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Disentangling the Effects of Technological and Organizational Changes in the Rise of the Factory: The Case of the Japanese Fabric Industry, 1905-1914

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Abstract

This paper attempts to contribute to the "factory debate" by disentangling the effects of the technological change and the organizational change in the rise of the factory, using a unique dataset from Japan in the early twentieth century. It is found that the productivity of a factory worker was 2.46 times larger than that of an outworker under the putting-out system, after controlling for the effect of the power loom. The impact of the factory system was almost as large as that of the power loom in the case where all the hand looms were replaced by power looms. This finding indicates how substantial the effect of the organizational change was that gathered dispersed workers under the one roof.

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 literature on economic history (Williamson 1985; Berg 1994; Jones 1994; Mokyr 2002; Hudson 2004). There is widespread consensus that the 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 Weber stated ([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 back 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 on the rise of the factory that separates the organizational change from the 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 U.S. 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 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 less than five employees were regarded as artisan shops.

The reason why there is so little quantitative research comparing production organizations in the early stages of industrialization is that there is a lack of appropriate data. In this paper, I attempt to overcome this challenge using data on the fabric industry in early twentieth-century Japan. As I show in the next section, the fabric industry was one of the major industries that led the process of early industrialization in Japan. It was composed of a variety of production organizations, including the factory, the home workshop and the putting-out system. Moreover, unique data that distinguish these production organizations are available. Focusing on the fabric 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).

Within the Japanese economic history literature, there are a number of studies on the fabric industry, and the form of production organization has been one of the main issues. The research interest 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 (Taniimoto 1998), and firm dynamics (Houri 2012). Although these studies are insightful and related to this paper, no research has

compared the performance of different production organizations systematically.

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 fabric industry in Japan: An overview

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

Table 1, Figure 1, Figure 2

It is well known that a large 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 fabric 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)*. Hereafter, I refer to the statistics as the "Weaving Table" to distinguish them from another set of statistics that I describe in Sections 3 and 4. 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 less than 10 workers, whereas the home workshop was defined as a workshop with less 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 referred to a "producer who weaves fabric using threads of other people". Finally, a weaver referred 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 provides an overview of the fabric industry by the type of production organization. A number of interesting observations emerge. First, there were numerous fabric producers, more than half of whom outworkers who weaved fabrics under weavers using threads prepared by the weavers. The second largest group was home workshops. These two groups accounted for around 95% of the producers. The scale of production of the individual outworkers and home workshops was very small. As shown in Table 2, for both of these groups, the average number of workers per producer was less than two. It can be assumed that both groups of producers were principally based on the owners and their family members (Sanbe 1961, pp.355–357; Tanimoto 1998, p.265).

Table 2

The average scale of production of weavers in terms of workers was also small. This is not surprising because weavers basically contracted weaving to outworkers. However, they sometimes had workshops themselves, which are captured in terms of the workers of weavers in Table 2. One of the purposes of the weavers' workshops was the training of future outworkers. That is, there was a practice whereby young women first worked in the weavers' workshops; they worked for low wage rates but gained skills. Once their skills were sufficient, they returned to their homes to work as outworkers for the weavers (Sanbe 1961, p.385; Ichikawa 1996, pp.367–368; Hashino 1997, pp.15–16)[1]. Dividing the number of outworkers by the number of weavers, I can estimate the average number of outworkers per weaver, which is 20 to 30. This estimate is consistent with case studies on weavers. For example, Abe (1989) reported the case of a weaver in the Sennan region of Osaka Prefecture who employed 19 outworkers in 1892 (Abe 1989, p.119). Tanimoto (1998) described the case of a weaver in the Iruma region of Saitama Prefecture who provided weaving work to 36 outworkers in 1914

[1] Until the early 1900s, daughters of small peasants regarded working in the weavers' workshops as an "apprenticeship" (*minarai*), as well as a means of receiving wages in advance (Sanbe 1961, p.385).

(Tanimoto 1998, p.405). Finally, the average number of workers in factories was around 30. It should be noted that the factories in Table 2 include large cotton fabric plants operated by cotton spinning firms (Abe 1989, p.17).

With respect to the number of workers by type of production organization, 40–50% of the total workers were under the putting-out system. Therefore, 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).

Table 2 also indicates the numbers of hand and power looms. The diffusion of power looms is known to have accelerated in the Japanese fabric industry in the 1900s. 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). As shown in Table 2, during this period, power looms were adopted principally by factories. Although the ratio of power looms to total looms in factories was 19.5% in 1905, it increased to 68.1% by 1914. As stated in the Introduction, factories using hand looms were not exceptional in the 1900s, even though the diffusion of power looms to factories was quite swift. Further, many outworkers organized within the putting-out system weaved fabrics using hand looms. 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 manufactory from those of technological change, namely the introduction of the power loom.

