From Lyon to Kyoto: Modernization of a Traditional Silk-Weaving District in Japan, 1887–1929

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ABSTRACT (193WORDS)

In 1872, three craftsmen were sent by the Kyoto prefectural government to Lyon, France, to learn about power-looms and other weaving innovations. Instead of bringing back a power-loom, they brought back the Jacquard mechanism and the flying shuttle to Kyoto because they thought power-looms were too expensive and inappropriate for their sophisticated fabrics. This paper explores the production trend from 1887 to 1929 to characterize growth phases—Jacquard-led, out-weaver-based, and power-loom-assisted—in Kyoto. By doing so, the importance of selective adoption of new technologies for industrial development is discussed.

Keywords: industrial district, technology import, technology choice, technology adoption, institutional change, division of labor

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INTRODUCTION

It is well-known that industrial districts or industrial clusters are characterized by organized and flexible specialization of production and the division of labor among enterprises (Scranton 2000, 2002, 2003; Sabel and Zeitlin 1997). In fact, industrial districts usually consist of many small enterprises, each specializing in a particular production process and is linked with other enterprises through contractual relationships. In addition, organizations, such as trade associations, technical schools, and industrial research institutes, facilitate the growth of the district in various ways in western countries and in industrializing modern Japan (Zeitlin 2009; Abe 1999; Sawai 1999; Calnevali 2004, 2011; Hashino 2012; Di Maltino, Popp, and Peter 2017; Hashino and Kurosawa 2013). Similar phenomena are observed in contemporary developing countries in Asia and Africa (Sonobe and Otsuka 2006, 2011; Hashino and Otsuka 2016). Certainly, industrial districts play critical roles in industrial development in history and in the developing world.

Historically, one of the driving forces that promote industrial development in developing countries has been technology transfer, which enabled backward regions to catch up with advanced countries (Gerschenkron 1962). Modern economic development in Japan since the Meiji Restoration (in 1868) is considered a typical case of successful economic development based on technological catch-up (Nakamura 1971; Minami 1994 Morris-Suzuki 1995). In Meiji Japan, the large-scale modern cotton-spinning industry was established based on technology import from the United Kingdom (Saxonhouse 1977; Otsuka, Ranis, and Saxonhouse 1988; Farnie and Jeremy 2004; Braguinsky et al. 2015). The most advanced large-scale modern silk-reeling factory was imported from France (Ma 1996; Hunter 2003; Kiyokawa 2005). There are many other examples of the development of modern industries because of imported technologies (Okazaki 1993; Nakamura 1998, 2000; Kuwahara 2004; Kurosawa and Hashino 2012). Although there is no doubt that the introduction of modern

industries contributed to the fairly rapid development of Japan during the prewar period since the end of the 19th century. It is also true that the modernization of traditional industries by means of technology imported from the West was no less important than the introduction of modern industries, particularly in terms of employment generation (Nakamura 1966; Tanimoto 2016). Nakamura estimated that more than 30% of workers in Japan worked at traditional industries around the turn of the century (Nakamura 1966). However, there have been scant quantitative empirical studies that inquired into the role of western technologies in the modernization process of traditional industries.

It is important to note that majority of traditional industries, especially weaving industries, historically developed by forming industrial districts (Tanimoto 1992; Abe 1992, 2019; Ōta 2002; Yamazaki 2002; Tamura 2003; Nakaoka 2006; Hashino and Otsuka 2013a, 2013b, 2020; Hashino and Saito 2004). The relevant question is whether and how the introduction of new technology affected the division of labor among these enterprises and production growth in these traditional districts. Related questions are what technologies were associated with the strengthening or weakening of the division of labor and what organizational changes took place to facilitate the division of labor or discourage it by vertically integrating production processes in the industry.

This study aims to examine the modernization process of Nishijin, a traditional silk-weaving district in Kyoto. It is by far the most advanced silk-weaving district in Japan in the late 19th century. Special attention is paid to the role of technology transfer from Lyon in France, which was the most advanced silk-weaving district in the world. The Kyoto prefectural government sent delegations to Lyon in the late 19th century in order to introduce modern silk-weaving technologies, particularly power-looms, to Kyoto. Technology import,

however, was not linear. Although Nishijin adopted the Jacquard[1] mechanism or attachment (Jacquard hereafter) relatively early, power-looms were widely adopted only several decades later.

Furthermore, organizational changes, such as the development of a small-scale out-weaver system led by contractor-cum-merchants (CCM), played critical roles in the long-term development of the Nishijin District. In this article, I would like to demonstrate that Nishijin successfully developed by selectively importing western technologies and making various technological and organizational adaptations.

The following sections provide an overview of the development of Nishijin from 1887 to 1929, identify the three distinct development phases, and postulate hypotheses to explain why such distinct development phases emerged. More specifically, the entire growth process in Nishijin is subdivided into three phases: Jacquard-led growth, out-weaver-based growth, and power-loom-assisted growth. This is then followed by an examination of the role of the introduction of the Jacquard in the first phase and why firm size declined and output expanded in the second out-weaver-based growth phase. The next section investigates the causes for the adoption of power-looms that accompanied the rise of family enterprises in place of out-weavers in the third phase. Finally, in section 6, major findings are summarized with policy implications.

1 According to the definition by Hall (2014), Jacquard is an attachment that can be added to a handloom or a power loom to control the warp threads. This means that a weaver does not have to remember the entire sequence of treadlings that make up a pattern, or keep track of where they are in the sequence—the Jacquard does this for them.

DEVELOPMENT OF NISHIJIN FROM 1887 TO 1929: AN OVERVIEW

Background history of Nishijin's development

Nishijin had been the most advanced silk-weaving district in Japan, producing high-quality fabrics for the privileged classes since the medieval period. In 794, the emperor moved the capital to Kyoto and established the Office of Textiles, or *Oribeshi*, which exclusively produced high-quality and sophisticated silk fabrics. In the medieval period, silk weaving was originally a government monopoly, but it gradually opened to the private sector. After the *Onin* War (1467–77), which devastated the Kyoto area and damaged the local weaving industry, people who had evacuated returned to Nishijin to resume the production of silk fabrics using textile technology introduced from China (Bank of Japan - Kyoto Branch, 1914, p. 3).

In the Edo period (1603–1868), Nishijin continued to be the most advanced silk-weaving district in Japan, producing high-quality silk products not only for the limited number of privileged people but also for the many wealthy people who could already afford such products. In the early 18th century, local weaving districts, such as Tango, Kiryu, Nagahama, Ashikaga, Isezaki, Hachioji, and Gifu, emerged in various parts of Japan by introducing technologies from Nishijin (Horie and Goto 1950, pp. 6–7; Hashino and Kurosawa 2013, p. 495).

Even after the capital was moved to Tokyo in 1868 at the Meiji restoration, Nishijin remained the leader in Japan's silk-weaving industry. The policies of the Kyoto prefectural government initially focused on the promotion of trading at the beginning of the Meiji period but gradually shifted to industrialization through the transfer and diffusion of western technology (Nakaoka et al. 1988, p. 125). The local government sent craftsmen to Lyon, France, to learn skills and introduce new technologies in weaving and dyeing in 1872. Their original mission was to introduce power-looms equipped with a steam engine, but power-

looms were considered not appropriate to produce high-quality and highly sophisticated products in Nishijin. The craftsmen, instead, brought back the flying shuttle and synthetic dyestuffs technologies, which diffused rapidly to all weaving districts throughout Japan (Hashino 2012). As will be discussed later, the Jacquard was also introduced, but it took a long time to diffuse within Nishijin, even though Nishijin craftsmen had already acquired the skills to introduce, absorb, and imitate western technologies.

There were 18,000 workers in Nishijin in 1877, and the number increased to 35,000 in 1905, reflecting rapid development. After that, it remained roughly 35,000 partly because labor-saving technologies were gradually adopted since the 1910s. According to the survey done by the Kyoto Branch of the Bank of Japan (1914), members of 11,000 households were engaged in silk-weaving-related businesses, and the livelihood of one-third of the population in Kyoto was dependent on the silk-weaving industry (Bank of Japan - Kyoto Branch 1914, p. 2).

