Price, Quality, and Organization

Branding in the Japanese silk-reeling industry*

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Abstract

Transaction costs depend on the degree of informational asymmetry in trading goods. This environment provides commitment to certain quality with an opportunity to earn quality premium given the degree of asymmetry. A device of commitment to quality could be inspection and branding either by a trader or manufacturer. In the market of raw silk, the largest export of Japan from the late nineteenth century, informational asymmetry between Japan and the Western destinations was serious and Western trading companies dominated quality control by the mid-1880s. Then, Japanese manufacturers internalized inspection and branding processes, earned quality premium, and began rapid growth.

Key words: Institutions, asymmetric information of quality, branding, textile industry, Japan.
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Introduction

Transaction costs of impersonal trades, particularly the cost of using the price mechanism (Coase (1937)), depend on the degree of asymmetry of information about items to be traded. If sellers are motivated to reveal the products' quality, the cost accordingly becomes smaller. If the quality information is seriously asymmetric, no trade, the worst equilibrium could be an outcome.

There are two potential remedies. One is the third party qualification. Governance of trade by the state court could include this function as its part, but another kind of organization such as trade association or chamber of commerce could work. While a state court is supposed to be equipped with ability of both verification and enforcement of a relevant contract, the part of verification has been historically taken also by private organizations, or, as in case of the commercial court in France, the state court sometime explicitly delegates the function to specific organization (Lemercier (2003)).

The other potential outcome is relational contracting, or a firm organization in which trading partners are fixed and pricing is shielded from the market such that inside prices do not necessarily synchronize with the market prices in a real-time basis (Coase (1937) and Williamson (1985)). Relational transactions and organizations with increasing the probability of the current trade to be continued in the next term, provide both parties, who maximize long-term streams of revenue, with incentives for honest trades.

A ramification of such devices for relational contracting is branding, whereby signaling commitment to certain quality to repeating customers. While buyers might be impersonal to the seller, the buyers can observe the history of the brand, which provides the seller with incentives to commit to certain quality in order to earn quality premium (Klein and Leffler (1981)). From production to consumption, multiple agents can be involved in trades. It is efficient for the one to establish a brand if she/he can know the quality, control it, and signal it to customers by the least cost. The agent who minimizes the cost might be either a manufacturer or a trader. On the one hand, manufacturers can know and control the quality by lower costs. On the other hand, given some fixed cost and thus increasing return on scale of establishment of a brand, a trader might be able to signal certain quality by smaller marginal costs. Depending on which effect dominates the other, either the manufacturer or a trader establishes a brand, such as a "mis en bouteille au chateau (bottled at the chateau)" brand or a "négociant (merchant)" brand of Bordeaux wines.

The modern silk-reeling was the largest export industry of Japan from the 1880s to the 1920s and was the first East Asian modern manufacturing that dominated international markets. Heterogeneity both in technologies and organizations for quality control a significant feature of the silk-reeling industry from the late nineteenth century to the early twentieth century. Governance of trades in the market was accordingly diverse. In Italy, third party inspection managed by the chamber of commerce in the region guaranteed quality of raw silk and small-medium sized factories remaind dominant. In China, trading companies' brands were dominant. In Japan, although Western trading companies' brands had dominated the export market until the early 1880s, the manufacturers' brands gradually replaced trading companies' ones from the mid-1880s, and firms that established their own brands grew world largest

ones. This paper focuses on internalization process of branding from trading companies to cooperatives of silk-reeling manufacturers and finally to individual manufacturers.

Section 1 first introduces a simple example of modeling brand establishment and second overviews an internalization of quality control and branding of raw silk. Section 2 deals with internal organizational changes of silk-reeling manufacturers during the internalization process. Section 3 compares the Japanese combination of the market institution and firm organization with other types.

1 From trading companies to silk-reeling manufacturers

1.1 An example of organization choice

In this economy, there are the manufacturer who produces raw silk and sells it to either the trader or the consumer, the trader who purchases raw silk in the intermediate market and sells it to the consumer, and the consumer who purchases raw silk from either the manufacturer or the trader. The consumer does not know the quality of raw silk in the market while both the manufacturer and the trader know it. Then, the manufacturer and the trader can either cheat the consumer and earn one-shot profit or guarantee certain quality and earn premium paid to the certain quality from the consumer. Suppose that the profit of cheating is denoted by π^C and that of committing to certain quality by π^B. Suppose also that it costs the seller who can be either the trader or the manufacturer unit cost b to certify certain quality and that, without the trader's quality control, the consumer incurs some cost to classify raw silk of volatile quality v to produce it by power looms whereas $E[v] = \bar{v}$.

We assume that both the consumer and the seller are risk-neutral and denote the common discount factor $\delta, 0 < \delta < 1$.

Then, suppose that both the consumer and the seller who is either the manufacturer or the trader infinitely play a trigger strategy as follows;

1. In the first period: The consumer assumes certified quality $\bar{v}$ and pays premium β for certified quality and the seller sells raw silk with certified quality $\bar{v}$.

2. From the second period: If sales of raw silk of certified quality $\bar{v}$ and payment of premium β have been observed in the all past periods, the seller sells raw silk with certified quality and the buyer pays premium for certified quality. Otherwise, the consumer does not pay premium for certified premium and the seller sells raw silk of volatile quality v.

Then, discounted value of expected unit profit stream of the seller when cheating in period $t(= 2, \ldots, n)$ is

$$\pi^C = (\bar{v} + \beta - \bar{v}) + \delta \times (\bar{v} - \bar{v}) + \cdots + \delta^n \times (\bar{v} - \bar{v}) = \beta.$$

Discounted value of expected unit profit stream of the seller when committing to the certified

quality is

$$\begin{aligned}\pi^B =&[(\bar{v}+\beta)-(\bar{v}+b)]+\delta\times[(\bar{v}+\beta)-(\bar{v}+b)]\\ &+\delta^2\times[(\bar{v}+\beta)-(b+\bar{v})]+\cdots+\delta^{n-1}\times[(\bar{v}+\beta)-(\bar{v}+b)]\\ =&\frac{1-\delta^n}{1-\delta}(\beta-b),\end{aligned}$$

and

$$\lim_{n\to\infty}\pi^B=\frac{\beta-b}{1-\delta}.$$

Therefore, if $\beta\leq\ (\beta-b)/(1-\delta)$, or

$$\frac{b}{\beta}\leq\delta, \tag{1}$$

then branding to commit to certain quality with taking cost b is the seller's optimal response. In other words, the seller is patient or the probability of trade being continued in the next period is high (δ is sufficiently large), and/or, premium paid for certified quality is high (β is sufficiently large), and/or the cost of branding with commitment to certain quality is low (b is sufficiently small), establishment of a brand of commitment to certain quality is the best response of the seller. Therefore, commitment to certain quality and payment of premium to certified quality is reached as an outcome of sub-game perfect equilibrium. Hereafter, we assume that the condition (1) is satisfied and let π_T denote the trader's on-the-path equilibrium profit and π_M denote the manufacturer's on-the-path equilibrium profit.

Then, to describe a choice between manufacturer' branding and traders' branding , let us introduce a simple example. Let p denote price of raw silk when the consumer purchases it, q denote quantity of traded raw silk, β denote premium paid by the buyer for certification of certain quality, $b(q)$ denote unit cost of branding, c denote unit cost of quality improvement, $v(c)$ denote quality given input of c, α denote premium paid by the buyer to marginal improvement of quality, and $\bar{v}$ denote quality of raw silk the trader purchases from the manufacturer.

The trader purchases raw silk of quality $\bar{v}$ in the competitive intermediate market. The value $\bar{v}$ is not known to the buyer. So, the trader can earn premium β of certified quality by branding. Then, the trader's profit π_T is

$$\pi_T=pq-\big(\bar{v}+b(q)\big)q=(\bar{v}+\beta)-\big(\bar{v}+b(q)\big)=\beta q-b(q)q. \tag{2}$$

Meanwhile, the manufacturer controls the production process and thus can earn premium of improved quality α by inputting cost c. Then, the manufacturer's profit π_M is,

$$\pi_M=pq-\big(c+b(q)\big)q=\big(\alpha v(c)+\beta\big)q-\big(c+b(q)\big)q. \tag{3}$$

Furthermore, assume that branding needs fixed cost B and

$$b(q)=\frac{B}{q}+\frac{q^2}{3B}-Bq$$

such that the marginal cost of branding is decreasing if $q \leq B^2$ and increasing if $B^2 < q$.

In addition, assume that $v(c) = c^\gamma, 0 < \gamma < 1$, which implies that return on quality improvement cost is marginally decreasing. Under this technology, we immediately get three straightforward implications.

Lemma 1. *If premium paid for improved quality is sufficiently large and/or if technology of quality improvement is sufficiently efficient, then the manufacturer's profit π_M is greater than the trader's profit π_T.*

Proof See the Appendix.

Lemma 2. *f premium paid for improved quality is sufficiently large and/or if technology of quality improvement is sufficiently efficient, then the optimal scale of shipment for the manufacturer is greater than that of the trader.*

Proof See the Appendix.

Lemma 3. *If premium paid for improved quality is greater and/or if technology of quality improvement is more efficient than the condition for **Lemma 1** requires, then marginal return on production scale is increasing in marginal increase in cost of quality improvement.*

Proof See the Appendix.