3. Data and descriptive analysis

Although the Weaving Table described in the previous section is comprehensive and contains valuable information, it has a shortcoming in terms of evaluating the effects of organizational and technological changes. The shortcoming is that it does not contain information on production, which is essential for measuring productivity. Fortunately, there is another series of statistics on the fabric 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 varieties of cotton, silk, wool and hemp fabrics that were produced in the designated prefectures. Information was collected on the amount and quantity of fabric products, in addition to the types of information contained in the Weaving Table, 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)[2].

Table 3 summarizes the data from the Special Survey. Comparing Tables 2 and 3, it can be seen that it focuses on a particular part of the fabric industry. The plants covered are 5–7% of the total fabric plants in Table 2. The Special Survey covers 20–40% of factories, around 15% of workers, and 40–60% of power looms. These figures indicate that the survey focuses on the relatively large and mechanized producers. Nevertheless, it covers large numbers of home workshops and outworkers as well. In addition, it is notable that although the ratio of power looms in Table 3 is higher than that in Table 2, even for the factories, the ratio was just 22.8% in 1905. Hence, there are sufficient variations in organizations and technologies.

Table 3

Table 3 shows the amounts of real production in 1905 prices. The nominal amount of production of each fabric variety was deflated by the relevant price indices, based on Ohkawa et al. (1967). That is, for the varieties of cotton, silk and wool fabrics, the price indices were applied[3]. For hemp fabrics, a weighted average of the cotton, silk and wool price indices was applied. Composition of fabric production in our data by material is shown in Figure3. It should be noted that the amount of products weaved by outworkers was recorded as the production of the weavers who were responsible for putting-out the production (Hosono 1912, pp.178–179)[4]. Hence, it is not possible to

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

[3] The price index of cotton fabrics is the weighted average of the price indices of "cotton shirting" and "bleached cotton cloth", and the price index of silk fabrics is that of "habutae silk". Finally, the price index of wool fabrics is the weighted average of "flannel cloth", "muslin", "woolen satin", and "rasha woolen cloth" (Ohkawa et al 1967, pp.198–199).

[4] The author, Hanso Hosono, was in charge of statistics at the Ministry of Agriculture and Commerce, and this book is based on his lecture to the officers of statistics in the Chiba Prefectural Government.

measure production and productivity separately for weavers and outworkers. For this reason, I add the producer type "weaver + outworker", which enables me to assess the productivity of the putting-out system. In Table 3, I measure the productivity of each type of producer using the real production amount divided by the number of workers (labor productivity). As Table 3 indicates, average labor productivity increased sharply from 1905 to 1914. Comparing the labor productivities across producer types, it can be seen that there was a stable order of labor productivity, with factories at the top, followed by home workshops, then weavers and outworkers. This order reflects the difference in the extent of power loom diffusion and the effects of the organizational forms themselves. I disentangle these two components in the next section.

Figure 3

4. Measuring the effects of the technological and organizational changes

As stated above, the Special Survey of the Designated Fabrics 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 (Appendix Table A1). I collected the data from 1905 to 1914, just prior to World War I. These data are unbalanced panel data with four dimensions (product variety, prefecture, type of production organization, and year). Concerning the type of production organization, weavers and outworkers are integrated into one category for the reason stated in the previous section. From the original data, I excluded the observations where the number of producers, the number of workers, the number of looms or the production amount is zero. Then, I excluded the outliers where the real production per worker (labor productivity) or the number of looms per worker is larger or smaller than the mean ± two standard errors. As a result, 889 observations remained.

To identify the effects of organizational forms and technologies, I estimate the following simple Cobb–Douglas type production function:

$$\begin{aligned} \mathrm{Ln}(\mathrm{Lp}_{ijkt}) = {} & \alpha + \beta \mathrm{Ln}(\mathrm{Percapitaloom}_{ijkt}) + \gamma(\mathrm{Powerloomratio}_{ijkt}) \\ & + \mathrm{Factory}_j + \mathrm{Homeworkshop}_j + \zeta_i + \eta_k + \theta_t + \varepsilon_{ijkt}, \end{aligned} \tag{1}$$

where i, j, k, and t index product variety, type of production organization, prefecture, and year, respectively. Percapitaloom refers to the number of looms (hand and power looms), which captures capital intensity. Powerloomratio refers to the ratio of power to total looms, which captures the technological quality of capital. Factory is a dummy

variable that takes a value of one if the observation is for a factory, and zero otherwise. Homeworkshop is a dummy variable that takes a value of one if the observation is for a home workshop, and zero otherwise. The reference category on the type of production organization is the weaver and outworker, that is the putting-out system. The symbols ζ, η and θ are the product variety dummy, the prefecture dummy and the year dummy, respectively. Using ζ and η, I can control for unobservable heterogeneity that is specific to product variety and prefecture. Finally, ε is the error term.