CHARACTERISTICS OF THE THREE PHASES OF NISHIJIN'S DEVELOPMENT (1887–1929)

What factors promoted growth in Nishijin after the introduction of new technologies from the West? To identify the major components of growth in production in Nishijin from the late 19th century to the early 20th century, I decomposed the *real value of production* (Q) into the *number of enterprises* (N), *enterprise size* in terms of the number of looms per enterprise (K/N), the *number of workers per loom* (L/K), and *labor productivity* (Q/L), according to the following formula:

$$Q = N \times (K/N) \times (L/K) \times (Q/L). \qquad (1)$$

By taking the logarithm, Equation (1) can be written as:

$$\ln Q = \ln N + \ln(K/N) + \ln(L/K) + \ln(Q/L), \qquad (2)$$

where *K/N* is an indicator of the type of production organization, such as out-weaver, family enterprise, and factory; *L/K* is an indicator of technologies, which are expected to be changed by the introduction of new technology (for example, 3–4 persons per traditional draw-loom, one person per hand loom with the Jacquard, and less than one person per power-loom); and *Q/L* is an indicator of the composite impacts of enterprise size and technology.

Figure 1 shows the logarithm of indexes of production, the number of enterprises, enterprise size in terms of number of looms, worker-loom ratio, and labor productivity in Nishijin with the common base year of 1899.[2] Several distinctive characteristics can be seen in Figure 1. First, the real value of production rapidly increased from 1887 to the turn of the century but dropped suddenly before the Russo-Japanese War (1904–05). Second, the worker-loom ratio tended to decrease toward the turn of the century, largely stagnated for a few decades and began to rise after 1910. Such a sharp decline in the worker-loom ratio before the turn of the century suggests that the introduction and spread of the Jacquard took place, which displaced workers previously engaged in drawing yarns. Third, the number of enterprises continuously rose for almost the whole period, even though it slightly declined occasionally and in the 1920s. Curiously, growth in enterprises was remarkably high for more than ten years after the Russo-Japanese War. Fourth, while enterprise size in terms of the number of looms continued to increase until the end of the century, it started shrinking toward the mid-1910s. From the third and fourth findings, it is clear that the number of small enterprises increased in the early years of the 20th century. Finally, labor productivity was largely stagnant from 1887 to 1905 but began to increase rapidly shortly after the Russo-

2 For obtaining the real value of production, I tried to apply several price indexes (*habutae*, *kaiki*, and silk-lining price indexes, for example). These silk-related price indexes undervalued the increase in price during the boom period in the late 1910s. When I used the textile products price index, which covered all types of materials including cotton, silk, wool, and others, the increase in the price in the boom period became higher than in the silk-related price indexes. On the whole, however, I found similar trends by using various price indexes. As will be shown later, since the materials of fabrics produced in Nishijin became diversified, I applied the textile products price index for constructing Figure 1.

Japanese War to around 1918. After declining in the early 1920s, it started rising again from the mid-1920s.

[FIGURE 1 ABOUT HERE]

Based on these observations, the entire development path in modern Nishijin can be divided into three growth phases. From 1887 to around 1905, increases in average enterprise size and number of enterprises and decreases in the worker-loom ratio were associated with growth in production. Relatively large factories that produced fabrics different from traditional ones were built in this period. In addition, though it is unclear why the worker-loom ratio slightly increased in the early 20th century, the introduction of the Jacquard mechanism seems to be responsible for the declining worker-loom ratio, as will be seen later. I consider this as Phase I. Phase II started around 1905 with increases in the number of enterprises and labor productivity, which continued until 1918. At the same time, a sharp decline in enterprise size is noticeable. The entry of small producers and the widespread use of the Jacquard seemed to contribute to the growth in this phase. The period after 1918 can be regarded as Phase III, when labor productivity, the worker-loom ratio, and enterprise size slightly and steadily increased.

HYPOTHESES OF THIS STUDY

Why such characteristically different phases of development emerged is a question that I would like to address in subsequent sections. Specifically, I would like to advance three hypotheses corresponding to each phase.

Hypothesis 1: Worker-loom ratio declined significantly in Phase I, particularly from the mid-1890s to 1900, due to the diffusion of hand looms with the Jacquard mechanism.

Hypothesis 2: There was a significant rise of small-scale out-weavers in the growth Phase II due to the increasing production of labor-intensive figured products under the

leadership of contractor-cum-merchants.

Hypothesis 3: The number of out-weavers decreased, and the adoption rate of power-looms increased in Phase III, probably because small family enterprises, which were larger than out-weavers, were more suited to use power-looms.

By utilizing quantitative data and qualitative information, I will explore how this structural transformation occurred in the most advanced silk-weaving district in Japan while paying attention to the introduction of new technologies, organization of division of labor, and changes in the facilitating roles of production organizations.

ROLE OF THE INTRODUCTION OF JACQUARD IN PHASE I (1887–1905)

FROM 'HUMAN JACQUARD' SYSTEM TO THE INTRODUCTION OF THE JACQUARD

As I mentioned in the previous section, local craftsmen were sent to Lyon by the local government in the early 1870s with two missions. One was to conduct a survey of advanced production systems and learn skills for dyeing, weaving, and finishing. The other was to purchase western looms, two for twilled fabrics and two for plain fabrics (Kyoto Municipal Center for Dyeing and Weaving 1990, p. 18). The two looms for plain fabrics seemed to be power-looms, which the craftsmen were requested to purchase on behalf of the Ministry of Public Works. This was a plan by Vice-Minister Yozo Yamao, who learned engineering and shipbuilding technology in London and Glasgow in the 1860s and returned to Japan in 1868. His evaluation was that although Nishijin had high skills for production, its production method was obsolete. Therefore, Mr. Yamao planned to purchase the power-looms and lend them to producers in Nishijin to make them realize how efficient and productive the mechanized machines were. Subsequently, the Ministry planned to lend them to other promising weaving districts in Japan for wider diffusion (Nakaoka 2006, pp. 94–95).

Visiting a factory in Lyon, Japanese craftsmen were overwhelmed by mechanized production. Factories that were equipped with as many as 90 power-looms were common. All the weaving processes, such as warping, weft winding, and reeling, were all mechanized. After a week-long survey, the craftsmen reached the conclusion that it was inappropriate to purchase power-looms, partly because they were too expensive and partly because it was not economical unless many power power-looms were operated to fully utilize a large-scale steam engine. In other words, they would have had to buy not only power-looms but also excessively expensive auxiliary machines and equipment indispensable in western-style factory operation.

Contrary to Mr. Yamao's expectation, what the craftsmen realized in Lyon was the usefulness of manual instruments, which, they found, would be more appropriate for facilitating production in Nishijin. One was the flying shuttle, and the other was the Jacquard attachment or mechanism (Nakaoka 2006, p. 97). Although both the flying shuttle and the Jacquard were introduced to Nishijin in the 1870s from Lyon, the diffusion of the Jacquard needed more time than the flying shuttle. Shortly after the arrival of the flying shuttle and the Jacquard, carpenters in Nishijin tried to imitate them. In Nishijin, Mr. Masashichi Hasegawa succeeded in producing an imitation of the flying shuttle in 1876. According to Horie and Goto (1950), the flying shuttle became widely used in Nishijin in producing the fabrics for military uniforms in 1877 when the civil war occurred. In the early 1890s, satin was produced using the flying shuttle in Nishijin (Horie and Goto 1950, p. 14). Thus, the flying shuttle diffused quickly (Nakaoka 2006, p. 107).

After the introduction of the Jacquard from Lyon, the Kyoto municipal government facilitated its diffusion in various ways. It was exhibited in Kyoto in 1874 and shown in an exhibition of weaving using the Jacquard attached to the hand loom at a model factory in Kyoto. From 1875, this model factory is where the craftsmen who had returned from Lyon

taught other craftsmen, some of whom came from other local weaving districts, how to use the flying shuttle and the Jacquard attachment. The Austrian Jacquard was also introduced to Japan, triggered by the attendance of the Japanese delegation to the Vienna Exposition in 1873.[3]

Despite the extraordinary effort to introduce Jacquard, there were reasons why it did not diffuse so easily. First, the draw-loom was more appropriate to weave sophisticated figured fabrics than the imported Jacquard, which could not deal with the complicated mechanism required to produce the *kimono*. However, the Jacquard mechanism was appropriate for producing simpler figured fabrics than those usually produced in Nishiijin. Therefore, the momentum for adoption of the Jacquard did not rise until the improved Jacquard, which could produce more complicated figured fabrics, became available. It must also be pointed out that imported Jacquard was expensive, especially high-quality ones, which could produce sophisticated fabrics. Local skilled carpenters struggled to imitate the Jacquard, but they needed engineers or mechanics who had knowledge of modern engineering to understand the complex mechanism, which can weave sophisticated fabrics like those made by traditional draw-looms (Nakaoka 2006, p. 100, pp. 106–107). In Nishijin, it was reported that full-scale diffusion of Jacquard started after 1885, more than ten years later after it was first imported (Tokutake 2014, p. 140). According to the Kyoto Municipal Center of Dyeing and Weaving (1990, p. 22), draw-looms were almost completely substituted by looms with Jacquard attachment around the turn of the century.