Shortly, as premium paid for quality improved in the manufacturing process increases and/or technology of quality improvement in the manufacturing process is improved, the manufacturer's profit becomes greater than the trader's profit, and therefore the manufacturer's branding becomes socially optimal. In addition, in that case, optimal scale of the manufacturer's production is greater than the trader's and the tendency is accelerated with increase in improvement of the manufacturer's efficiency and/or premium paid for improved quality.

1.2 Free trade imposed on two East Asian giants

Due to defeat in the Opium War in 1842, The Qing Dynasty of China was forced to abandon state control on international trades and to open five ports including Shanghai under the Treaty of Nanking with the United Kingdom. Treaties with Western countries in 1844 finalized a legal structure of forced free trades; China was to allow the Western counterparts consular jurisdiction within concessions in the five treaties specified in the treaties and the unilateral most-favored-nation status and to loose tariff autonomy. The forced free trades unleashed the potential of the Chinese traditional silk-reeling industry. Export of hand-reeled raw silk from China to Europe since surged its share in France, the primary market in Europe, reached at more than 50 percent in the mid-1880s. Combined with machine-reeled raw silk, filature, produced in the Shanghai region, the Chinese dominance in France was remained until 1920s. Chinese raw silk production is estimated to have grown from 12,000 tons in 1880 tons to 16,950 tons in 1920, or more than 40 percent increase, while Italian raw silk production is estimated to be 2,820 tons and 3,620 tons in the same years, or less than 30 percent increase.[1]

[1] See Nakabayashi (2003), pp. 480-483 (Original source is Direction Generale des Douanes et des Contributions Indirects, *Tableau general du commerce de la France avec ses colonies et les puissances etrangeres*, Paris: Impriemerie Nationale/Imprimerie Impriale); and Federico (1997), p. 203.

The treaty port regime designed by 1844 treaties became a standard of imposed free trade in East Asia. Conceding to the US military presence, Japan also accepted the regime in treaties with Western counterparts in 1858 and the regime became effective in 1859. Since Japan began trading freely with Western countries in 1859, hand-reeled raw silk had been exported to France. In the early 1870s the price of raw silk dropped as other commodities did, and then had been decreasing until the middle 1890s. During this market-wide downturn, the Japanese traditional raw silk industry lost a competitive advantage over its Chinese rival in export markets. While exports of Chinese raw silk to France increased during the period of world-wide decrease in commodities' prices, Japanese exports of raw silk diminished. As the French silk market was largely stagnant for a few years after the recession in 1882, severely damaging those peasants engaged in sericulture and hand-reeling. Similarly, the machine silk-reeling factories, introduced to Japan since the middle 1870s, found diminished export opportunities for their machine-reeled filatures owing to the French depression.

1.3 Rise of the American modern fabric industry

On the other hand, the American silk fabric industry began to develop after the late 1870s, a growth accelerating in the 1880s. Differences between the United States and French markets in institutional details explain the different experiences of the industries serving different markets. In Lyon, the silk fabric industry kept a feature of "flexible specialization" as a luxury industry using hand-looms until the 1900s and so during this period had demanded various kinds of raw silk from hand-reeled raw silk whose threads were uneven to machine-reeled filature.[2] Meanwhile, in the American silk fabric industry, a factory system was established and power throwing machines and power-looms prevailed rapidly in the 1880s. Unlike its French competitor, the American industry developed by concentrating on medium-low grade fabrics for mass consumption. Accordingly, the American industry demanded non-expensive filature of even threads in large lots, raw silk suitable to mass production by power-looms.

Under this change in the international market, the modern silk-reeling industry of Japan rose in earnest. This developing industry was led by raw silk manufacturers in Suwa County of the Nagano Prefecture in Central Japan. Cooperatives of silk-reeling manufacturers, the largest one of which was called Kaimeisha, formed an organization that incorporated inspection and branding processes and reflected inspection results to improve member factories' production lines. Led by newly established manufacturers' brands, the Japanese share of the United States silk fabric market reached 50 percent by the end of the 1880s, 70 percent through the 1910s, and 80 percent in the 1920s. This successful expansion was the first Japanese experience of economic development produced through an export orientation, an orientation since followed by various Japanese manufacturing industries. With grasping the US demand, the output of the Japanese raw silk is estimated to have grown from 1,297 tons in 1873 to 25,335 tons in 1923, or, roughly twenty times.[3] This growth was achieved not only by expansion, also by rapid increase in labor productivity, which was naturally accompanied by rapid growth of real wages in Suwa (**Figure 1**). Development of the Japanese silk-reeling was not an expansion

[2] See Duran (1913), pp. 72-77; Rawlley (1919), pp. 66-73; Federico (1997), p. 77; and Cottereau (1997).
[3] See Federico (1997), pp. 204-205.

of cottage industry without improvement of labor productivity but was salient modernization of the industry.

This paper will first address the organization of the Kaimeisha, the first cooperative which succeeded in the establishment of its brand by the re-reeling technique. There are two important points to consider when analyzing the organization. First, the price of raw silk was, like all other commodities, determined by multiple factors of quality. The pricing of raw silk in market was mapping multidimensional factors of quality to an amount of money, and thus a price was a multidimensional function of a multidimensional quality. Second, internalization of quality control and signaling the quality into an organization is, by definition, replacement of a partial function of the price mechanism, under which multidimensional valuation is conducted. By this integration, or, internalization, the manufacturers acquire more detailed information about consumers' multidimensional preference watching at price movement of its own brand (Thomas (1995)). In the case of silk-reeling cooperatives, they established quality inspection organization and brands certified by their own inspections, replacing ones previously conducted by Western trading companies in the treaty port of Yokohama. That is, it incorporated a previously external transaction of the market. This successful incorporation of market transactions, with the express purpose of acquiring information on the multidimensional price function of the market, was one of the principle efforts of the silk manufacturers in Suwa.

2 Internalized qualification

2.1 Internalization by manufacturers' cooperatives

In the 1880s given their capital constraint, these Japanese factories were equipped with only dozens of basins, and initially produced an amount too small to meet the level of evenness in large lots demanded by the US market. As a consequence, this new industry established cooperatives for re-reeling. Re-reeling was literally reeling again after reeling from each cocoon, in order to make the raw silk dry.[4] After re-reeling, raw silk from factories and firms was shipped cooperatively. By cooperative re-reeling and shipment, small manufacturers could make their shipment larger and their raw silk evener in the same lots. Thus, one important reason for their following success was this technological advantage. However, the pioneering firms which first introduced the technology into Japan in the late 1870s or early 1880s did not become dominant. An association of silk manufacturers in Suwa, the Kaimeisha, introduced re-reeling system and constructed an innovative organization in 1884. Silk manufacturers in Suwa specifically, and then, in Japan more broadly, followed the re-reeling technique.

The Kaimeisha was established in 1879 for cooperative shipment by the silk-reeling manufacturers. They gathered raw silk produced by small member factories, and then shipped the product to a wholesale commissioned merchant in Yokohama. The wholesaler then sold

[4]The reeling process is one of drawing silk threads from boiled cocoons and winding them. While in Italy silk wound could be taken off the reel and shipped immediately, Japan's high humidity levels raised the possibility that once-reeled threads would stick to each other. Accordingly, Japanese raw silk had to be wound again on a second, larger reel for drying and conditioning.

the raw silk to Western trading companies. After it bought the raw silk from wholesalers, the Western trading company classified the raw silk from No. 1 to No. 3, re-packed it, and put its own chop (trademark) on it. These trading companies then exported the raw silk as its private brand to Europe.

However, in 1882 Japanese silk manufacturers faced a recession in France. By this recession Kaimeisha also made a loss and so sought to redirect their exports to the US silk fabric market.[5] Although export to the US market required the manufacturers to meet the higher standard of thread evenness demanded in that market, many of the procedures at Yokohama remained the same; the raw silk was inspected, classified, priced by Western trading companies, and then exported to the United States as the trading companies' brands, which were called "private chops" in the New York market.[6]

Establishing a brand, the seller could acquire information about marginal increase in price due to marginal improvement of quality as well as could earn quality premium accompanied with commitment to certain quality. Thus the agent has both necessary information and incentives to improve and commit to quality (Thomas (1995)). That kind of agent in this case was Western trading companies. Manufacturers in the hinterland thus lacked both the information and the incentives to improve the quality in the correct direction guided by the price function in New York. This was what was seriously felt by manufacturers of Kaimeisha before 1884. Letters with shipment from Kaimeisha to the wholesaler at Yokohama, Ryohei Tomura, tell the point.[7]

> [Letter with the 1st shipment. from Kaimeisha to Ryohei Tomura, July 19, 1879]
> For classification of raw silk of individual manufacturers when sold (to Western trading companies), a card is inserted to each unit (2.2t kilograms), and so, when inspected (by Western trading companies), for No.1, No.2 and 3, please pull out each card, and bundle cards of No.1 together and seal them, please do the same for No.2 and No. 3 and please send them to us. Even when raw silk was rejected (by the Western trading companies), please do the same for classification into No.1, No.2, and No. 3, seal them and send them to us, but, if foreigners (Western trading companies) did not classify raw silk, we would like you to classify it, quote price differences for No.1 and No.2, and send them to us.

Thus, Kaimeisha totally depended on inspections by Western trading companies for quality control and for distribution of proceeds.

> [Letter with 11th shipment, from Kaimeisha to Ryohei Tomura, November 4, 1879]
> The other day, . . ., while all boxes[8] were sold as No.1, member manufacturers complain that there should be good or bad raw silk which should be differentiated

[5] Nakabayashi (2003), p. 169.
[6] See Duran (1913), pp. 105-106.
[7] "Oguchi Keiko Ke monjo (Archives of Keiko Oguchi)," held by Yokohama Archives of History.
[8] 1 box of raw silk is 37.5 kilograms.