I estimate equation (1) using Ordinary Least Squares. The basic statistics is reported in Table 4, and the estimation results are reported in Table 5. Column (1) is the baseline result using the full 889 observations. All of the coefficients reported are statistically significant and have substantial magnitudes. The coefficient on Powerloomratio, 0.882, implies that the labor productivity would be 2.42 (=exp(0.882)) times larger if producers completely substituted power looms for hand looms and the other conditions remained the same. The coefficient on Factory, 0.900, implies that the labor productivity of a factory worker was 2.46 times larger than that of an outworker under the putting-out system. Likewise, the coefficient on Homeworkshop, 0.453, implies that the labor productivity of a factory worker was 1.57 times larger than that of an outworker under the putting-out system. It should be noted that these effects of the organizational forms are found after controlling for the effect of power looms. Also, it is remarkable that the effect of the factory organization was as large as that of the power loom.

Table 4, Table5

As stated in Section 2, the Weaving Table of the *Statistical Report of the Department of Agriculture and Commerce* includes large-scale weaving plants operated by cotton spinning firms. Taking account of the effect of those plants of integrated firms, I split the samples into observations that include and exclude cotton fabrics; i.e., I have the observations for silk, wool and hemp fabrics, and observations for cotton fabrics. Column (2) of Table 5 shows the former observations, and column (3) shows the cotton fabric observations. As shown, the results are qualitatively the same as that in column (1). Therefore, it can be concluded that the organizational change, i.e., the substitution of the factory system for the putting-out system, and the technological change, i.e., the substitution of the power loom for the hand loom, had impacts of almost the same magnitude on labor productivity.

It is difficult to systematically explore the sources of the productivity differences

between a factory worker and an outworker. However, one of the major sources would be the differences in working days between the organizational forms. Holidays for factory workers were limited to Sundays, national holidays and the days of seasonal festivals (Ministry of Agriculture and Commerce [1903], 1988, p.318). On the other hand, outworkers tended to be engaged in agricultural work during the farming season (Tanimoto 1998, chapter 7). In addition, the working hours of factory workers were long, especially at factories with hand looms. Working hours ranged from 12–13 hours to 15–16 hours at hand loom factories, whereas they were around 12 hours at power loom factories (Ministry of Agriculture and Commerce [1903], 1988, p.308). Therefore, the difference in the labor productivity is not the same as the difference in efficiency in the narrow sense, and this includes the effect of the factory system that fully mobilized the capacity of workers.

Using the estimated coefficients, I can decompose the actual change in labor productivity to identify the separate impacts of technological and organizational changes. Substituting the actual average value of Percapitaloom and Powerloomratio in each year for $\hat{\beta}$Ln(Percapitaloom) and $\hat{\gamma}$(Powerloomratio), I obtain the contributions of these factors in terms of the log of labor productivity in each year. With respect to the valuables, Factory and Homeworkshop, I use the ratios of workers in factories and home workshops, respectively. Thus, the log of labor productivity is decomposed into the contributions of (a) the looms per capita, (b) the power loom ratio, (c) the share of factories, (d) the share of home workshops, and (e) the residual. Figure 4 shows the difference between these five components in each year and those in 1905. Although the residual remains, a substantial part of the labor productivity growth in this period is attributable to the components (a)–(d), in particular (b) and (c). For instance, although average labor productivity increased 2.64 times from 1905 to 1914, 45.5% of that increase can be attributed to the diffusion of the power loom, and 20.7% to the diffusion of the factory system.

5. Concluding remarks

In the early twentieth century, the fabric 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 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 the type of production organization. Using the data from these

surveys provides us with an excellent opportunity to compare productivity across the different types of production organizations.

In this paper, I found that the productivity of a factory worker was 2.46 times larger than that of an outworker under the putting-out system, after controlling for the effect of the power loom. The impact of the factory system was almost as large as that of the power loom in the case where all the hand looms were replaced by power looms. This finding indicates how substantial the effect of the organizational change was that gathered dispersed workers under the one roof. As pointed out in the previous section, it should be noted that an increase in labor productivity as a result of the introduction of the factory system was not the same as an increase in efficiency in the narrow sense, as it includes the effects that occurred as a result of the factory system fully mobilizing the capacity of workers. Conducting a more precise analysis of the sources of productivity increase that were achieved by the factory system remains a task for future research.