Traditionally in Nishijin, more than a few workers were needed per hand loom to weave figured fabrics because, in addition to the weaver, the supervisor had to give instructions

3 Mr. Yasuke Date attended the Vienna Exposition in 1873 and brought the Austrian Jacquard, more than 120 instruments, and samples of fabrics after visiting weaving districts in Europe for two years. The exhibition of weaving using the Austrian Jacquard also started at the industrial-promotion center in Tokyo (Nakaoka 2006, p. 100).

to one or two child workers who sat on top of the draw-loom. Thus, the craftsmen in Lyon were impressed with the Jacquard, which could weave figured fabrics operated by only one weaver. That is why they decided to write to the government that they wanted to start learning how to operate the Jacquard machine. In fact, weaving by hand looms equipped with the Jacquard mechanism saved on at least one worker and halved the production time, compared with weaving by the traditional draw-loom. As a result, productivity increased four times by using hand looms with the Jacquard mechanism (Hattori 1948, p. 158).

Figure 2 shows changes in the average worker-loom ratio from 1887 to 1927 and that by production organization from 1905 to 1919.[4] When the traditional draw-loom was used for production, more than two people were needed per loom.[5] Therefore, the worker-loom ratio would have been more than three, including the people engaged in the preparation process and supervision. This is consistent with the data in Figure 2 for 1887–94. Although the worker-loom ratio grew again toward 1903, it began to drop again, and the average worker-loom ratio has declined rapidly since then. These trends indicate that the spread of the Jacquard occurred in Nishijin during Phase I, resulting in a worker-loom ratio of roughly by the first decade of 20th century.

[FIGURE 2 ABOUT HERE]

Table 1 shows the diffusion of the Jacquard in 1886, 1891, and 1895 in which relevant data are available. Not only did the total number of looms rapidly increase, especially from 1891 to 1895, but the number of looms with the Jacquard mechanism also increased 18-fold during the nine-year period. The share of looms with the Jacquard to the total number of looms

4 The types of production organization are defined as follows. A factory is a workshop with more than ten workers; a family enterprise is one with less than nine workers; and an out-weaver worked for merchant-cum-manufacturers, which out-sourced the weaving process by providing hand looms and raw materials.

5 To produce highly sophisticated and complicated fabrics, two drawers per loom were needed (Tokyo Regional Taxation Bureau 1905, p. 41).

was almost 25% and reached nearly 50% of looms used for figured fabrics by 1895 (also see Yamaguchi 1974, p. 210). The Jacquard was likely introduced primarily by large enterprises since enterprise size significantly increased in Phase I (see Figure 1).

[TABLE 1 ABOUT HERE]

FROM MEN'S WORK TO WOMEN'S WORK

In general, weaving had traditionally been men's work in Nishijin. Before the modern period, only male craftsmen who belonged to the guild were allowed to be engaged in weaving. Women and children supported men's work in the preparatory processes by drawing the warp while sitting on the top of the draw-loom and in the finishing processes. After the Meiji Restoration (1868), traditional guilds were dissolved, free business was allowed, and many people entered the weaving industry (Hashino 2012). The question is, *Did the diffusion of the Jacquard in Phase I affect gender division of labor?*

Figure 3 represents changes in the proportion of female workers in Nishijin. Unfortunately, the data on production organization for Phase I is not available, but the detailed data in Phase II will help us to conjecture the trend in the employment of female workers during the period of the wide diffusion of the Jacquard in Nishijin. The average proportion of female workers had been around 40% until the turn of the century, then it increased to 60% in 1905, regardless of the type of production organization. This suggests that the wide diffusion of the Jacquard resulted in the emergence of the female worker class who were freed from being limited to working in draw-looms. *What did female workers do then?*

According to the Kyoto Branch of the Bank of Japan (1914), whereas male workers generally engaged in weaving the figured *obi* or sash of the *kimono*, female workers engaged in both preparatory processes and in the production of the kimono. Such gender division of

labor appeared because, unlike female workers, male workers had accumulated the skill to weave complicated and sophisticated fabrics such as those used in the *obi* (Bank of Japan - Kyoto Branch 1914, p. 16). This is supported by a statement that can be found in a report about the first decade of the 20th century: “Female workers generally engaged in weaving simple fabrics, such as satin, simple obi, and half-width obi” (Tokyo Regional Taxation Bureau 1905, p. 362). From these observations, the introduction and spread of the Jacquard mechanism, even with the trial-and-error process, played a significant role in facilitating the restructuring of the gender composition of workers in Nishijin.

[FIGURE 3 ABOUT HERE]

INCREASING DOMINANCE OF OUT-WEAVERS IN PHASE II (1905–18)

INCREASE IN THE NUMBER OF OUT-WEAVERS

Phase II was characterized by increases in the number of enterprises and labor productivity. At the same time, it was remarkable that enterprise size declined sharply. Now the question is, *why did the number of enterprises increase so substantially*?

Figure 4 presents the changes in the number of enterprises from 1887 to 1929 and in the production organization from 1899 to 1929 by using different data sources.[6] Interesting observations can be made. Firstly, the total number of enterprises started to grow at the beginning of Phase II. Although it dropped with the outbreak of World War I, it began to increase again until the end of Phase II. It increased almost three times during the period. This rise is mainly due to an increase in the number of out-weavers in Phase II. An out-weaver is under contract with a contractor-cum-merchant (CCM), and they weave fabrics by

6 For 1905 to 1919, I found data on the number of factories and family enterprises in the Statistical Survey of the Kyoto Prefecture (various years).

using looms and yarns provided by the CCM, who gives them piece-rate wages. The number of out-weavers increased from about 4,000 in 1905 to nearly 10,000 in 1919. Secondly, the numbers of both family enterprises and factories remained stagnant during Phase II, although the former started growing around the end of Phase II. Although the data on production shares of the three types of production organizations are unavailable, the employment share of factories decreased from 32% in 1905 to 18% in 1918, whereas that of out-weavers increased from 30% to 60% during the same period. It is clear that out-weavers became the dominant production organization in Phase II.

It is interesting to note that such an increase in the number of out-weavers in Nishijin was quite similar to the experience in Kiryu in the 1910s, which developed its fabric production system through advanced technologies introduced from Nishijin (Hashino and Otsuka 2013b; Hashino and Kurosawa 2013). In Kiryu, too, the organization of a division of labor and the expansion of the contractual relationship between out-weavers and CCMs took place (Hashino and Kurosawa 2013, p. 504; Editorial Group of History of Kiryu Textile Industry 1938).[7]

[FIGURE 4 ABOUT HERE]

DIFFUSION OF JACQUARD AND DEVELOPMENT OF DIVISION OF LABOR

It is interesting to inquire why out-weavers became dominant in Phase II. Nishijin had a long tradition of division of labor among small enterprises to produce high-quality and sophisticated fabrics. However, production by hand loom with the Jacquard mechanism

7 In Kiryu, local producers attempted to introduce modern machines for weaving and related processes not only from Nishijin but also directly from the United States and European countries. Like in Nishijin, Kiryu craftsmen also made the effort to acquire Jacquard looms and related machines (Editorial Group of History of Kiryu Textile Industry 1938, pp. 370–92). Subsequently, the introduction of the power-loom started in Kiryu in the late 1910s (Hashino 2007, p. 19).

needed a larger number of subdivided processes, such as preparation processes for the Jacquard's perforated card-chain; and making original designs, transforming it onto a section paper, perforating cards, and combining cards to a chain of cards (Nakaoka et al. 1988, p. 134). It appears that many of such tasks were carried out by factories in Phase I because of the absence of various service provisions in this phase. Since loom prices were too high for poor out-weavers to purchase and the preparation and finishing services and the service to provide card chains were initially unavailable, out-weavers were unable to engage in weaving with the Jacquard.