> into No.1 or 2 in the boxes sold, by which managerial manufacturers are troubled, and therefore, hereafter, when selling in such a way, we would like you to roughly classify raw silk into No.1 and 2, stamp classes on cards, and send them to us. There were no classification for 1st, 2nd and 3rd shipment, which naturally induced quality worse, and thus, though we understand it is costly to you, please classify raw silk into as many classes as possible, then member manufacturers should make effort to improve quality. We would like you to accept this and handle it.

A few important points are reported in this letter. First, classification of raw silk was directly linked to quality control as incentives through distribution of proceeds, which depended on classification. Second, classification was still completely managed by Western trading companies, and otherwise, manufacturers requested the wholesaler at Yokohama to do so. Third, without having its own brand, manufacturers could not recognize how the quality they produced was valued in the market.

After 4 years of this ignorant business, to increase evenness of raw silk produced by member factories, the Kaimeisha organized cooperative finishing system in 1884. Cooperative finishing process consisted of cooperative re-reeling and cooperative inspection. Cooperative re-reeling was a practice which traditional silk-reeling farmers in Gunma Prefecture seeking to enter the US market introduced in the late 1870s.[9] Once it became clear that cooperative re-reeling was useful in producing the kind of uniform raw silk demanded in the United States, machine-reeling manufacturers hastened to adopt the practice. Indeed, this cooperative technique was technologically helpful to improve the evenness of threads.[10] Thus cooperative re-reeling was not a break-through in its technology. Advancement was rather organizational particularly in inspection process and distribution of proceeds strictly linked to reults of cooperative inspection.

Member manufacturer was supposed to transfer every singly reel of raw silk with sings of factory and reeling worker in charge. Inspectors sampled the silk thread to measure the denier.[11] The weight of each bundle and the denier of thread were measured and entered in the record card. The bundle of raw silk then underwent the final quality inspection, receiving a grade of 1, 2, 3, or substandard, according to denier evenness, luster and uniformity of threads. It was then baled, imprinted with the chop of its grade and shipped to a wholesale merchant in Yokohama. Then the wholesale merchant sent market information by telegram to the Kaimeisha and received the Kaimeisha's selling order in reply.

[9] See Takashi Kato, Yasuo Sakata and Norio Akitani, eds., *NichiBei-kiito-boeki shiryo (Historical materials on the silk trade between Japan and the United States) 1*, shiryo-hen (documents) 1, Tokyo, 1987, pp. 145-199 and Federico (1997), p. 120.

[10] Mostly because, in the 1880s, factories were too small to keep uniform quality in large lots, and partly because hand-powered reeling machines were still in use in a number of factories in the 1880s, machines which made it difficult to maintain the constant speed necessary for producing uniform thread. To partially offset this problem, re-reeling wheels were generally operated by waterpower. In 1892, there were twenty member factories of the Kaimeisha and a total of 1,590 basins. In the same year, eight factories, accounting for 328 of basins, were hand driven. Noshomusho Nomukyoku, *Dai-ichiji- zenkoku-seishi-kojo-chosahyo (Report on the first investigation of silk-reeling factories in Japan)*, 1895.

[11] "Denier" is the unit for thickness of threads. 1 denier is 0.05311 grams per 476 meters.

The record cards, on the other hand, were sent to the Kaimeisha accountant, who entered the date, denier, quality, and quantity under the name of the worker in charge of the reel in a section of the "Raw Silk Detailed Record". The "Detailed Record" was passed to a rounding inspector, who transferred the information into each female employee's section in the "Denier Book" (**Figure 2**).

It is important to note that the "Detailed Record" and the "Denier Book", which logged the daily performance of individual workers at their respective factories, were used as means of controlling the incentives of respective manufacturers by provision of information necessary to improve the quality. After the raw silk was sold, proceeds of the sales were distributed according to the grade the inspectors of the Kmaieisha recorded. Thus, the higher quality they realized, the more money the manufacturers received. The rounding inspectors guided the factories by passing on the information about quality that accumulated in the "Detailed Record". By the guidance based on the "Detailed Record", the manufacturers knew the information about the respective terms of quality to be improved.

Member silk-reeling manufacturers were thus given financial incentives to control quality and the concrete information about quality. Under this scheme, did high become the possibility that the member manufacturers could get more proceeds by the improvement of the quality. Thus it became incentive compatible for member manufacturers to sustain the quality as advised by the cooperative rounding inspectors because quality control to meet the market demand was now less costly due to information transmitted by the rounding inspectors and improved quality was rewarded by the inspection prior to shipment and distribution of proceeds.[12] The Kaimeisha incorporated a part of pricing in the market into the organization.

As shown in the example model above, in order to motivate manufacturers to improve production efficiency, it was necessary that the product be evaluated accurately and receive an appropriately high price at final sale and that this quality premium should belong not to a trading company or a wholesale merchant but to the manufacturer, in order to provide the incentive to the manufacturer for the improvement of quality. Certification of quality by silk-reeling manufacturers' chops was a device to realize such an organizational coordination.

The Kaimeisha set the design for its chop in its 1884 Rules and its 1888 Rules further prescribed strict control over the brand quality. Raw silk was to be classified into three groups. Group 1, the best one, would be recognized as the Kaimeisha brand, within which there were three numbered ranks. Group 2 was sold with another name, the Soseigumi brand. Group 3, for sale only in the domestic market, was sold without a brand name. According to the 1888 Agreement, the Kaimeisha No.1 brand accounted for about 70 percent of total production of the Kaimeisha. By the late 1880s, trading companies in Yokohama were receiving orders from New York which specified the Kaimeisha brand. The Kaimeisha brand thus seems to

[12] High-quality production costs more than low-quality production and the amount of cost increase is determined by the manufacturer's level of efficiency. Therefore, high-quality production may not mean maximization of profit for a manufacturer who was less efficient. The Kaimeisha organization provided little incentive for less efficient factories. In fact, it prohibited as members factories that could not achieve the Kaimeisha average in quality with 80 percent of the Kaimeisha average in productivity (Article 7 of Rules, 1884). Continuity of membership was also important for quality control: most of the original members remained in the Kaimeisha until at least the late 1890s. By contrast, associations which had fluid members could not sufficiently control quality even by introducing cooperative re-reeling.

have become trusted in New York by the end of the decade. The Kaimeisha brand gained a quality premium clearly from 1884 (**Figure 3**), and the cooperating member factories of the Kaimeisha developed rapidly.[13]

The outcome was straightforward. **Figure 3** and **Figure 4** depict weekly price series of filature produced in Shinshu, which is the old name of Nagano prefecture including Suwa) and other regions on five weeks moving average and those of Kaimeisha filature. From 1884, Kaimeisha filature earned an obvious quality premium. The practice was followed by other cooperatives. A typical example is a cooperative in Suwa, Kyoryoskusha, and Kairyosha, to which Kyoryokusha was renamed in 1885. Kyoryoshokusha was an organization for co-operative shipment. In 1885, member manufacturers copied the Kaimeisha method and re-named their own brand name to Kairyosha. Then, along with Kaimeisha, though smaller, the Kairyosha brand successfully earned quality premium.

With other machine-reeling manufacturers following the Kaimeisha's lead, by the end of the 1880s, the total Japanese share of the US market reached over 50 percent. Recognizing that the growth in market share in the United States resulted from the consistent provision of a certified quality, the silk-reeling manufacturers that already obtained a quality premium had sufficient incentive to maintain the higher quality of their brand names.[14] Henceforth, with the rapid success of this production model, the organization of the Kaimeisha became a standard in the development of Japan's modern silk-reeling industry.

Earned premium resulted in accelerated growth of member manufacturers of Kaimeisha. Number of basins, on each of which reeling worker operated, rapidly increased from the mid-1880s to the early 1890s. The growth was accompanied by increased labor and productivity that is shown as growth of per basin output (**Table 1**). This rapid growth is consistent with predictions of **Lemma 1**, **2** and **3**.

2.2 Development of the US fabric industry and the challenge from Shanghai filature

The Japanese share of the US market, however, stopped increasing in the middle 1890s when Chinese filatures produced in Shanghai rapidly increased export to the United States. In the mid 1890s, productivity gained by further increased speed of throwing machines and power-looms in the American silk fabric industry. Through increased productivity of the American

[13] Shinshu filature was appreciated especially after 1884. 'July [1884]c About the middle of the month Shinshu Silks came in to some extent, and gave evidence of excellent quality. The price of Hanks weakened continually, but towards the close filatures were decidedly strong, the good quality apparently making them prime favorites for the American Market', "The silk trade of Japan", taken from Messrs. Griffin & Co.'s Half-yearly Silk report, *The Japan Weekly Mail*, Apr 18, 1885, p.373. There were 1,624 basins in Suwa in 1884, 691 of which were affiliated with the Kaimeisha. In 1890 a total of 1,310 basins were affiliated with the Kaimeisha.