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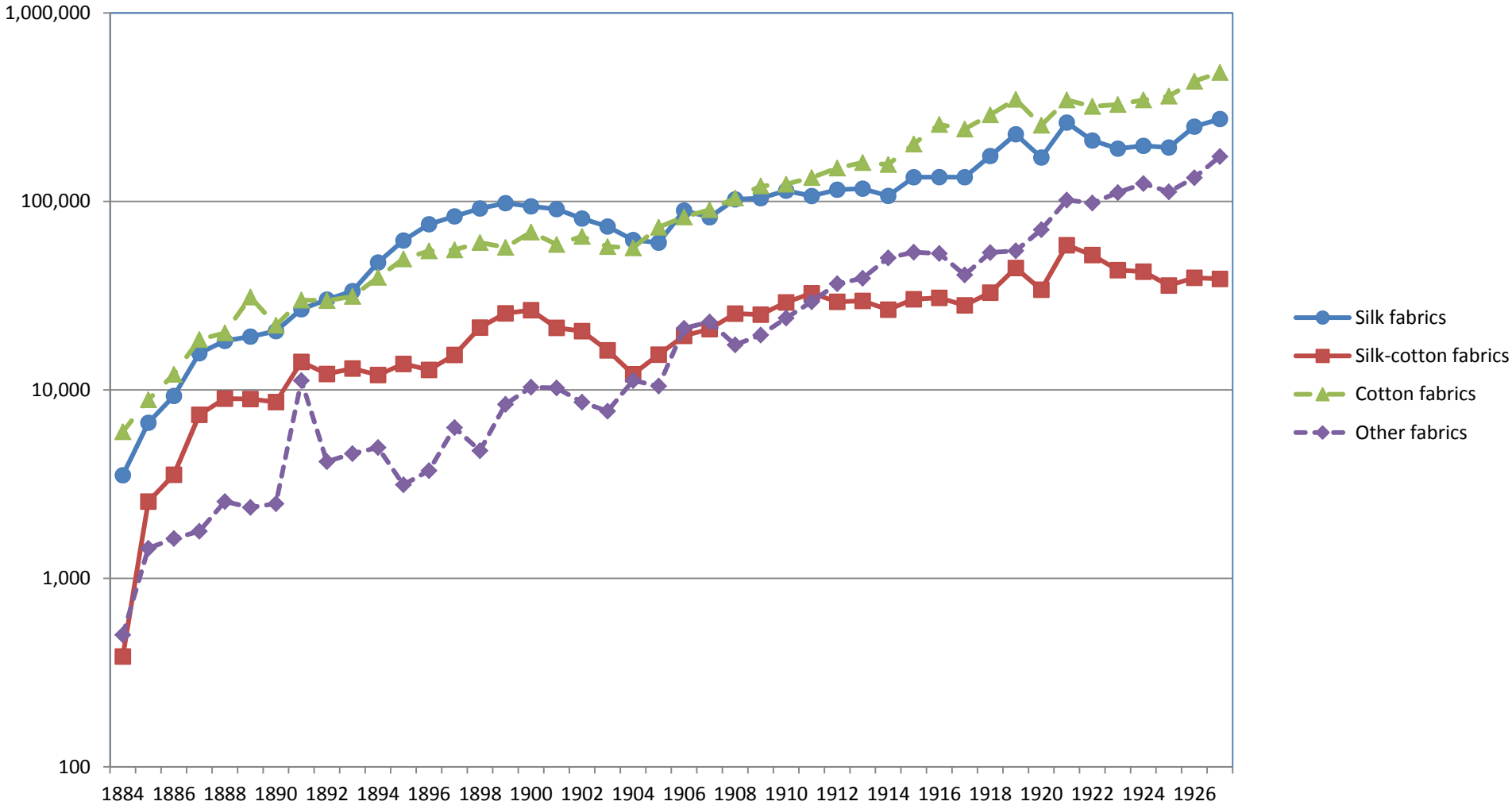