However, the putting-out system was developed gradually for the diffusion of the Jacquard, especially for producing obi and sash, under the leadership of CCM (Nakaoka et al. 1988, p. 138). Nakaoka (2006) argues that while the introduction and diffusion of the Jacquard contributed to labor-saving, more importantly, it also promoted the restructuring of the division of labor in Nishijin through out-weavers (Nakaoka 2006, p. 119).[8] Figure 5 illustrates a highly simplified picture of the division of labor among CCM, out-weavers, and other enterprises. In Figure 5, while two-headed arrows indicate a contract between CCM and other enterprises, a one-headed arrow shows a one-way transaction with other enterprises. Designing and making figures includes drawing the original design, transforming the original design onto a section paper, preparing the perforated card chain for the Jacquard, perforating cards, and combining cards into a chain of cards. Yarns were cleaned and sorted out by yarn processors before these were delivered to out-weavers. Woven fabrics produced by out-weavers are then sent to finishing processors before they are sold to wholesalers.[9] CCM

8 In such situation, the massive order received from the Imperial Household Agency to produce fabrics for the interior decoration of the new Emperor House in 1888 was the main occasion for promoting the introduction of the Jacquard in Nishijin (Tsunoyama 1983, p. 297).

9 Note that since workers engaged in designing and making figures, yarn processing, and finishing processes are not counted in the computation of worker-loom ratio and labor productivity reported in Figure 1, the "true" worker-loom ratio would have been underestimated and labor productivity overestimated.

actively coordinated the whole production process and even employed out-weavers. In this way, a refined system of division of labor gradually evolved.

[FIGURE 5 ABOUT HERE]

Table 2 depicts changes in the number of CCM and out-weavers in Phase II. Not only did the number of CCM increase, but the number of out-weavers more than doubled from 1905 to 1917. The number of out-weavers per CCM also tended to increase, and in 1917, one CCM outsourced to almost as many as 60 out-weavers.

[TABLE 2 ABOUT HERE]

Thus, growth was promoted by the increased number of out-weavers in Phase II, which was possible based on developing a division of labor system. Interestingly, what happened in Nishijin after introducing the Jacquard contrasted with India's experience in the early 20th century. Roy (2002) argued that the major reason why the Jacquard did not diffuse in India so easily was the failure to develop a division of labor supporting weaving using the Jacquard (Roy 2002, p. 514).

POWER-LOOM ADOPTION IN FACTORIES AND SMALL ENTERPRISES

Let us examine the enterprise scale in terms of the number of looms and the introduction of power-looms in Nishijin in Phase II. Figure 6 shows the changes in the average number of looms per enterprise (K/N) from 1887 to 1929 and by production organization from 1905 to 1919. On average, it can be easily found that the average enterprise size was quite small in Nishijin throughout the whole period. It was almost five looms per enterprise at most and remained unchanged until 1905. A typical out-weaver exclusively used a few hand looms in Phase II. It was factories that introduced power-looms and expanded the

enterprise size. As shown in Figure 6, a remarkable expansion of enterprise size in factories with power-looms took place, especially in the 1910s. Nishijin was regarded as one of the earliest weaving districts to adopt the use of the power-loom, but its diffusion lagged behind other districts (Minami and Makino 1983, p. 4; Hashino and Otsuka 2013a). In fact, the average adoption rate of the power-loom in Nishijin rose very slowly in Phase II, even though the adoption rate in factories grew rapidly to 60% at the end of this phase (Figure 7). It is clear that there were significant differences between factories and other production organizations, such as out-weavers and family enterprises, regarding the willingness to adopt power-looms and expand their enterprise size in Phase II.

[FIGURE 6 AND FIGURE 7 ABOUT HERE]

Although it is not possible to obtain detailed production information about all factories due to the lack of data, Table 3 shows the major characteristics of the seven largest factories in Phase II.[10] It is interesting to note that figured fabrics were not reported as the main product in almost all the seven factories from 1904 to 1916. Even at the end of Phase I in 1904, five out of the seven factories had already introduced power-looms with the employment share of female workers quite high. Though less information was available in 1907 and 1916, almost all of the factories became larger in terms of the number of workers and more progressive in the employment of female workers. The largest factories seemed to produce less complicated non-figured fabrics by employing female workers and using power-looms.

[TABLE 3 ABOUT HERE]

What kind of fabrics were produced by smaller enterprises in Nishijin? Figure 8

10 These seven largest factories were introduced in the Tokyo Regional Taxation Office (1905, pp. 44–45). These factories were also found in the *Statistical Survey of Factories* reported by the Ministry of Agriculture and Commerce (1906), which can be regarded as original data source. They were the seven largest factories, in terms of number of workers, out of 45 factories which were operating in the Kyoto Prefecture in 1904.

presents the changes in the real value of production by product, which was roughly categorized by the materials used (silk and cotton) and the figures produced in Phase II. The production of almost all kinds of fabrics did not change markedly until 1914, even though the production of silk figured and silk-cotton figured fabrics slightly increased. However, the production of silk non-figured, silk figured, and silk-cotton figured fabrics rapidly grew from 1915 to 1919. The production growth in silk non-figured fabrics likely took place in factories that used power-looms. This is one of the most important characteristics of Phase II.

[FIGURE 8 ABOUT HERE]

As Figure 9 shows, in 1907 and 1916, non-figured fabrics were produced in factories with more than ten workers, even though some factories produced a small number of figured fabrics. According to Hattori (1948), the early adoption of the power-loom in Nishijin was limited to the production of inexpensive popular fabrics, such as cotton fabrics, lightweight clothes, simple figured fabrics, and fabrics for the export market (Hattori 1948, p. 173). These fabrics were not traditional fabrics produced in Nishijin using draw-looms or later by hand looms with the Jacquard mechanism.

[FIGURE 9 ABOUT HERE]

ADOPTION OF POWER-LOOMS AND THE EXPANSION OF ENTERPRISE SIZE IN PHASE III (1918–29)

Although the data by type of production organization is limited in Phase III, the available data indicate that factories, particularly large ones, tend to specialize in producing simple fabrics for export by using power-looms made of iron. In contrast, many family enterprises and out-weavers began to use cheap power-looms made of iron and wood to produce narrow fabrics for the domestic market, which were cheaper and more popular than

before.[11] Furthermore, the distinction between out-weavers and family enterprises became unclear because out-weavers, who used to rent hand looms from CCM, purchased their own power-looms as well as hand looms. It seems that some out-weavers have climbed up the ladder to become family enterprises in this phase.

POWER-LOOMS AND SPECIALIZATION OF FACTORIES

According to the survey conducted by the Nishijin Textile Association (1920), there were a total of 3,344 power-looms in Nishijin, and 1,620 of them were utilized for producing fabrics for the export market. These were 'silk non-figured fabrics' (shown in Figure 8). As Shinkokai (1914, p. 67) attested, power-looms in Nishijin were mainly used to produce fabrics for the export market and some fabrics that competed with imported simple fabrics in the domestic market.

Table 4 shows the number of factories in Nishijin, which used power-looms in 1920 by product type. Two-thirds of power-looms were installed in factories that produced silk fabrics for export. In addition, more than 90% of their power-looms were made of iron, and their average enterprise size in terms of the number of looms was also large at 127.4 looms (2,421/19). On the other hand, power-looms made of wood and iron, which were much cheaper and sold by domestic loom producers, were used in the factories which produced *omeshi* or high-quality silk crepe for the domestic market. Though their number of enterprises and power-looms made of iron do not appear in Table 4, their enterprise size was only 6.2 looms (320/52=6.2 looms)[12], which was much smaller than the factories producing fabrics for the export market.

11 According to the survey by the Nishijin Textile Association, the share of silk-cotton fabrics rose to 25% of the total value of fabrics produced in Nishijin in 1925. In the case of the figured obi, the one made of silk and cotton was much cheaper than that of pure silk. In fact, the price of silk-cotton obi was only 60 percent that of silk (Nishijin Textile Association 1928, appendix).

12 The source of these figures are as same as that of Table 4.

[TABLE 4 ABOUT HERE]

According to the report of the Nishijin Mission about newly-emerging silk-weaving districts in Eastern Japan, including Kiryu, Ashikaga, Isezaki, and Hachioji, Nishijin had an advantage over them due to the availability of electricity (Nishijin Shinkokai 1914, p. 55).[13] There is evidence that the diffusion of electricity facilitated the utilization of power-looms by small weaving enterprises throughout Japan (Minami and Makino 1983, p. 15) because electric motors enabled small factories and workshops to shift from human to mechanical power (Minami 1977, p. 956). This may explain why small factories could afford to introduce power-looms in Phase III.