[14] 'In filatures and re-reels, some of the manufacturers who have a reputation to maintain have turned out good, worthy silk; while other chops especially in the Medium Grades, have been uneven and unreliable as of old,' "The silk trade of Japan", taken from Messrs. Griffin & Co.'s (trading company in Yokohama) half-yearly silk report, *The Japan weekly mail*, Jan 19, 1884, p.68. In addition, it was a real business practice that silk fabric manufacturers were willing to pay quality "premium" for credible "original chops." See Duran (1913), pp. 105, 109.

silk fabric industry, the real price of silk fabrics fell and so became more popular for mass consumption.[15] At the same time, the replacement of high-skilled male workers with low-skilled female workers, which had begun since the 1880s, was progressed further in the production of medium-low grade cloth in the American silk fabric industry. The raw silk demanded in these increasingly capital intensive factories was, above all, raw silk of evener threads, because such silk was suited to the high speed operation of the power-looms and made higher labor productivity possible.[16]

On the other hand, large factories equipped with 150-500 basins were established in Shanghai by Western trading companies from the 1880s to 1890s.[17] As threads of Chinese filatures were evener than those of their Japanese competitors, American silk fabric manufacturers changed Japanese filatures to Shanghai filatures for the use of organzine.[18] This substitution of Chinese silk was clearly felt in Japan, reflected by the stagnation in the Japanese share of the US market.

It was also reflected in decreased quality premium of Kaimeisha brand at the Yokohama market. In the mid-1890s, quality premium belonging to Kaimeisha and other Nagano brands diminished, and finally disappeared (**Figure 5**).

[15] See Kumasaburo Tanabe, a staff member of the New York consulate, "Shika toki no gen-in narabini Beikoku ni okeru kinuorimono ryuko no keikyo (The cause of the rise of the silk price and the popularity of silk fabrics in the United States)," *Kampo (The Official Gazette)*, 2,936, Apr 17, 1893. Matsui (1930), p. 149.

[16] "[T]he high-speed-looms introduced between 1890 and 1900 are said to have caused a substitution of women for men, because the ease in manipulation made the work suitable for women," The Senate of the United States, *Report on Condition of Woman and Child Wage-earners in the United States, vol.9: History of Women in Industry in the United States*, Washington DC: Government Printing Office, 1910, p.61. See also Clark (1929), pp. 210-215; Scranton (1989), pp. 195-197. On wage difference between male and female workers in the US silk industry in the 1900s, see Aldrich and Albelda (1980), pp. 329-340. In Paterson, New Jersey, Italian immigrants rapidly increased to become the main labor source of the industry after the depression of 1893-1894, surpassing British and French immigrants in number. See Brockett (1876), 1876, p. 119; The Senate of the United States, *Reports of the Immigration Commission: Immigrants in Industries*, vol. 11, Washington DC: Government Printing Office, 1911, pp. 17-20.

[17] See Nishikido (1897), 1897, pp.39-44, and Li (1981), pp.163-168.

[18] Both organzine and tram were silk threads made of twisted strands of raw silk. Organzine was mainly used as warp and tram as woof. When a raw silk was processed to an organzine, the raw silk had to be evener than it was when processed to a tram because evener warp was strongly demanded for the increase of productivity. See Federico (1997), p. 214; a report from B. Richardson, president of the American silk association, *Dai Nihon Sanshi Kaiho (Journal of the Sericultural Association of Japan)*, no. 19, Jan 1894, pp. 27-34; reports from the New York branch of Yokohama Kiito Gomei Kaisha, *Dai Nihon Sanshi Kaiho*, no. 29, Nov 1894, pp. 34-35; no. 32, Feb 1895, pp. 42-43; no. 44, Feb 1896, p. 45; and no. 46, Apr 1896, pp. 24-25. The American silk fabric industry was in stagnation during the mid 1890s, when manufacturers struggled to increase productivity. Scranton (1989), pp. 112-227. Organzine was used as warp of fabric and warp had to be evener than weft for power-looms. See the report of Iwajiro Honda, a technical official with Noshomusho, *Dai Nihon Sanshi Kaiho*, no.52, Oct 1896, pp. 34-38. If the warp was uneven, it got entangled in the loom and the worker had to stop the loom to remove it. In addition, looms needed to be adjusted by skilled male workers. See Chittick (1913), pp. 16-17; Tariff Commission, *Broad-silk Manufacture and the Tariff*, p. 51; The Senate, *Report on condition of woman and child wage-earners in the United States, vol.4: The silk industry*, Washington DC: Government Printing Office, 1912, p. 34; and Matsui (1930), p. 138.

2.3 Independent production organizations

Meanwhile, in the mid-1890s, many of the chops of Japanese raw silk became jumbled as competing silk-reeling manufacturers responded to their individual incentives.[19] While major manufacturers aimed to gain the quality premium permanently, minor manufacturers tried to make short-term profits by cheating buyers by selling lower quality silk at a higher chop. Overall, however, the major silk-reeling manufacturers, led by the Suwa-based businesses, maintained sufficient confidence in their brands leading to further development of the Japanese silk-reeling industry.[20]

At the same time, the capital restraint of the silk-reeling manufacturers in Suwa was loosened by their large profits of the late 1880s. Growth of individual member factories also enabled leading factories to satisfy technological optimal scale of production for manufacturers' brand discussed in the example model above. Furthermore, the optimal level of quality $v(c)$ depends on efficiency of manufacturers to improve quality (γ). Therefore, as heterogeneity of member factories increased, efficiency loss due to suboptimal level of quality targeting accordingly became serious. The increased heterogeneity was indeed what was observed at Kaimeisha. As it grew rapidly in the early 1890s, variation of scale also increased, which made cooperation more technically difficult (**Table 1**). This inference is not just a theoretical hindsight but rather an issue explicitly recognized as the reality by contemporary manufacturers.

> It is totally impossible for current organizations of silk-reeling manufacturers in Suwa to specifically produce high-quality raw silk, . . ., even if you alone produce high-quality raw silk taking any necessary cost and handle the raw silk to cooperative re-reeling factory, after packed, you can get no effect due being mixed with low-quality raw silk, . . ., therefore, if you try to alone produce high-quality raw silk, you definitely need to carefully select cocoon, . . ., to carefully re-reel, to strictly inspect disconnection, denier, and shine, and to carefully choose boiling water on your own.[21]

Consequently, leading manufacturers and established large factories equipped with several hundreds to a thousand basins outside of cooperatives in the mid-1890s. A typical case was Kanetaro Katakura, the chief manager of Kaimeisha. While having his founding factory as a member of Kaimeisha, he established a factory equipped with 300 basins outside of Kaimeisha, independently conducted quality and shipped its products by a different brand name. Katakura later increased factories, each of which shipped its product as a different brand name, and grew to the world-largest silk-reeling company consisting.

[19] United States Tariff Commission, *Broad-silk manufacture and the tariff*, Washington DC: Government Printing Office, 1926, p.50.

[20] Several studies have emphasized that some Japanese filature brands were not trusted and that trading companies or wholesale merchants had to participate in quality control (Ishii (1972), pp. 70-71, 208-209, and Federico (1997), pp.162-164). Although this observation describes the conditions of the early 1880s, it does not apply to the leading silk-reeling manufacturers after the middle years of that decade.

[21] "Suwa seishika keiken dan (Story of silk-reeling manufacturers' experience in Suwa)," Shinano Mainichi Shimbun (Shinano Mainichi Newspapers), December 1, 1895.

Another typical case was Okaya Silk Reeling and Company. Otojiro Oguchi, Unokichi Hashizume, and Gen-emon Yokouchi, all of whom were smaller members in Kaimeisha, understand necessary transformation of organization, withdrew from Kaimeisha, jointly form a company, and established a factory equipped with 400 basins, in order to achieve "standardization of raw material, boiling water, and management" by "one large factory" run by one integrated management.[22] The factory was expanded to 794 basins in 1899, and more than 1,000 basins in the early 1900s. In the early 1900s, Okaya was the largest standing alone factory whose products were shipped by the same brand name. Its brand, "White Chicken," was recognized as the standard brand of the "Japanese Filature No.1" at the New York Market.[23] The factory increased productivity during the growth and profitability became stable (**Table 2**). Rapid expansion until achieving 1000 basins consistent with the idea that improved quality and recognition of that by the market extend the optimal size of production under the same brand, suggested by **Lemma 2** and **3**.

One important advantage of such large independent factories had to be built was, again, a technological one. The production of raw silk with even threads required a constant speed from the powered reels and a consistent temperature of steam from boilers, factory requirements with high fixed costs.[24] Another advantage was an organizational one, as well as technologically optimal target of quality, both of which were also associated with the withdrawal from cooperative re-reeling.

One of the significant changes in organization accompanying the transition from cooperative to independent large factories was the internalization of the inspection process and the establishment of individual brands. If the level of efficiency was the same in all factories belonging to an association, the optimal level of quality, which was the level of quality that maximized their profit, was also the same. However, if the level of efficiency differed among factories, the optimal level of quality itself could be different. Such differences in efficiency could be most pronounced when a higher level of quality was required, as any cooperative with less efficient factories could impose losses on the more efficient factory. In such a case, a larger and more efficient manufacturer could be better off by withdrawing from the association, incorporating the inspection process into its won factory, and establishing its own brand. Thus, in response to these incentives, manufacturers' "original chops" of large independent firms were established as credible brands in the New York market from the late 1890s to the early 1900s.

With this organizational change, silk-reeling manufacturers came to acquire information about the multidimensional quality vector in the New York market and more efficiently connect it to the operation of silk-reeling. Indeed, this learning process became one of factors for a growing advantage over the Shanghai filatures. While Japanese filatures production began to grow and to increase its share of the US market again, the growth of the silk-reeling industry in Shanghai became considerably slower in the 1900s. There were several reasons for this loss of advantage by the Shanghai filatures. Among faults of the Chinese silk-reeling industry

[22]Memorandum by Otojiro Oguchi, 1903. "Hashizume Ke shiryo (Archives of Hashizume)," held by Okaya Silk Museum.