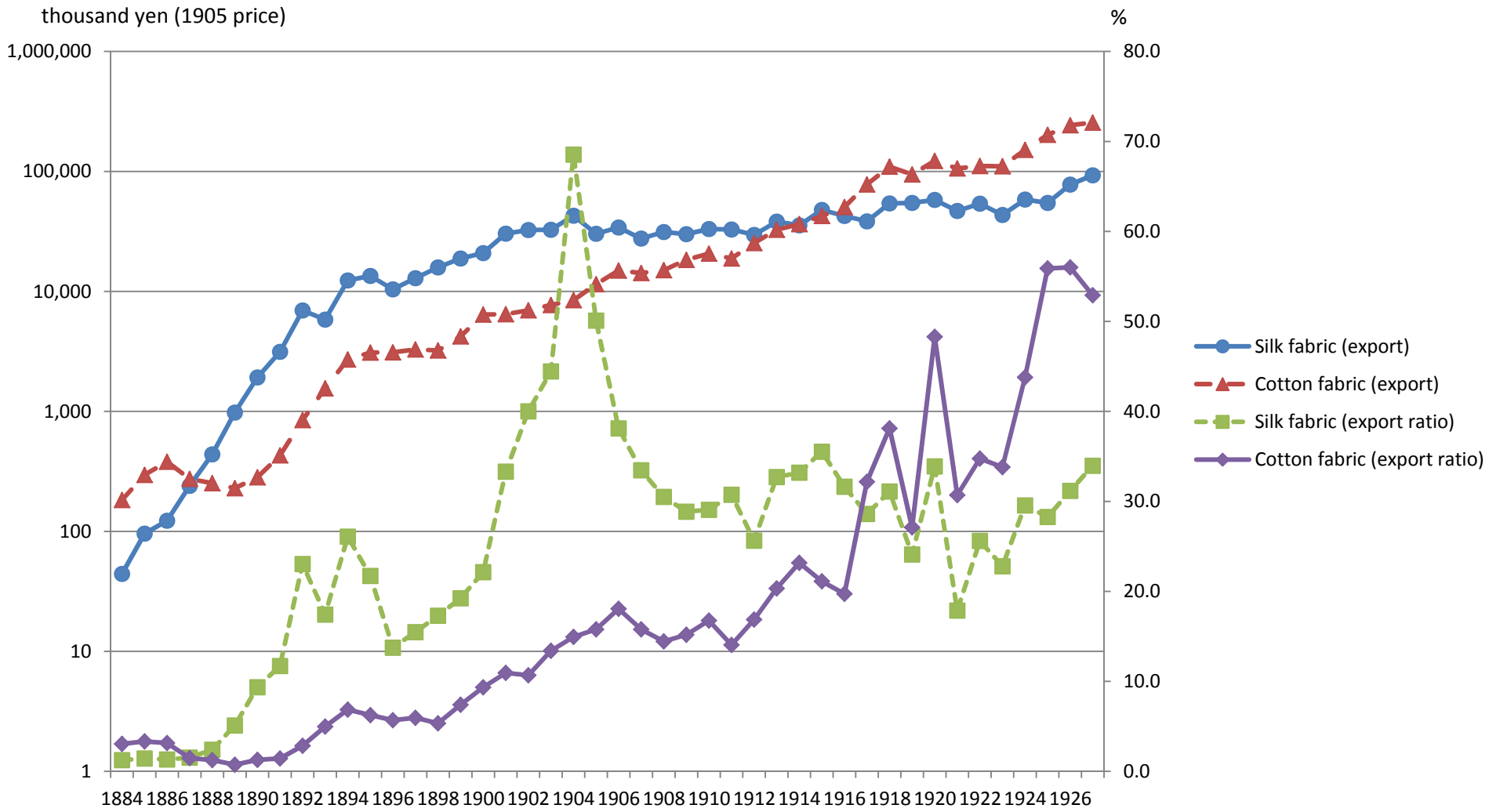
Figure 1 Production of fabrics in Japan