POWER-LOOMS AND OUT-WEAVERS

As shown in Figure 7, the average adoption rate of power-looms in Nishijin rose quite slowly in both Phases II and III, close to reaching 30% by 1929. This contrasts with Kiryu, the second most advanced silk-weaving district in Japan and an imitator of Nishijin, which produced similar but cheaper and popular fabrics. In Kiryu, the adoption rate of power-looms began to increase in the 1910s and was more than 80% in 1929 (Hashino and Otsuka 2013, p. 791). The rising wage rate in the late 1910s accelerated the introduction of the power-loom in Kiryu, as previous studies suggested (Hashino 2007, pp. 25–27; Hashino 2016, p. 57).

The average adoption rate of power-looms continued to increase in Nishijin in the 1920s. In all likelihood, such a rise in the adoption rate of power-looms was induced by the sharp increase in wage rate in the late 1910s, as in Kiryu. The expansion of the demand for

13 Nishijin's mission was organized by Eijiro Honjo and five other students. Honjo was a graduate student at the Kyoto Imperial University at that time and became an economic historian later.

labor led to a sharp rise in wage rate, resulting from an accelerated increase in economic activity during World War I (Minami 1968, p. 385). In fact, this is the case in Nishijin and other districts, including Kiryu and Fukui, where the wage rate increased markedly during the economic boom (Hashino 2016, p. 57; Hashino and Otsuka 2020, p. 60). Producers, including out-weavers, in Nishijin became keen to introduce power-looms due to increases in wage rates, the increasing cost of materials, such as dyestuffs and raw silk, and increased competition with other silk-weaving districts (Kuromatsu 1965, p. 21). As Kuromatsu (1951) suggested, however, the silk product prices fell in the recession period in the 1920s, and the adoption of power-looms became necessary for the survival of the Nishijin factories (p. 50).

It is important to note that the Nishijin Textile Association played an important role in promoting the shift from hand looms to power-looms in the 1920s. The association implemented a policy that encouraged the adoption of power-looms in 1920 by subsidizing and offering low-interest loans to producers who introduced power-looms. In addition, the association trained workers to operate power-looms and gave advice to producers who wished to have their factory or workshop renovated for the installment of power-looms. While the subsidy waned over time, the training of workers by the association continued. Kyoto City and the Kyoto Municipal Center of Dyeing and Weaving cooperated to run another training program on the operation of power-looms. This series of efforts by the association to promote power-looms contributed to the increasing adoption rate of power-looms from only 12.3% in 1919 to 28.9% in 1927 (Otsuki 1939, pp. 82–84), although this was still low compared with other silk-weaving districts.[14] The unanswered question is, *Who introduced power-looms in Nishijin in Phase III?* Could it be out-weavers, family enterprises, or factories?

14 According to Kuromatsu (1951), the adoption ratio of power-looms increased to 55.4% at the end of 1937 (Akamatsu 1951, p. 50).

It is well-known that many local suppliers attempted to produce various kinds of cheap power-looms which were suitable for producing special fabrics in local weaving districts (Suzuki 1996, pp. 278–281). Power-looms made of wood and iron were a popular innovation by Sakichi Toyoda, the "father" of the Toyota Automobile Company, in the late 19th century. They were diffused in both the cotton- and silk-weaving districts due to lower prices. A detailed examination of the information from the report by the Nishijin Textile Association (1922) shows that as many as 20 types of power-looms made of wood and iron were newly installed in Nishijin in 1921. Table 5 shows the types of power-looms that members of the association who applied for subsidized loans purchased in 1921. Although there seem to have been some factories that purchased power-looms made of iron to produce broad-width looms, most association members who applied for the loan were likely to be small enterprises, such as family enterprises and out-weavers. As shown in Table 5, almost all the power-looms purchased (257 out of 287) were narrow in width (less than 27 inches), which were appropriate for the production of figured fabrics for the domestic market (Nishijin Textile Association 1922, pp. 22–23). There were at least 20 suppliers of such looms. In the case of iron looms, half of them were the narrow-width type, and the other half were the broad-width type suitable for producing fabrics for export. Although the detailed document is unavailable, it seems clear that domestic loom suppliers managed to innovate the production of power-looms suitable for the production of figured products by small enterprises.

[TABLE 5 ABOUT HERE]

Since the price of the power-loom made of wood and iron was much lower than the power-loom made of iron, small factories and much smaller workshops could afford to introduce power-looms in Phase III. According to the survey conducted by the Kyoto

Prefecture (1934) in 1933, 271 out-weavers households owned one power-loom, 307 owned two, and 224 owned more than three (Table 6). Note that in Phase III, out-weavers already owned looms, while all of them only rented looms in Phase II.

The above observations are reminiscent of the emergence of the family-based cottage industry pointed out by Hareven (2002, p. 55), who argued that the cottage industry gained momentum as Nishijin's dominant production organization in the early 1920s. Family-based cottage industries received orders for fabrics from CCMs, including designs, the warp, and raw materials. They either owned looms or rented looms from CCMs and wove fabrics by piece-rate. In all likelihood, the rise of family enterprises, some of which used to be out-weaver households, was a major factor underlying the steady increases in production, worker-loom ratio, and labor productivity in Phase III (see Figure 1 and also the number of family enterprises in 1929 shown in Figure 4).

[TABLE 6 ABOUT HERE]

CONCLUDING REMARKS

This study explored the development process in Nishijin, Japan's most advanced silk-weaving district that has been producing figured-silk fabrics since the medieval period, with particular focus on the adoption of new technologies from Lyon, which was the most advanced silk-weaving district in the world. The important factors underlying the development of Nishijin from 1887 to 1929 were markedly different in the three major phases. The introduction of the Jacquard mechanism triggered the structural transformation in Nishijin, which laid the groundwork for sustainable long-term growth in Phase I from 1887 to 1905. In Phase II, out-weavers grew due to the re-organization of the division of labor within the district from 1905 to 1918. Finally, small workshops, such as family enterprises and out-weavers, began to use power-looms (presumably responding to the rising wage rate) and

played a significant role in the growth in Phase III from 1918 to 1929. Cheap power-looms with narrow-width for small workshops were diffused partly because of encouragement from the Nishijin Textile Association and partly because of emerging domestic suppliers producing power-looms made of wood and iron.

Although the mission of the three craftsmen sent from Nishijin to Lyon was to purchase power-looms with a steam engine, they decided to introduce the Jacquard mechanism to Japan because they believed that it was the most appropriate technology for the development of silk-weaving. In other words, brand-new technology was not always preferred. It is worth emphasizing that Nishijin craftspeople made several adaptations in order to adopt new technologies. The best example is the development of a refined system of division of labor that included small-scale out-weavers, Jacquard-related suppliers, and other supporting enterprises within the district organized under the leadership of CCM.

It must also be pointed out that a local trade association played a significant role in supporting the introduction and adoption of new technologies. Local trade associations in weaving districts in Japan had supported small producers in adopting synthetic dyestuffs (Hashino 2012). In the case of Nishijin, the local trade association encouraged not only the adoption of synthetic dyestuffs but also that of power-looms especially for small workshops. This resulted in the emergence of a new class of out-weavers who owned power-looms and who have become dominant in Nishijin since the 1920s.

Finally, the findings of this study suggest that *selective adoption of new technologies* is a critical strategy for developing economies eager for industrialization. New technologies should be imported based on the right understanding of factor endowment in the country. However, as discussed, factor endowment would change with economic growth and development change. This is why labor-using hand loom with Jacquard was chosen in the Phases I and II and labor-saving power-loom was selected in Phase III. Such a dynamic

perspective could be helpful in further understanding Japan's catch-up process as well as in planning effective development strategies for contemporary developing economies.

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TABLE 1

DIFFUSION OF JACQUARD, 1886, 1891, 1895

	1886	1891	1895
Total number of looms	3,615	5,241	28,421
Number of looms with Jacquard	400	800	7,000
Percentage of looms with Jacquard	11.0	15.2	24.6
Total number of looms used for figured fabrics	-	-	14,800
Percentage of looms with Jacquard used for figured fabrics	-	-	47.3

Source: Maeda (1960, p. 105, 167).

TABLE 2

NUMBER OF CONTRACTOR-CUM-MERCHANTS (CCM) AND OUT-WEAVERS, SELECTED YEARS

	Number of CCM	Number of Out-weavers	Out-weavers per CCM
1905	100	3,914	39.1
1907	134	4,886	36.5
1909	205	5,790	28.2
1911	295	7,770	26.3
1913	-	8,886	-
1915	198	7,228	36.5
1917	166	10,545	56.7
1919	249	10,202	41.0

Source: Kyoto Prefecture (selected years).