[23]"Classification of raw silks," *The American Silk Journal*, New York, vol. 27, no. 7, Jul 1908, p. 23.

[24]The reeling process involved the boiling of cocoons in steam.

was in its firm organization. In most Chinese factories, owners and managers of factories were different people, with the managers usually contracting annual use of a factory. The managers, who controlled the production process, had weaker incentives to pursue long-term profit given the probability for their contracts not to be renewed. This organization structure therefore implied a weaker incentive for factories to expand and to establish their own brand.[25] In contrast, the silk-reeling manufacturers in Suwa had a strong incentive to keep long-term profits, and so used the information acquired through the price of its own chop to control the process of production optimally.

Furthermore, information acquired through brand establishment was effectively utilized to motivate workers to operate such that quantity and quality of output was to be balanced at the level that maximized profit. In the cooperative re-reeling system, the inspection process was incorporated in the cooperative re-reeling factory, meaning that all information about workers' performance in the reeling factories was collectively accumulated in the cooperative re-reeling factory, not acquired in individual reeling factories. With the extraction of involvement in the cooperative system, this information became acquired separately at the individual factories.

The devolution of information acquisition resulted in drastic changes to the wage system of employed workers. Since the late 1880s, silk-reeling manufacturers in Suwa had adopted relative wage system, under which wage of workers were decided by the relative evaluation among workers. By the late 1890s with separate production and inspection, however, firms monitored almost exclusively a quantitative measure of labor productivity, because feasibility and cost concerns limited observation in respective reeling factories to this measure alone. Lacking oversight in a multidimensional production situation, opportunistic behavior ensured that workers devoted increasing effort towards labor productivity at the expense of product quality. To avoid such multi-task moral hazard, it would have been helpful to monitor other dimensions of work including quality (Holmstrom and Milgrom (1991)). Nevertheless, information about aspects of performance including the quality of raw silk reeled was collected in the cooperative re-reeling factory.

With the establishment of large independent factories, this information came to be accumulated in individual factories. Therefore, large manufacturers introduced a new wage system in the 1900s. This new wage system utilized a four-dimensional wage function composed of productivity of labor, productivity of material, evenness of threads, and luster of threads as independent variables. By inducing incentives through this wage function, workers essentially were simultaneously maximizing factory profits through their own earnings maximization choices. Indeed, vectors of workers' effort became better coordinated under such wage function in the 1900s.[26]

Therefore, incorporation of the market pricing into production organization rendered deep-seated in the shop floor level of individual process workers' operation, whereby operating

[25] See Lieu (1933), pp. 39-47; Lieu (1940), pp. 96-102; Li (1981), pp. 171-173; and Eng (1986), pp. 70-79. While Federico (1997) is against this argument on the grounds that some Shanghai filature was of high quality (Federico (1997), p.24), the important issue is whether a management oriented to brand consolidation was predominant or not. It should be noted as a point of fact that the Japanese silk-reeling industry, in which a management orientation to maintaining brand name and quality premium was predominant, boosted its share of the US market again after the 1900s.

[26] See Nakabayashi (2006), pp. 200-203.

workers were organized along with streamlined information flow from the market through feeding information from the inspection process back to the production process, pricing the brand in the market, and providing multidimensional incentives to operating workers within the firm in the 1900s. In the 1880s, the inspecting process, which had been a market transaction, was first incorporated into associations for cooperative re-reeling. With the resulting the establishment of quality differentiated brands, associations could acquire information of the multidimensional price function, and could use this information to control the incentives of member manufacturers through the distribution of proceeds. In the mid 1890s, a similar change occurred in organization of the silk-reeling industry. The inspection process was disaggregated to the individual factories again, and brands of respective factories were established. Manufacturers used information about the multidimensional price function acquired through their own brands to control the incentive of workers directly through the multidimensional wage function. At this point, information about the multidimensional quality vector required in the foreign export markets, reflected by the multidimensional price function, was then efficiently connected to the incentives of factory workers. This organizational change made the advantage of the Japanese filature robust. Commencing with the growth period during the first decade of the 1900s, the Japanese share of the US market continuously increased up to the end of the 1920s.

3 Two institutions

3.1 Branding or classification?

Signaling by brands is a device of relational contracting to overwhelm opportunistic behaviors and to realize a better equilibrium. The modern Japanese silk reeling industry developed under this governance mechanism of trades. At the same time, every manufacturer's original chop was not credible. Rather, the chops of large manufacturers received a persistent quality premium because the chops of other manufacturers were not credible. Silk fabric manufacturers purchased credible chops at a quality premium or unreliable chops for a significantly diminished price. Therefore, in the 1910s, some American silk fabric manufacturers came to request the introduction of another institution to govern the trade; an inspection and classification without exceptions by a third party.

There was an informal classification in the Yokohama market. Before major manufacturers established manufacturers' brands, trading companies classified raw silk into No. 1 to No. 3 and put "private chops" on them. After major manufacturers established manufacturers' brands, their credible "original chops" became the measures to classify chops of minor manufacturers. Chops of minor manufacturers and classifications of them, however, were often unreliable. Thus, the American silk fabric manufacturers came to request the implementation of a third party classification procedure. This specific demand became a big issue between the American silk fabric manufacturers and Japanese silk-reeling manufacturers in the 1910s.[27]

[27] See "The American manufacturers' viewpoint," *Silk*, vol. 11, no. 9, Sep 1918.

3.2 Institution in Europe

Obviously, American manufacturers considered a different institution for the governance of trade, the institution in Europe, as their model. In the 1830s, a modern inspection method for raw silk was established by the Silk Conditioning House of Lyons (la Condition de soie de Lyon), which was called Talabot system. The Talabot system was introduced as the official inspection measure by the Chamber of Commerce of Lyons (la Chambre de Commerce de Lyons), and raw silk was inspected by this method. By the late 19th century, the Talabot system (le systeme Talabot), or the modified version Talabot-Persoz-Roget system had been introduced by almost all commercial communities in markets in France and Italy, and by primary markets in Germany, Switzerland and the U.K.[28] In the late 1880s, when Japan started to export raw silk to the United States, the classification by a third party had prevailed in Southern Europe, and thus the classification of Italian filature from the Milan market was credible.[29] Indeed, in the case of Italian filatures, they could be traded according to the classification of the Milan market and so the effectiveness of the third party classification and certification procedure mitigated the need for firms to individually differentiate their product with a distinct brand, in fact, few such brands existed for Italian filatures during this period.

Different from manufacturers' branding, where optimal scale of production tends to be larger than in the case of traders' branding (**Lemma 2**), the Italian system of signaling by reginal associations did not require large scale of production. It provided small factories favorable conditions to survive. In contrast, the compulsory classification was not introduced into the business between Japan and the United States and the governance by brands was maintained, with probable effects on the organization of production in the silk-reeling industry in Japan.[30]

Furthermore, under strategic environment instead of competitive market, vertical separation of branding to outside of manufacturers could weaken competition between manufacturers, make coalition between them easier, and enable them to make larger profit (Bonanno and Vickers (1988)). The Italian system, the chamber of commerce as monopoly branding association in the region was separated from any individual manufacturer and provided environment favorable to coalition between then instead of making competition steer. This is assumed to help medium-small sized factories survive.

3.3 Organization of production and institution of market

The organization of production in the Japanese silk-reeling industry relied on the establishment of brands. Manufacturers completely inspected multidimensional quality of their products, and utilized manufacturers' "original chops" to guarantee the particular qualities. The

[28] There were 41 conditioning houses that adapted the Talabot system in 1878, 17 of which were in France, 15 of which were in Italy, with another 9 in other regions. In 1888, there were 33, 14 of which were in France, 11 of which were in Italy. Vignon (1890), pp. 187-196, 349-352, and Tolaini (1996), p. 219-224.

[29] See Tolaini (1996), p. 205.

[30] Akira Shito, the director of the Silk Conditioning House of Yokohama, thought the quality guaranteed by the reputation of famous factories was credible, that is, he recognized the governance of trade by brands as credible. See Akira Shito, "The problem of classification of raw silk," *Silk*, vol.11, no.9, Sep., 1918, pp. 29-31.

example above indicates that this organizational choice itself could set a larger optimal size of production, in particular for more efficient firms (**Lemma 1**, **2**, and **3**). When these "original chops" were priced in the market, the manufacturers could acquire information about the multidimensional quality demanded in the market through the multidimensional price function. Manufacturers used this information to control the process of production and the control of incentives for workers. If their products were deemed of an even higher quality standard than their competitors, it was possible for these firms to earn an even higher quality premium on their chops - providing strong incentives to improve the process of production and the control of workers. In other words, those competitive firms were provided with incentives to pursue the firm-specific innovation of technology and organization and try to acquire premium from the firm-specific superiority. This was the Japanese system. Obviously, some efficient major manufacturers could receive a large quality premium. Indeed, a remarkable feature of Japanese silk-reeling industry was that several huge firms developed.

By contrast, under the classification without exception by a third party, little surplus remained for the manufacturers that produced a higher quality silk than other firms within the same class. Few winners were motivated to emerge. Indeed, there were no Italian firms as large as the several ones existent in Japan.[31]

These empirical facts, therefore, indicate a complementarity between the institutions of market and organizations of production in the late nineteenth century silk-reeling industry. The raw silk market was characterized by a significant and increasing premium to higher quality in a costly procedure to inspect and ensure product. While different productive organizations were considered and used to earn the highest possible profit from their efforts, the Japanese silk-reeling industry developed multidimensional incentive schemes for their labor directly linked with their individual brands and not limited by compulsory third party classification or still restricted solely by the trading of brands. This was the key development ensuring the persistent success of the Japanese silk-reeling industry over its global competitors in the export market.