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

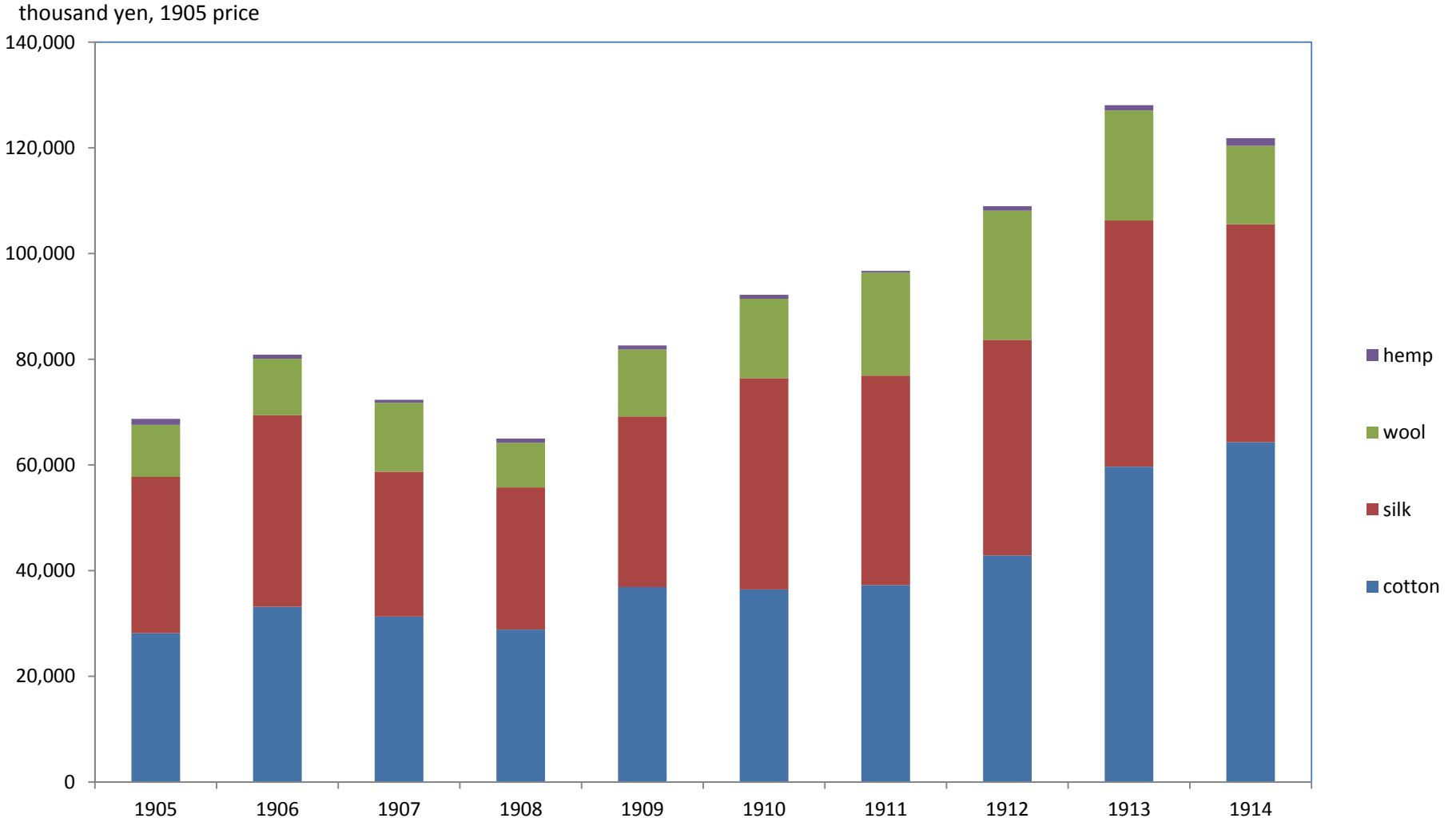
Figure 2 Export of fabrics from Japan



Note: Export ratio=export/production.

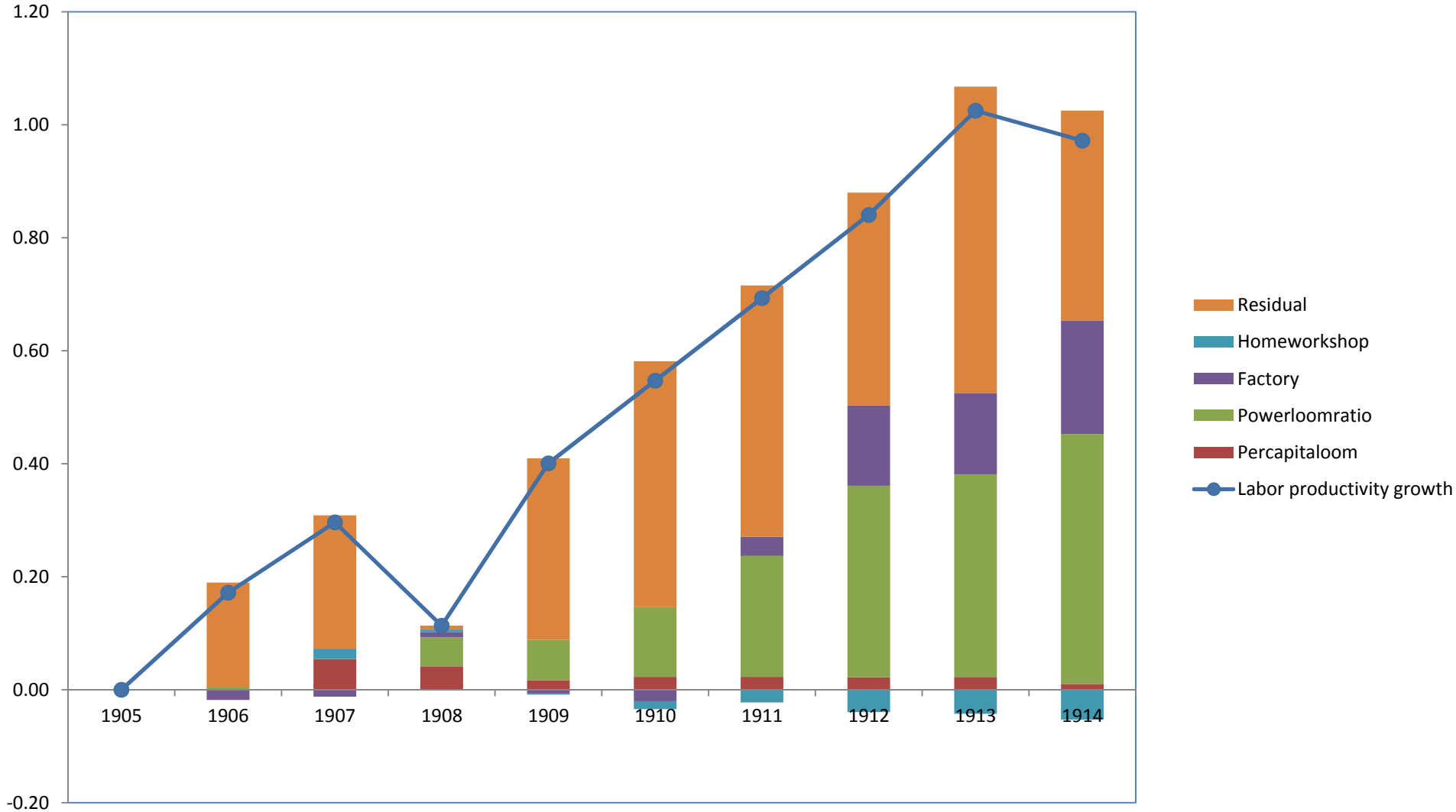
Source: Asahi Shinbunsha (1930), pp.248-249, p.744.