TABLE 3

CHANGES IN THE SIZE OF THE SEVEN LARGEST FACTORIES, 1904, 1907, 1916

Year Established	1904				1907		1916	
	Main Product is Figured Fabric	No. of Hand Looms (% Unused)	No. of Power-looms (% Unused)	No. of Workers (% Female)	Main Product is Figured Fabric	No. of Workers (% Female)	Main Product is Figured Fabric	No. of Workers (% Female)
1889	No	100 (45.0)	288 (27.4)	633 (80.8)	No	615 (74.4)	No	1,059 (70.1)
1898	No	0	508 (9.4)	410 (86.5)	No	466 (86.4)	-	-
1893	Yes	0	48 (27.1)	65 (87.6)	-	-	No	91 (73.6)
1897	No	0	77 (35.1)	108 (86.1)	No	157 (92.3)	No	403 (94.0)
1891	No	50 (56.0)	0	99 (90.0)	No	141 (94.3)	No	37 (91.8)
1895	No	52 (32.7)	0	37 (40.5)	No	71 (33.8)	No	88 (20.4)
1890	No	0	40 (12.5)	74 (93.2)	No	85 (92.9)	No	80 (87.5)

Source: Tokyo Regional Taxation Bureau (1905, pp. 43–44), for data on the number of looms and main products; Ministry of Agriculture and Commerce (1906, pp. 126–128), for year of establishment; and information about main product, number of workers, and share of female workers in 1907 and 1916 is from Ministry of Agriculture and Commerce (1909) and (1918), respectively.

TABLE 4

NUMBER OF FACTORIES USING POWER-LOOMS, BY PRODUCT, 1920

	Number of factories	Number of power-looms made of wood and iron	Number of power-looms made of iron	Total
Fabrics for domestic market	72	461	109	570
Fabrics for export	19	214	2,207	2,421
Other fabrics	5	161	192	353

Source: Nishijin Textile Association (1920, p. 8).

Note: Fabrics for the domestic market include *omeshi* crepe and silk linings; fabrics for export are comprised of ‘silk fabrics for export’ and ‘cotton fabrics for export’ in the original source. ‘Ribbons’ are included in other fabrics.

TABLE 5

NUMBER OF NEWLY-EQUIPPED POWER-LOOMS IN NISHIJIN, 1921

	Total Number of Looms	Number of Narrow-width Looms	Number of Suppliers of Looms
Power-looms made of wood & iron	287	257	20
Power-looms made of iron	257	124	15

Source: Nishijin Textile Association (1921, p. 8).

Note: Two out of the 15 suppliers of power-looms made of iron were foreign companies.

TABLE 6

NUMBER OF OUT-WEAVING HOUSEHOLDS IN NISHIJIN BY OWNERSHIP OF LOOMS, 1933

	No. of Looms Purchased			No. of Looms Rented from CCM		
	1	2	3+	1	2	3+
Handlooms	1,053	960	311	1,070	746	197
Power-looms	271	307	224	58	29	15

Source: Kyoto Prefecture (1934, p. 13).

Notes: According to the same source, the total number of out-weaving households was 4,937 in 1933.

The question was multiple answer type, allowing ownership and renting simultaneously.

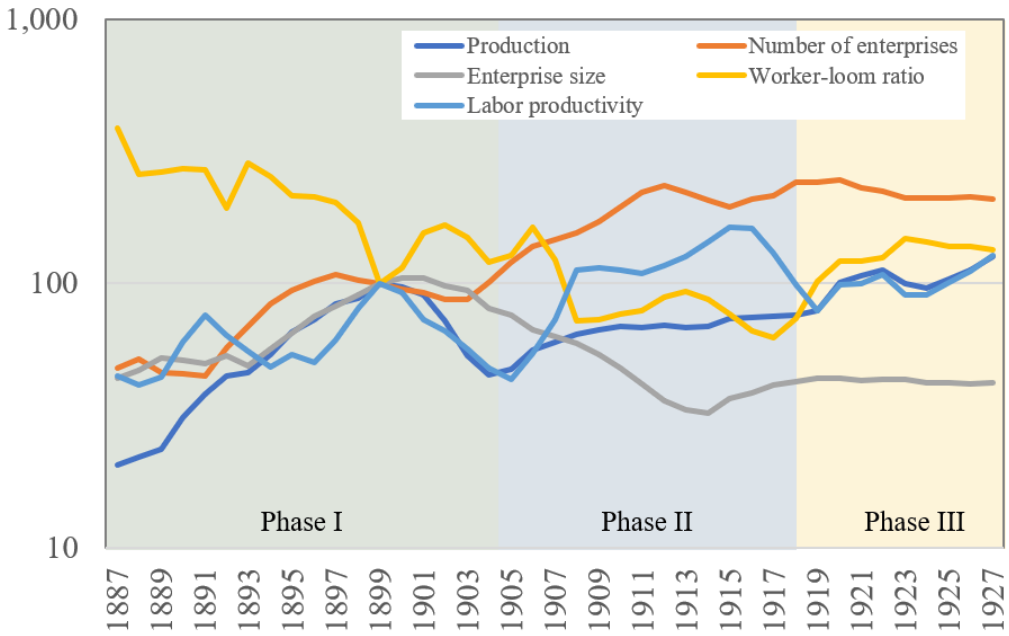

FIGURE 1

LOGARITHM OF INDEXES OF PRODUCTION, NUMBER OF ENTERPRISES, ENTERPRISE SIZE IN TERMS OF NUMBER OF LOOMS, WORKER-LOOM RATIO, AND LABOR PRODUCTIVITY IN NISHIJIN, 1887–1927
(THREE-YEAR AVERAGE, 1899=100)

Sources: Maeda (1960) is used for data of production, number of enterprises, and number of looms. Data on the number of workers from 1886 to 1911, from 1912 to 1920, and from 1920 to 1928 are from Kyoto Prefectural Library and Archives (1970), Kyoto Prefecture (every year), and Kyoto Prefectural Library and Archives (1970), respectively.

Notes: Value of production is deflated by 'Textile price index' from Ohkawa et al. (1967), pp. 192–193. Enterprise size is calculated by dividing the number of looms by the number of enterprises. I obtained labor productivity by dividing the real value of production by the number of workers. All indexes are set to 100 in 1899.

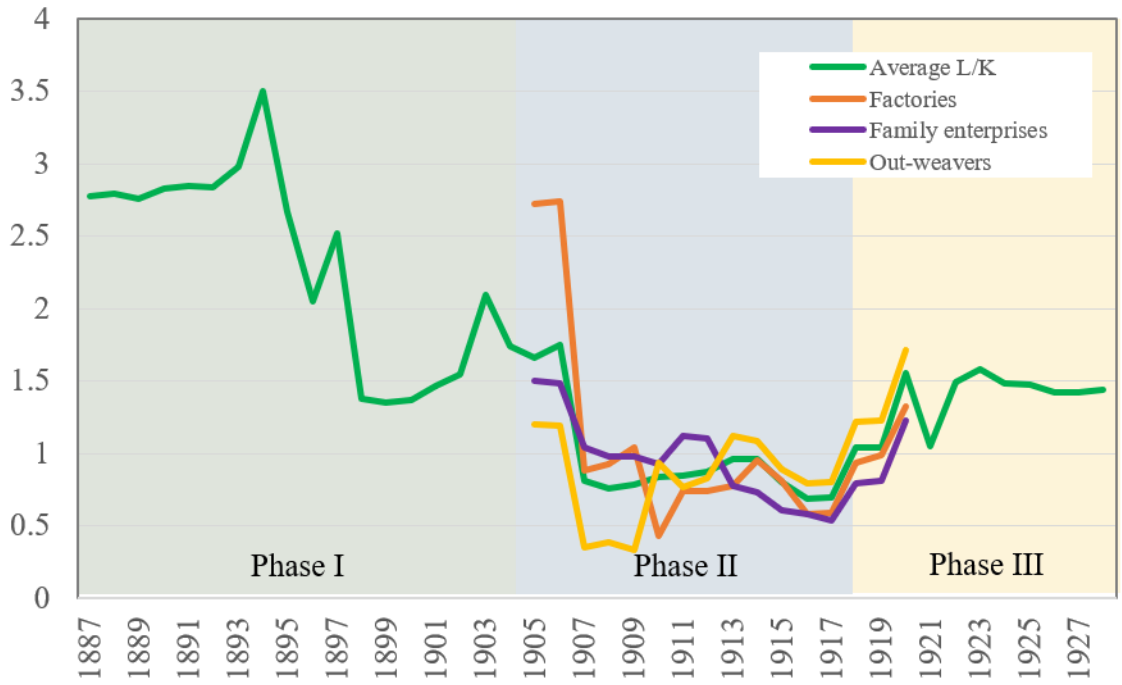

FIGURE 2

CHANGES IN WORKER-LOOM RATIO BY PRODUCTION ORGANIZATION (L/K)

Sources: *L* or number of workers and *K* or average number of looms are from Maeda (1960), while *L* and *K* for factories, family enterprises, and out-weavers are from Kyoto Prefecture (all years).