Conclusion

This paper however adds an important third case, linking market institutions of products and organizations of production. Under the governance of trade by brands, the multidimensional price function could be directly and efficiently connected to the multidimensional wage function. Such governance of trade would lead to the emergence of huge firms, and the Japanese silk-reeling industry rose as the most successful. On the other hand, under the governance of trade by classification, more diversified industrial organization could emerge, as those in the European markets governed by the chambers of commerce.

Construction or extension of an organization involves the incorporation of transactions from markets, often in order to acquire and process information about a multidimensional price function. This means that construction or extension of organization changes the field where players choose their strategies, strategies that determine the structures of organizations.

[31] See Federico (1997), p. 22.

Therefore, the complementarity between market institutions and different organizations of production is worth thinking about carefully.

Appendix

Proof of Lemma 1. $\pi_M > \pi_T \Leftrightarrow \alpha > c^{1-\gamma}$, which is satisfied if α and/or γ are sufficiently large. □

Proof of Lemma 2. The first order condition of π_T with respect to q gives optimal q^* such that

$$q_T^* = \frac{2B^2 + \sqrt{4B^4 + 4\beta^2 B}}{2}.$$

The first order condition of π_M with respect to c provides optimal c^* such that

$$c^* = (\alpha\gamma)^{\frac{1}{1-\gamma}}.$$

The first order condition of π_M, with replacing c with $(\alpha\gamma)^{1/(1-\gamma)}$, with respect to q yields optimal q^* such that

$$q_M^* = \frac{2B^2 + \sqrt{4B^4 + 4\left[\alpha^{\frac{1}{1-\gamma}}\left(\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}}\right) + \beta\right]B}}{2}.$$

Therefore,

$$q_M^* \geq q_T^* \Leftrightarrow \alpha^{\frac{1}{1-\gamma}}\left(\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}}\right) + \beta \geq \beta^2,$$

which is the case, given that $0 \leq \beta$, if

$$0 \leq \beta \leq \frac{1 + \sqrt{1 + 4\alpha^{\frac{1}{1-\gamma}}\left(\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}}\right)}}{2}.$$

Since $\left(\gamma^{\gamma/(1-\gamma)} - \gamma^{1/(1-\gamma)}\right)$ is increasing in $\gamma < 1$, the lemma holds. □

Proof of Lemma 3. The condition

$$\frac{\partial^2 \pi_M}{\partial c \partial q} = \gamma\alpha c^{\gamma-1} - 1 \geq 0,$$

is rearranged to

$$\alpha \geq \frac{c^{1-\gamma}}{\gamma},$$

which requires greater γ and/or greater α than the condition for **Lemma 1** requires. □

References

Aldrich, Mark and Randy Albelda, "Determinants of working women's wages during the progressive era," *Explorations in Economic History*, October 1980, *17* (4), 323–341.

Bonanno, Giacomo and John Vickers, "Vertical separation," *The Journal of Industrial Economics*, Mar 1988, *36* (3), 257–265.

Brockett, L. P., *The Silk Industry in America. A history*, New York: The Silk Association of America, 1876.

Chittick, James, *Silk Manufacturing and its Problems*, New York: James Chittick, 1913.

Clark, Victor S., *History of Manufactures in the United States, volume 3, 1893-1928*, New York: McGraw-Hill, 1929.

Coase, R. H., "The nature of the firm," *Economica*, November 1937, *4* (16), 386–405. New Series.

Cottereau, Alain, "The fate of collective manufactures in the industrial world: the silk industries of Lyons and London, 1800–1850," in Charles F. Sable and Jonathan Zeitlin, eds., *World of Possibilities: Flexibility and Mass Production in Western Industrialization*, Cambridge University Press Cambridge 1997, pp. 75–152.

Duran, Leo, *Raw Silk: A Practical Hand-book for the Buyer*, New York: Silk Publishing Company, 1913.

Eng, Robert Y., *Economic Imperialism in China: Silk Production Exports, 1861-1932*, Berkeley: Institute of East Asian Studies, University of California, Berkeley, 1986.

Federico, Giovanni, *An Economic History of the Silk Industry, 1830–1930*, Cambridge: Cambridge University Press, 1997.

Holmstrom, Bengt and Paul Milgrom, "Multitask Principal-Agent analyses: Incentive contracts, asset ownership, and job design," *Journal of Law, Economics & Organization*, January 1991, *7* (Special Issue), 24–52.

Ishii, Kanji, *Nihon Sanshigyo Shi Bunseki: Nihon Sangyo Kakumei joron (A Historical Analysis of the Silk Industry: Introduction to the Japanese Industrial Revolution)*, Tokyo: The University of Tokyo Press, 1972.

Klein, Benjamin and Keith B. Leffler, "THe role of market forces in assuring contractural performance," *The Journal of Political Economy*, August 1981, *89* (4), 615–641.

Lemercier, Claire, *Un si discret pouvoir: aux origines de la Chambre de commerce de Paris, 1803-1853*, Paris: Découverte, 2003.

Li, Lillian M., *China's Silk Trade: Traditional Industry in the Modern World 1842-1937*, Cambridge, MA: Harvard University Press, 1981.

Lieu, D. K., *The silk reeling industry in Shanghai*, Shanghai: The China Institute of Economic and Statistical Research, 1933.

____ , *The silk industry of China*, Shanghai: Kelly and Walsh, Ltd., 1940.

Matsui, Shichiro, *The history of the silk industry in the United States*, New York: Howes, 1930.

Nakabayashi, Masaki, *Kindai Shihonshugi no Soshiki: Eeishigyo no Hatten ni Okeru Torihiki no Tochi to Seisan no Kozo (An Organization in Modern Capitalism: The Governance of Trade and the System of Production in the Development of the Silk Reeling Industry)*, Tokyo: University of Tokyo Press, 2003.

____ , "The rise of a factory industry: silk reeling in Suwa, Nagano," in Masayuki Tanimoto, ed., *The Role of Traditional Factors in Japanese Industrialization: 1880–1920*, Oxford University Press Oxford 2006, pp. 183–216.

Nishikido, Umon, *Shinkoku Kenshi Jijo (Silk Industry in China)*, Yokohama: Inoue Shoten, 1897.

Rawlley, Ratan C., *The silk industry and trade*, London: P. S. King and Son, Ltd., 1919.

Scranton, Philip, *Figured Tapestry: Production, Markets, and Power in Philadelphia Textiles, 1885-1941*, Cambridge: Cambridge University Press, 1989.

Thomas, Louis A., "Brand capital and incumbent firs' positions in evolving markets," *The Review of Economics and Statistics*, Aug 1995, *77* (3), 522–534.

Tolaini, Robert, "Progrès technique et perfectionnement des systèms d'evaluation de la qualité dans l'industrie de la soie," in Jean Claude Hocquet, ed., *Cahiers de Métrologie: La diversité local des poids et mesures dans l'ancienne France, vol. 14-15*, Editions du Lys Caen, France 1996, pp. 205–224.

Vignon, Leo, *La soie: Au point de vue scientifique et industriel*, Paris: J. -B. Bailliére et Fils, 1890.

Williamson, Oliver, *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting*, New York: The Free Press, 1985.

Figure 1 Productivity and real wages of the modern silk-reeling in Suwa, Nagano, 1877-1919

Source: Nakabayashi (2003), pp. 468-469, 489-490.
Notes: Productivity: Average in Village of Hirano, Suwa County. 1880-1888 wage: Average daily wage of Kaimeisha manufacturers. 1889-1919 wage: Average daily wage of factory of Seinojo Miyasaka.

Figure 2 Silk Re-reeling and Inspection System of *Kaimeisha* from 1884.