Figure3 Composition of production of the designated fabrics



Source: Ministry of Agriculture and Commerce ed., Noshomu Tokei Hyo (Statistical Report of the Ministry of Agriculture and Commerce, various issues.

Figure 4 Decomposition of labor productivity growth



Source: See the text.

Table 1 Fabric 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 Organizations and technologies of the fabric indusrtry

		1905		1908		1911		1914	
Number of producers	Toal	448,821	(100.0)	507,975	(100.0)	444,778	(100.0)	352,754	(100.0)
	Factory	3,142	(0.7)	4,173	(0.8)	5,019	(1.1)	4,922	(1.4)
	Home workshop	138,957	(31.0)	150,157	(29.6)	145,324	(32.7)	119,729	(33.9)
	Weaver	14,380	(3.2)	15,858	(3.1)	10,702	(2.4)	7,791	(2.2)
	Outworker	292,342	(65.1)	337,787	866.5)	283,733	(63.8)	220,312	(62.5)
Number of power looms	Toal	19,422	(100.0)	40,350	(100.0)	89,003	(100.0)	129,823	(100.0)
	Factory	14,874	(76.6)	35,872	(88.9)	78,939	(8.7)	116,512	(89.7)
	Home workshop	2,161	(11.1)	2,935	(7.3)	6,783	(7.6)	5,366	(4.1)
	Weaver	89	(0.5)	526	(1.3)	309	(0.3)	450	(0.3)
	Outworker	2,298	(11.8)	1,017	(2.5)	2,972	(3.3)	7,495	(5.8)
Number of hand looms	Toal	717,164	(100.0)	748,386	(100.0)	638,412	(100.0)	502,909	(100.0)
	Factory	61,562	(8.6)	72,971	(9.8)	64,606	(10.1)	54,661	(10.9)
	Home workshop	213,706	(29.8)	229,226	(30.6)	212,524	(33.3)	166,232	(33.1)
	Weaver	57,641	(8.0)	43,591	(5.8)	17,119	(2.7)	13,764	(2.7)
	Outworker	384,255	(53.6)	402,598	(53.8)	344,163	(53.9)	268,252	(53.3)
Number of workers	Toal	772,858	(100.0)	773,637	(100.0)	748,881	(100.0)	630,675	(100.0)
	Factory	94,964	(12.3)	116,080	(15.0)	137,705	(18.4)	168,653	(26.7)
	Home workshop	230,864	(29.9)	245,824	(31.8)	241,003	(32.2)	178,487	(28.3)
	Weaver	58,675	(7.6)	41,278	(5.3)	21,880	(2.9)	14,060	(2.2)
	Outworker	388,355	(50.2)	370,455	(47.9)	348,293	(46.5)	269,475	(42.7)
Number of workers per producer	Toal	1.7		1.5		1.7		1.8	
	Factory	30.2		27.8		27.4		34.3	
	Home workshop	1.7		1.6		1.7		1.5	
	Weaver	4.1		2.6		2.0		1.8	
	Outworker	1.3		1.1		1.2		1.2	
Ratio of power looms	Toal	2.6		5.1		12.2		20.5	
(%)	Factory	19.5		33.0		55.0		68.1	
	Home workshop	1.0		1.3		3.1		3.1	
	Weaver	0.2		1.2		1.8		3.2	
	Outworker	0.6		0.3		0.9		2.7	

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

Table 3 Organizations and technologies of the fabric indusrtry: Survey on the designated fabrics

