological and organizational change on production per worker

	1905	1914	Change from 1905 to 1914
(a) ln(production value per worker)	6.14	7.12	0.98
(b) ln(power looms per worker in factories)	−1.77	−0.31	1.47
(c) ln(power looms in home workshops)	−3.97	−1.13	2.85
(d) Ratio of factories in terms of workers	0.48	0.71	0.22
(e) Ratio of home workshops in terms of workers	0.17	0.06	−0.12
(f) (b)×(d)	−0.86	−0.22	0.64
(g) (c)×(e)	−0.69	−0.06	0.63
(f) Contribution of (f)	−0.21	−0.05	0.16
(g) Contribution of (g)	−0.09	−0.01	0.08
(h) (f)+(g)	−0.30	−0.06	0.24
(i) Contribution of (d)	0.93	1.36	0.43
(j) Contribution of (e)	0.17	0.06	−0.12
(k) (i)+(j)	1.10	1.42	0.31

Source: See the text.

Table 11 Basic features of the Habutae industry in Fukui Prefecture

	1913			1914		
	Factories	Home workshops	Weavers+outworkers	Factories	Home workshops	Weavers+outworkers
Power loom (unit)	6,743	503	11	7,057	1,249	6
Hand loom (unit)	3,073	1,691	1,688	1,802	999	1,354
Worker (person)	7,233	2,224	1,643	7,019	1,930	1,416
Production quantity (1,000 kin)	1,480	375	33	1,485	311	31
Production value (1,000 yen)	15,345	4,099	383	16,806	3,526	350
Power loom ratio (%)	68.7	22.9	0.6	79.7	55.6	0.4
Average price (yen/kin)	11.8	12.4	11.4	12.6	12.6	11.4
Production quantity per worker (kin/person	205	169	20	212	161	22
Production value per worker (yen/person)	2,122	1,843	233	2,394	1,827	247

Source: Fukui Prefecture, Fukui Ken Tōkei Sho (Statistical Yearbook of Fukui Prefecture), 1913 and 1914 issues.

Table 12 Comparison between powered and non-powered factories at the plant-level: Habutae factories in Fukui Prefecture

		1913		1914	
		Powered Factories	Non-powered factories	Powered Factories	Non-powered factories
Worker (person)	Mean	30.21	19.63	26.42	20.79
	Stdev.	22.79	16.26	22.12	15.03
	Max	126	170	160	100
	Min	10	10	10	10
Production value (yen)	Mean	78,963	16,170	62,025	13,375
	Stdev.	76,380	14,640	71,456	7,506
	Max	441,000	118,569	527,000	33,300
	Min	3,000	2,400	1,013	4,150
Production value per worker (yen)	Mean	2,552	866	2,222	696
	Stdev.	1,146	587	1,138	307
	Max	5,267	3,522	6,545	1,333
	Min	60	185	29	271
Work hours per day (hour)	Mean	11.67	11.63	11.73	11.38
	Stdev.	1.15	1.79	1.16	1.18
	Max	14.00	17.00	14.00	14.00
	Min	9.00	8.00	8.00	9.00
Wage per day for a female worker aged 14 years or over (sen)	Mean	31.08	22.47	26.87	21.15
	Stdev.	5.41	4.67	4.46	4.78
	Max	40.00	40.00	40.00	38.00
	Min	18.00	15.00	15.00	15.00
Number of obs.		151	128	198	39

Source: See Table 11.

Table 13 Basic statistics of work days and work hours of non-powered Habutae factories in Fukui Prefecture in 1908

	Mean	Stdev.	Max.	Min.	Obs.
Work days per year	307.15	32.12	355	100	297
Work hours per day	12.49	1.13	15	10	297

Source: Fukui Prefecture, Fukui Ken Tōkei Sho (Statistical Yearbook of Fukui Prefecture), 1908 issue.

Table A1

A. 1905–1908

Product variety		Prefecture to be surveyed						
Yushutsumuke habutae	Habutae for export							
Kikaiori hirohaba shiro menpu rui	Caloco etc.	Gunma	Fukushima	Fukui	Ishikawa	Toyama		
Men Furanneru	Flannel (cotton)	Tokyo	Kyoto	Osaka	Mie	Okayama	Wakayama	
Men moufu	Blacket (cotton)	Osaka	Aichi					
Taoru	Towel	Osaka	Hyogo					
Men chjimi	Crapes	Gunnma	Tochigi	Nara	Shiga	Toyama	Shimane	Yamaguch Tokushima
Kobai kaiki	Kobai kaiki	Gunnma	Tochigi	Toyama	Ishikawa			
Kikaiori kinu men shusu	Shusu (silk and cotton mixed)	Kyoto	Gunnma					
Kikaiori men hanpu	Sail-cloth (cotton)	Osaka	Shiga					
Kikaiori asa hanpu	Sail-cloth (hemp)	Osaka	Tochigi	Shiga	Hokkaido			
Ribon	Ribbon	Tokyo	Kyoto	Gunnma	Shizuoka			
Furanneru	Flannel	Tokyo	Osaka					
Mosurin	Muslin	Tokyo	Osaka					
Moufu	Blancket	Tokyo	Osaka	Hyogo				
Rasha sonota keorimono	Woolen goods	Tokyo	Osaka	Hyogo				

B.1909–1914

Product variety		Prefecture to be surveyed						
Yushutsumuke habutae	Habutae for export	Gunnma	Fukushima	Fukui	Ishikawa	Toyama		
Kikaiori hirohaba shiro menpu rui	Caloco etc.	Tokyo	Kyoto	Osaka	Mie	Okayama	Wakayama	
Men Furanneru	Flannel (cotton)	Kyoto	Osaka	Wakayama	Tokushima	Ehime		
Men moufu	Blacket (cotton)	Osaka	Aichi					
Taoru	Towel	Osaka	Hyogo					
Men chjimi	Crapes	Gunnma	Tochigi	Nara	Shiga	Toyama	Shimane	Yamaguch Tokushima
Kobai kaiki	Kobai kaiki	Gunnma	Tochigi	Ishikawa	Toyama			
Yushutsumuke kohakuji	Taffeta for export	Kyoto	Gunnma	Tochigi	Yamagata	Toyama		
Kikaiori kinu men shusu	Shusu (silk and cotton mixed)	Kyoto	Gunnma					
Kikaiori men hanpu	Sail-cloth (cotton)	Osaka	Shiga					
Kikaiori asa hanpu	Sail-cloth (hemp)	Osaka	Tochigi	Shiga	Hokkaido			
Ribon	Ribbon	Tokyo	Kyoto	Gunnma	Shizuoka			
Furanneru	Flannel	Tokyo	Osaka					
Mosurin	Muslin	Tokyo	Osaka					
Kinu mosurin	Muslin (silk)	Kyoto	Yamagata	Toyama				
Moufu	Blancket	Tokyo	Osaka	Hyogo				
Rasha sonota keorimono	Woolen goods	Tokyo	Osaka	Hyogo				

Source: Ministry of Agriculture and Forestry 1932, p.446, pp.516–518, p.521, pp.561–562.