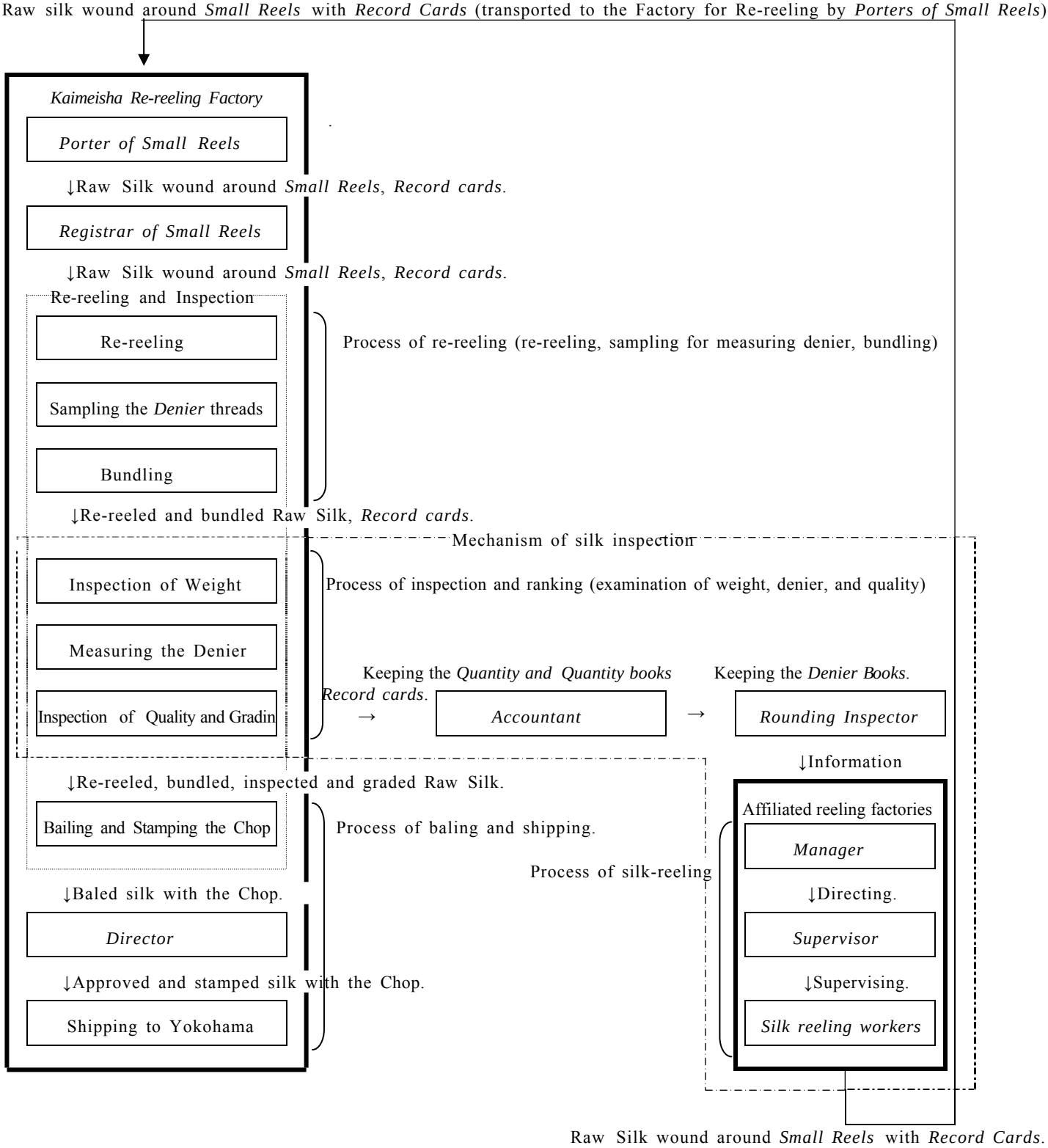
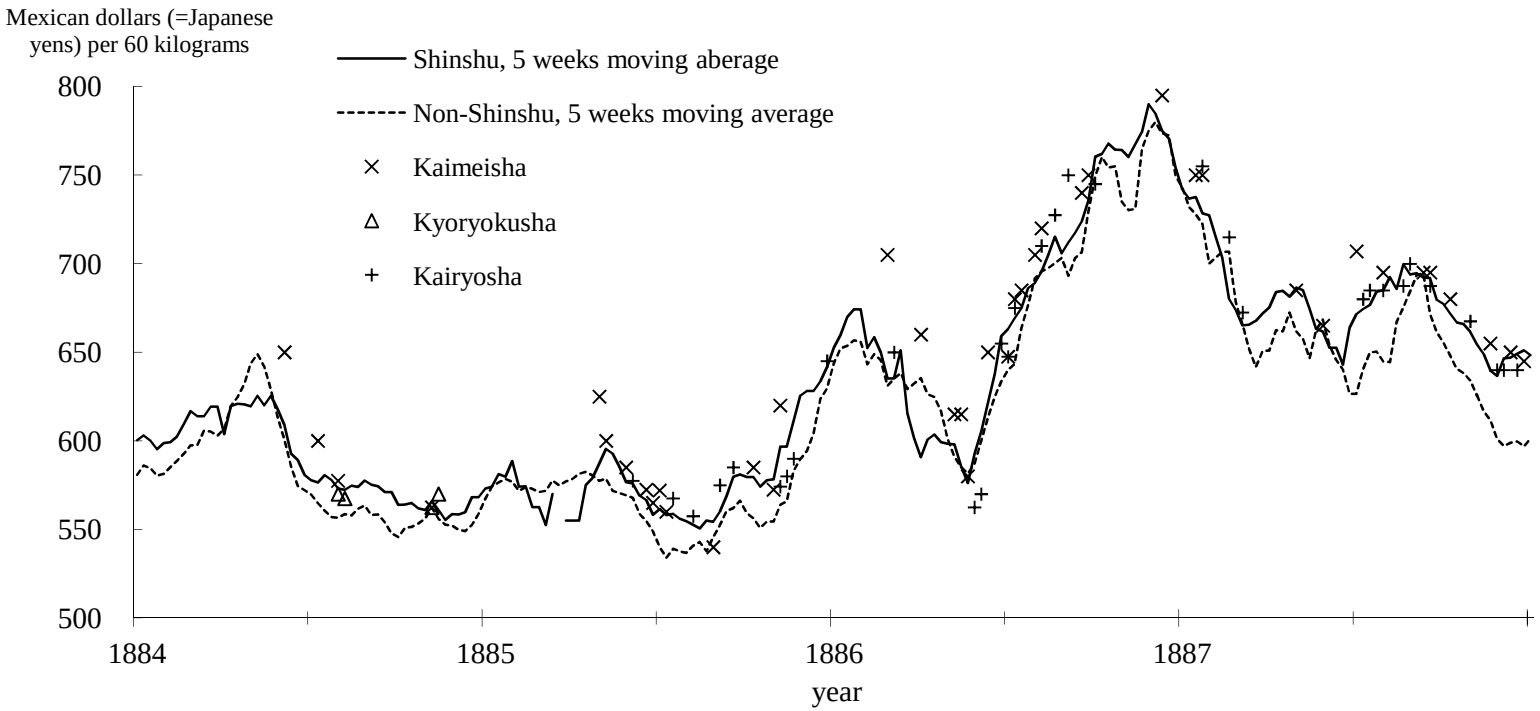
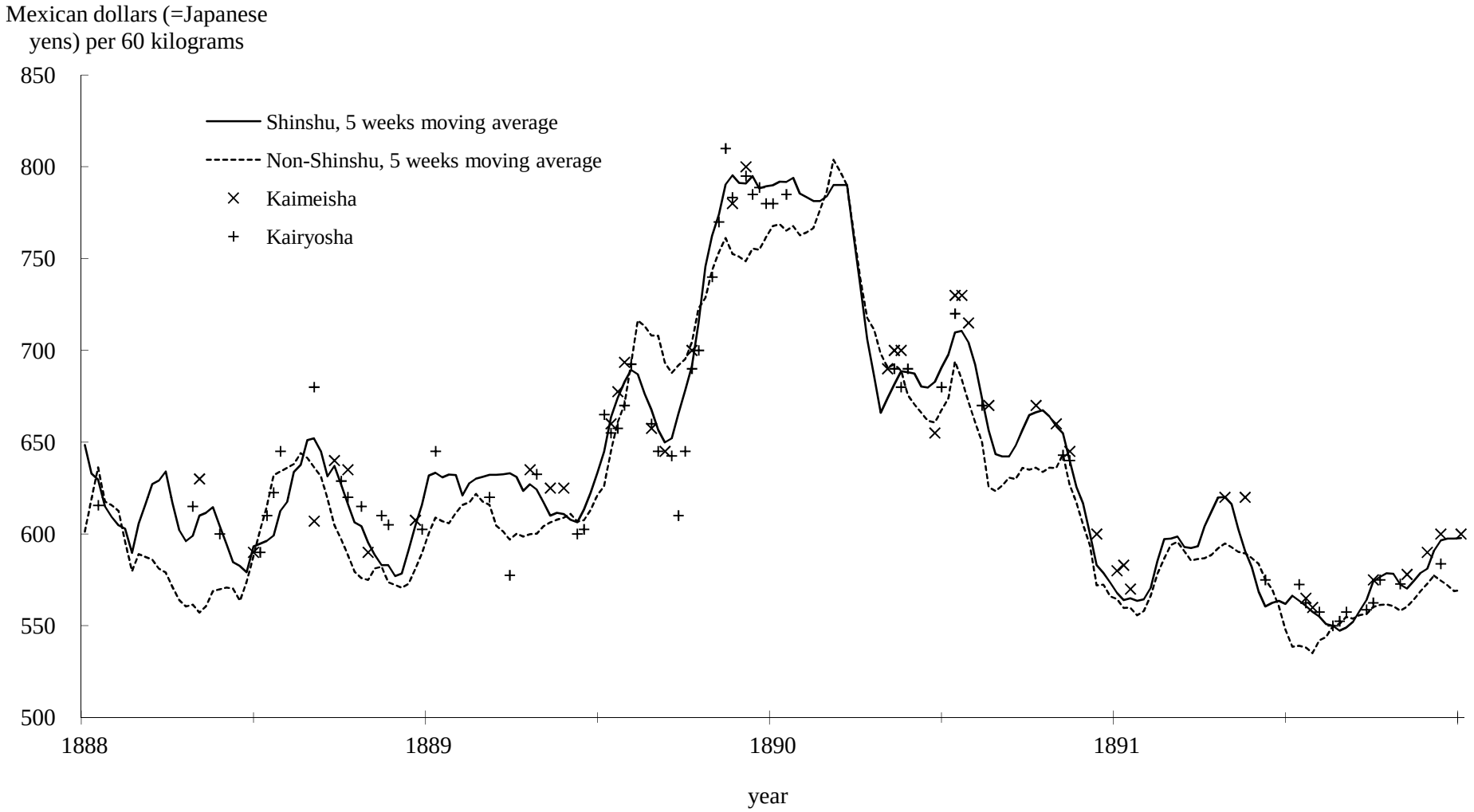


Figure 3 Filature (machine-reeled raw silk) prices at the Yokohama market, weekly, 1884-1887.