		1905	1908	1911	1914
Number of producers	Toal	23,052 (100.0)	36,677 (100.0)	28,981 (100.0)	21,114 (100.0)
	Factory	1,470 (6.4)	1,471 (4.0)	1,328 (4.6)	1,015 (4.8)
	Home workshop	6,495 (28.2)	12,284 (33.5)	4,393 (15.2)	1,759 (8.3)
	Weaver	1,368 (5.9)	948 (2.6)	709 (2.4)	699 (3.3)
	Subcontractor	13,719 (59.5)	21,974 (59.9)	22,551 (77.8)	17,641 (83.6)
	Weaver＋outworker	15,087 (65.4)	22,922 (62.5)	23,260 (80.3)	18,340 (86.9)
Number of power looms	Toal	12,561 (100.0)	20,683 (100.0)	34,233 (100.0)	53,894 (100.0)
	Factory	12,079 (96.2)	20,011 (96.8)	32,623 (95.3)	51,856 (96.2)
	Home workshop	482 (3.8)	106 (0.5)	1,355 (4.0)	1,808 (3.4)
	Weaver	0 (0.0)	120 (0.6)	16 (0.0)	17 (0.0)
	Subcontractor	0 (0.0)	446 (2.2)	239 (0.7)	213 (0.4)
	Weaver＋ourworker	0 (0.0)	566 (2.7)	255 (0.7)	230 (0.4)
Number of hand looms	Toal	113,708 (100.0)	110,834 (100.0)	65,861 (100.0)	35,996 (100.0)
	Factory	40,799 (35.9)	31,926 (28.8)	18,199 (27.6)	10,043 (27.9)
	Home workshop	22,441 (19.7)	25,309 (22.8)	11,281 (17.1)	3,994 (11.1)
	Weaver	28,922 (25.4)	14,562 (13.1)	3,318 (5.0)	2,157 (6.0)
	Outworker	21,546 (18.9)	39,037 (35.2)	33,063 (50.2)	19,802 (55.0)
	Weaver＋outworker	50,468 (44.4)	53,599 (48.4)	36,381 (55.2)	21,959 (61.0)
Number of workers	Toal	147,707 (100.0)	129,505 (100.0)	105,429 (100.0)	101,558 (100.0)
	Factory	71,210 (48.2)	65,554 (50.6)	54,345 (51.5)	72,231 (71.1)
	Home workshop	25,604 (17.3)	23,269 (18.0)	12,867 (12.2)	5,574 (5.5)
	Weaver	29,236 (19.8)	7,674 (5.9)	3,603 (3.4)	2,136 (2.1)
	Outworker	21,657 (14.7)	33,008 (25.5)	34,614 (32.8)	21,617 (21.3)
	Weaver＋outworker	50,893 (34.5)	40,682 (31.4)	38,217 (36.2)	23,753 (23.4)
Production	Toal	68,710 (100.0)	94,974 (100.0)	100,481 (100.0)	122,990 (100.0)
(thousand yen, 1905 price	Factory	42,626 (62.0)	62,463 (65.8)	79,915 (79.5)	103,514 (84.2)
	Home workshop	14,261 (20.8)	20,784 (21.9)	10,193 (10.1)	6,959 (5.7)
	Weaver	6,614 (9.6)	5,064 (5.3)	9,426 (9.4)	12,204 (9.9)
	Outworker	5,209 (7.6)	6,663 (7.0)	947 (0.9)	313 (0.3)
	Weaver＋outworker	11,823 (17.2)	11,727 (12.3)	10,373 (10.3)	12,517 (10.2)
Number of workers	Toal	6.4	3.5	3.6	4.8
per producer	Factory	48.4	44.6	40.9	71.2
	Home workshop	3.9	1.9	2.9	3.2
	Weaver	21.4	8.1	5.1	3.1
	Outworker	1.6	1.5	1.5	1.2
	Weaver＋outworker	3.4	1.8	1.6	1.3
Ratio of power looms	Toal	9.9	15.7	34.2	60.0
(%)	Factory	22.8	38.5	64.2	83.8
	Home workshop	2.1	0.4	10.7	31.2
	Weaver	0.0	0.8	0.5	0.8
	Outworker	0.0	1.1	0.7	1.1
	Weaver＋outworker	0.0	1.0	0.7	1.0
Production/worker	Toal	465.2	733.4	953.1	1,211.0
(yen, 1905 price)	Factory	598.6	952.8	1,470.5	1,433.1
	Home workshop	557.0	893.2	792.2	1,248.5
	Weaver	226.2	659.9	2,616.2	5,713.3
	Outworker	240.5	201.9	27.4	14.5
	Weaver＋outworker	232.3	288.3	271.4	527.0

Source: Ministry of Agriculture and Commerce, *Noshomu Tokeihyo (Statistical Report of the Ministry of Agriculture and Commerce)*, various issues.

Table 4 Basic statistics

	Obs.	Mean	Stdev.	Min.	Max
Ln(Lp)	889	6.086	1.376	−0.257	9.097
Ln(Percapitaloom)	889	0.883	0.427	0.003	6.377
Powerloomratio	889	0.322	0.419	0	1
Factory	889	0.488	0.5	0	1
Homeworkshop	889	0.272	0.445	0	1

Table 5 Estimation of production function

	(1) All samples		(2) Excluding cotton		(3) Cotton	
Dependent variable: Ln(lp)						
Ln(percapitaloom)	0.218	(0.908) **	0.227	(0.121) *	0.245	(0.169)
Powerloomratio	0.882	(0.175) ***	0.911	(0.281) ***	0.907	(0.242) ***
Factory	0.900	(0.116) ***	0.956	(0.215) ***	0.856	(0.134) ***
Homeworkshop	0.453	(0.101) ***	0.642	(0.172) ***	0.339	(0.117) ***
Constant	4.231	(0.258) ***	4.220	(0.503) ***	5.047	(0.352) ***
Product FE	Yes		Yes		Yes	
Prefecture FE	Yes		Yes		Yes	
Year FE	Yes		Yes		Yes	
Number of obs.	889		388		501	
R^2	0.530		0.526		0.553	

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.