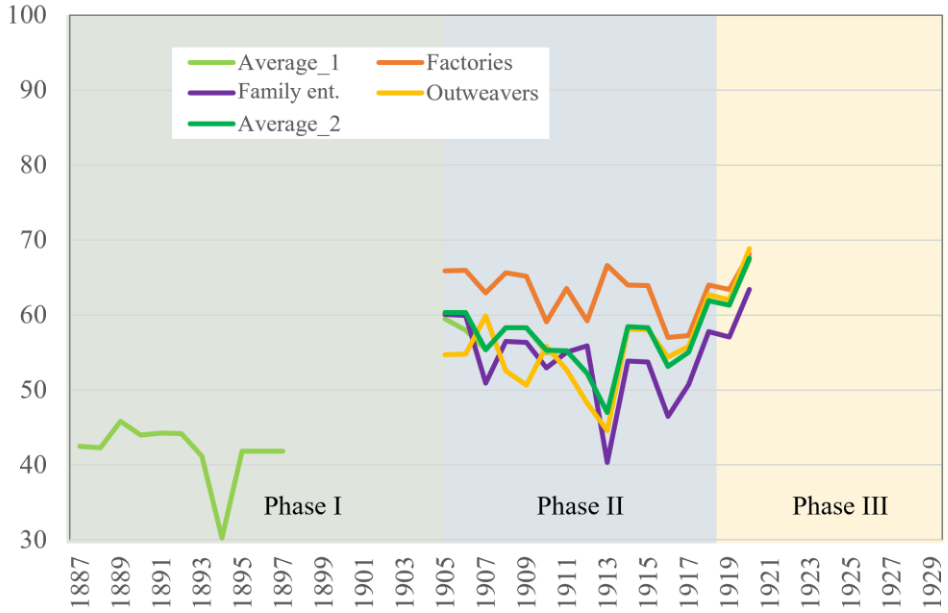

FIGURE 3

PROPORTION OF FEMALE WORKERS BY PRODUCTION ORGANIZATION IN NISHIJIN, 1887-1898 AND 1905-1920 (%)

Sources: Data for average_1 are from Maeda (1960). Data for factories, out-weavers, and average_2 are from Kyoto Prefecture (all years).

Note: Other enterprises is the total of factories and family enterprises

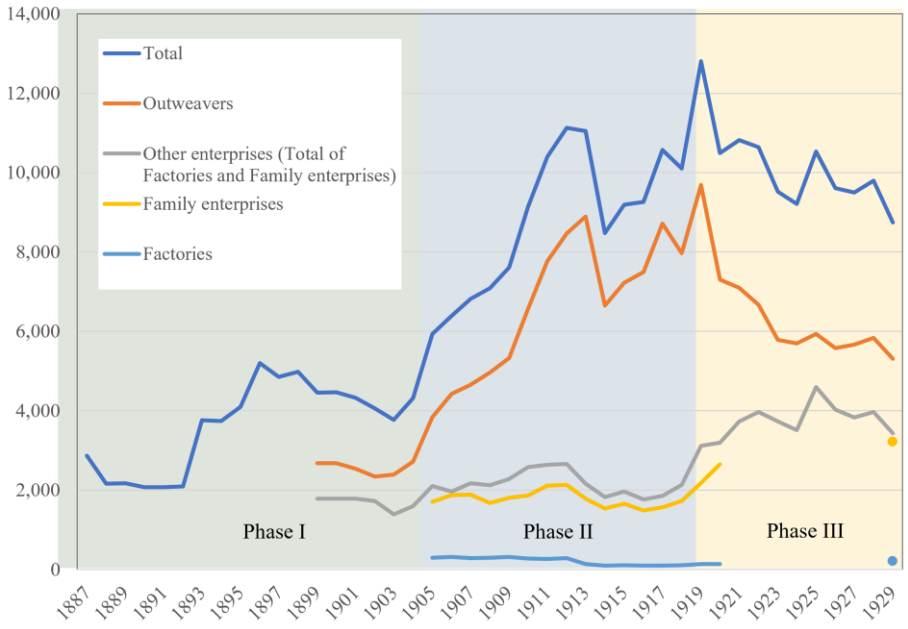

FIGURE 4

CHANGES IN THE NUMBER OF ENTERPRISES BY PRODUCTION ORGANIZATION, 1887-1929 (N)

Sources: Data for the total number of all enterprises, number of out-weavers, and other enterprises are from Maeda (1960). Data for family enterprises and factories are the same as Figure 2. The number of factories in 1929 is from the Ministry of Commerce and Industry (1931), in which all workshops with more than 10 workers were surveyed.

Note: The number of family enterprises in 1929 is the difference in the number of other enterprises from the number of factories in the same year.

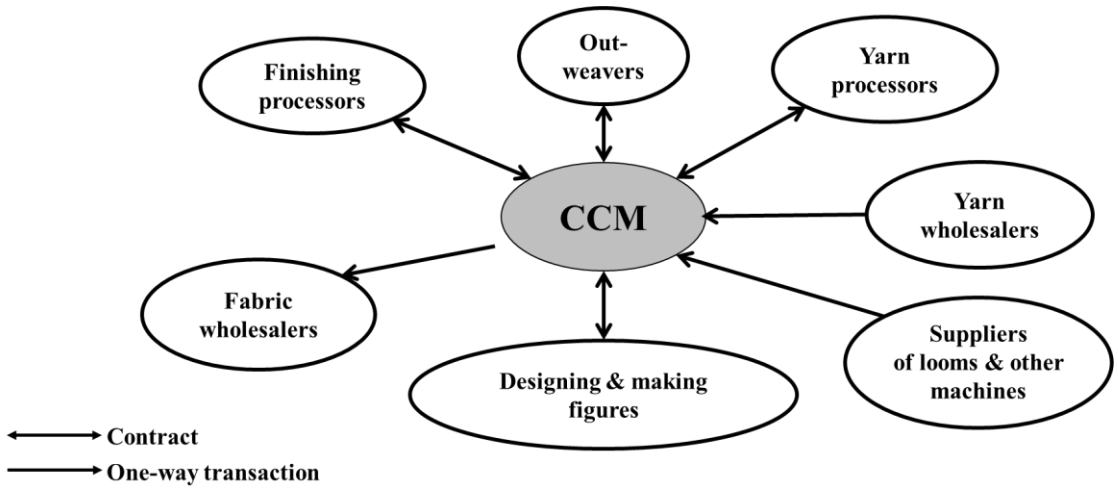

FIGURE 5

DIVISION OF LABOR AMONG CONTRACTOR-CUM-MERCHANTS (CCM), OUT-WEAVERS, AND OTHER ENTERPRISES

Notes: I simplified the original figure ‘The organization of Nishijin weaving industry) in Honjo (1914) for readers’ convenience.