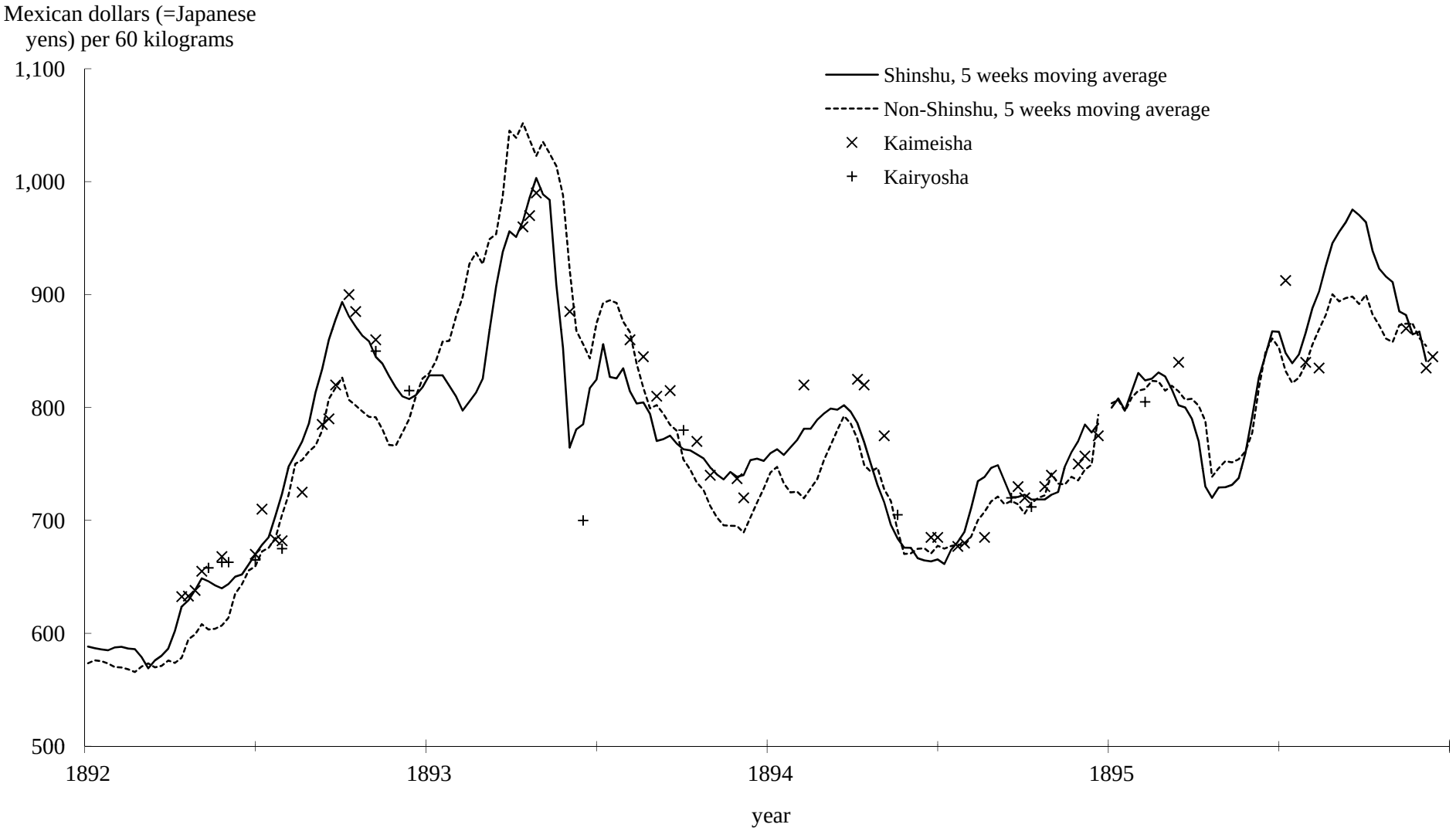
Source: Nakabayashi (2003), p. 178 (Orignal source is *Tokyo Keizai Zasshi (Tokyo Economic Journal)*).

Figure 4 Filature (machine-reeled) raw silk prices at the Yokohama makret, weekly, 1888-1891.



Source: Nakabayashi (2003), p. 178 (Orignal source is *Tokyo Keizai Zasshi (Tokyo Economic Journal)*).

Figure 5 Filature (machine-reeled raw silk) prices at the Yokohama makret, weekly, 1892-1895.



Source: Nakabayashi (2003), p. 178 (Orignal source is *Tokyo Keizai Zasshi (Tokyo Economic Journal)*).

Table 1 Growth of Kaimeisha manufacturers, 1884-1901.

	year		1884	1885	1886	1887	1888	1889	1890	1891	1892	1894	1895	1896	1897	1898	1899	1900	1901
Number	Kanetaro Katakura		90	90	90	90	125	160	160	160	160	160	160	160	160	160	160	160	160
of basins	Kurataro (Kunizo) Hayashi		64	64	64	64	80	80	130	130	180	180	300	300	300	340	540	540	476
	Kinzaemon Ozawa		50	50	51	70	100	100	150	150	200	200	200	200	200	200	200	200	200
	Sehei Hayashi		26	30	30	36	50	70	160	160	180	180	180	180	180	300	332	332	332
	Katsuzaemon Komatsu		23	28	28	28	34	40	50	50	80	100	106	106	106	106	106	106	168
	Keijiro Hayashi				22	22	28	40	51	52	60	60	100	100	100				
	Tatsunosuke (Kikujiro) Ozawa		40	40	40	34	34	48	70	70	100	100	100	100	100	100	100	100	100
	Seikichi Hayashi		26	26	26	26	26	40	60	60	100	100	100	100	100	100	100	100	100
	Otojiro Oguchi		42	42	42	42	42	62	62	62	62	62	62	62					
	Ikutaro Katakura		36	44	44	44	44	54	54	54	54	54	56	56	58	58	58	58	58
	Sakutaro Hanaoka		14	14	14	14	14	20	26	26	26	40	42	44	49	44	44		
	Yokichi Hayashi		12	25	25	25	25	30	34	34	34	42	42	42	42	52	52	52	64
	Risaburo Hayashi			20	20	20	30	35	40	40	40	40	40	40	40				
	Ichiju Hayashi		20	20	20	20	20	27	27	27	30	37	37	37	37	37	37		
	Kinzaemon Hayashi		20	20	20	20	20	32	32	32	32	32	35	35	35				
	Tamizo Hanaoka		14	14	14	14	19	20	20	20	20	32	32	32	32				
	Unosuke Hashizume		17	17	17	17	20	20	20	20	20	32	32	32					
	Gen-emon Yokouchi		27	30	30	30	30	30	30	30	30	30	30	30					
	Kakuzaemon Katakura		20	20	20	20	20	20	20	20	20	20	30	30	30	30	32		
	Genza-emon Hayashi		10	10	16	16	17	20	20	20	20	27	27	27	27	27	39	39	39
	Kamesaburo Yokouchi		14	14	14	14	19	20	20	25	25	25	25	25	25	25	25		68
	Senza-emon Hayashi		53	61	61	36	36	54	54	54	100	100	100						
	Kinroku Ozawa						20	20	20	20	21							32	
	Others		73	23	0	0	0	0	0	0	0	0	0	0	0	32	0	0	32
	Total		691	702	708	702	853	1,042	1,310	1,316	1,594	1,653	1,836	1,738	1,621	1,611	1,825	1,719	1,797
	Variation		0.66	0.63	0.61	0.62	0.76	0.73	0.82	0.81	0.85	0.76	0.85	0.88	0.84	0.91	1.11	0.99	0.84
Output	Total	tons	20.4	20.3	30.4	31.3	41.3	56.3	60.0	62.3	66.4	73.1	80.3	71.3	105.0	71.6	79.9	82.5	90.8
of raw silk	per basin	kilograms	29.5	28.8	42.9	44.6	48.4	54.0	45.8	47.3	41.6	44.2	43.7	41.0	64.8	44.5	43.8	48.0	50.5

Source : "Kamasu daicho (Number of basins)," "Kamasu sankaku (Number of basins and outpu)," edited by Kaimeisha. "Oguchi Keiko ke shozo monjo (Arhives of Keiko Oguchi)," (8), held by Okaya Silk Museum.

Notes : There is no record for number of basins and ouput in 1894. "Others" are rented basins to outsiders. Variation ([standard deviation]/[average]) does not include "others."

Table 2 Facilities, outputs and profits of Okaya Silk Reeling and Company.

year	Number of basins	Output of raw silk		Assets and profit		
		Total	per basin	Asstes		Profit
	a	*b*	*b/a*	Total	Fixed	
		kilograms	kilograms	yens	yens	yens
1897	440			114,981	30,044	5,651
1898	440	24,435	56	179,972	35,260	-36,905
1899	794	36,180	46	355,889	55,153	18,540
1900	794	45,900	58	544,750	55,153	-14,701
1901	794	52,144	66	333,577	64,849	9,409
1902	931	60,008	64	364,780	72,801	22,686
1903	937	52,515	56	399,765	84,470	-12,847
1904	1,016	61,425	60	484,847	91,524	18,851
1905	979	53,704	55	457,330	103,701	-7,550
1906	1,010	73,508	73	647,340	108,198	76,053
1907	1,050	73,888	70	930,256	113,490	2,543

Source : Nakabayashi (2003), pp. 194-195.