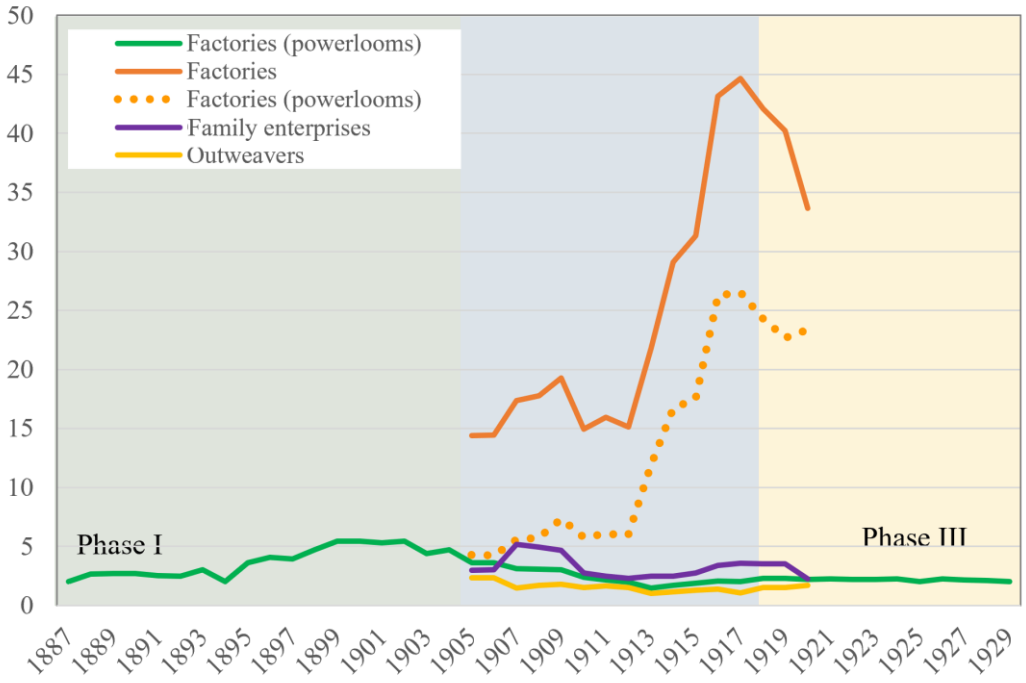

FIGURE 6

CHANGES IN AVERAGE NUMBER OF LOOMS PER ENTERPRISE BY PRODUCTION ORGANIZATION (K/N)

Sources: Data for the number of factories and power-looms from 1887 to 1929 are from Kyoto Prefecture (all years). Other data regarding the number of looms and other production organizations are from Kyoto Prefecture (all years) and Honjo (1914), respectively.

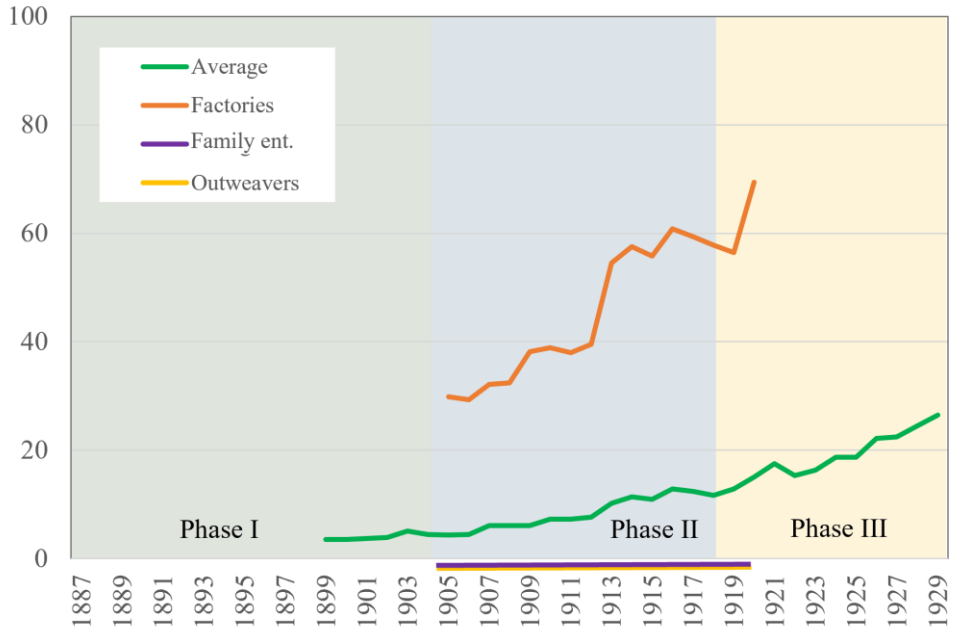

FIGURE 7

ADOPTION RATE OF POWER-LOOMS BY PRODUCTION ORGANIZATION (%)

Sources: Data for the number of factories and power-looms from 1887 to 1929 are from Kyoto Prefecture (all years). Other data regarding the number of looms and other production organizations are from Kyoto Prefecture (all years) and Honjo (1914), respectively.

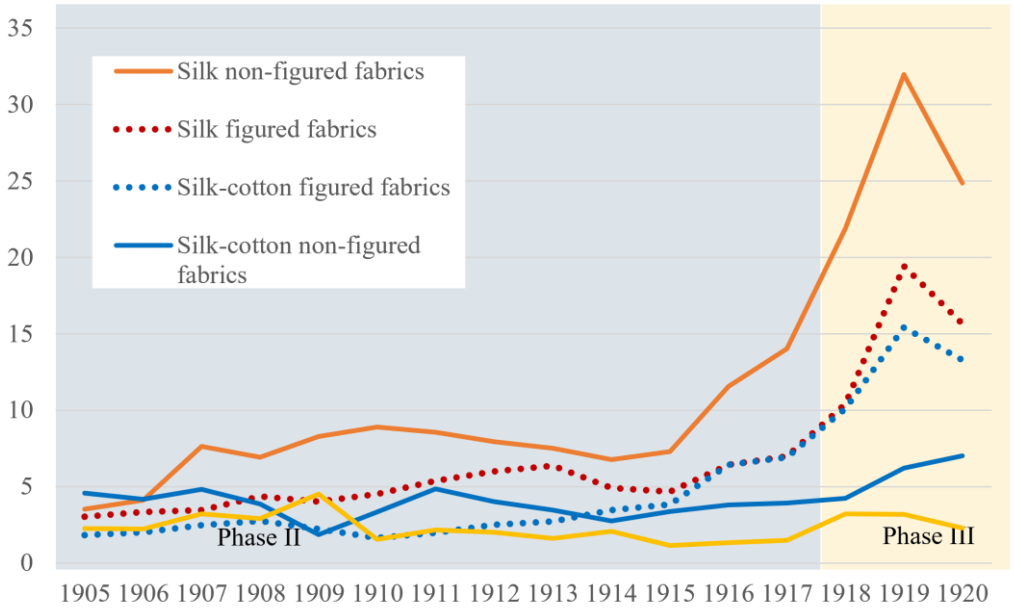

FIGURE 8

CHANGES IN THE REAL VALUE OF PRODUCTION BY PRODUCT, 1905-1920 (IN MILLION YEN)

Sources: Otsuki ed. (1939)

Notes: Value of production is deflated by 'Textile price index' from Ohkawa et al. (1967), pp. 192–193.

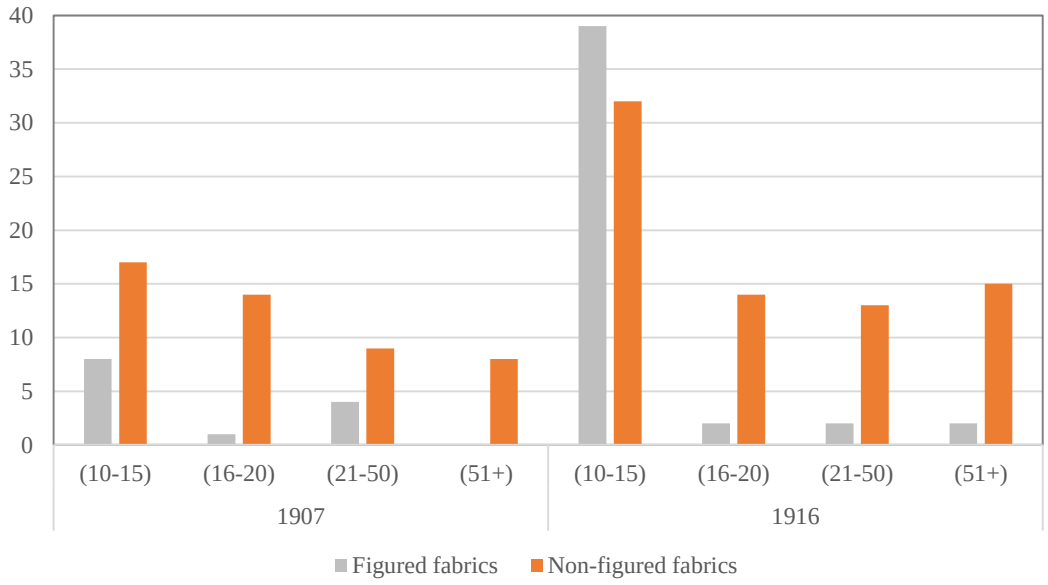

FIGURE 9

SIZE DISTRIBUTION OF FACTORIES IN TERMS OF NUMBER OF WORKERS AND PRODUCTION OF FIGURED AND NON-FIGURED FABRICS, 1907 AND 1916

Sources: Data in 1907 and 1916 are from the Ministry of Agriculture and Commerce (1909) and (1918), respectively.