

Between Cottage and Factory: the Evolution of Chinese and Japanese Silk-Reeling Industries in the Latter Half of 19th Century*

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Abstract

This article analyzes the differential patterns of evolution in Chinese and Japanese silk reeling industries in the latter half of the 19th century. It shows that while Japanese exports of raw silk overall grew the fastest, the Guangdong region of China also expanded rapidly in the exports of machine-reeled silk, with the Lower Yangzi lagging far behind in machine-reeling production. This paper constructs a simple partial equilibrium model linking the differential rates of growth with patterns of technological borrowing and economy wide transaction costs. Through a historical narrative, this article argues that the contrasting performance in the two countries' silk exports is directly linked to the differential rates of decline in barriers to learning and economy-wide transaction costs, which themselves were intimately associated with the divergent political and economics changes between these two countries in the late 19th and early 20th century.

In a classic poem taught to every school child in China, the famous Tang dynasty poet, Bai Jui-yi (772-846 AD), mused that silkworm was a selfless creature who spun silk for others till its last breath. This allegory is an apt depiction of the historical role of raw silk to developing East Asia. Between 1850 and 1930, raw silk was the leading export item for Japan and China, accounting for 20-40% and 20-30% of their total exports respectively.¹ Revenue from raw silk exports supported the capital accumulation for industrialization in both countries, and more importantly,

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¹ Li, *China's Silk*, p.77. Yamazawa and Yamamoto, *LTES*, vol. 14. p.5.

sustained the livelihood of millions of workers and farm households who raised silk cocoons. But it was precisely the very rise in living standards initially brought about by raw silk production that phased out this labour-intensive silk sector.

The development of modern Japan is supreme testimony to the historical role of raw silk. In 1873 China exported three times as much raw silk as Japan, but by 1905, Japanese raw silk exports exceeded the Chinese, and in 1930, Japanese raw silk exports tripled those of China, gaining a dominant 80% share in the global market.² By 1970, having long “graduated” from the status of a developing economy, Japan turned from once an exporter to a net-importer of raw silk since the 1970s.

The Japanese overtaking of Chinese silk production in the early 20th century marked the first time China had ever lost this lead since silk had been invented two millennia ago. And China had to wait until 1977, at the end of more than two decades of political turmoil and economic isolation under Mao’s rule, to recapture her historical supremacy. By the 1990s, Chinese raw silk output exceeded Japan’s historical record set in 1934 and produced close to 70 percent of the world total.

The China-Japan contrast is both puzzling and significant. By the mid-19th century when both countries emerged out of relative isolation, geography, factor endowments, technology as well as global reputation all seemed to favour the Chinese silk over that of Japan. Both nations had been deprived of tariff autonomy under similar unequal treaties imposed by Western imperial powers. Meanwhile, the global market for raw silk, particularly following the pebrine crisis that had devastated sericultural crop

² See Giovanni Federico, *An Economic History of the Silk Industry*, (Cambridge: Cambridge University Press, 1997) Chap. 3, p. 36, Table 3.4, p.200, Table AIII.

in Southern Europe around mid-19th century, was thrown wide open. Global market for raw silk was truly free and integrated.

This article argues that, to reap the full benefits of a growing foreign demand, the traditional economies of China and Japan had to confront and overcome severe technological and organizational constraints, which posed both barriers to learning and high transaction costs, directly and negatively impacting the rise of well-functioning markets for capital, labour and other inputs for a traditional economy. Thus, the contrasting performance in the two countries' silk exports is directly linked to the differential rates of decline in barriers to learning and economy-wide transaction costs, which themselves were intimately associated with the divergent political and economics changes between these two countries in the late 19th and early 20th century.

This article concentrates on the second half of 19th century, a period of transition from hand-reeling to machine-reeling where technical change and progress mostly involved borrowing and adaptation only. Restricting this study to this period enables me to focus on the role of learning, transaction cost and market development. I leave to future research for the 20th century when major technological innovation supported by some degree of R&D investment occurred.

The rest of the paper is divided into three major sections followed by a summary. The first section gives a brief account of the main features of European and East Asian reeling technology, major quantitative trends and a partial equilibrium model. The second section provides a historical narrative on the process of transplanting European reeling technology to China and Japan. The third section summarizes the differential regional patterns in the analytical framework of the model.

1. Stylized Facts and Model

The 20th century eclipse of Chinese technological leadership in silk production by Japan in fact had its early modern historical precedent. Although it is beyond dispute that the prototype of the foot-treadle silk-reeling machine in Southern Europe was fundamentally Chinese, or more specifically, Lower Yangzi in origin, the French and Italian machines, aided by a series of subtle but crucial technological innovations, had risen to world leadership by the late-17th century. These innovations came to East Asia around the mid-19th century as a bundle consisting of four new features.

The first was the adoption of rigid axle and cogwheel mechanism to transmit the power to move the reel in place of the driving-belt it had borrowed from China. The second was the design of an additional twisting mechanism (Chambon style in France and Tavelle in Italy) to cross silk threads dry. The first mechanism stabilizes the reeling movement, while the second innovation greatly enhances the cohesiveness, evenness and uniformity of the silk thread, features that are absolutely essential for high quality raw silk (Zanier, 1994). The third was the use of a centralized steam boiler that provided continuous and even heating for the reeling basins of cocoons. The fourth, which came the last, was mechanization. However, the use of steam power had not been crucial early on for the reeling of delicate silk threads - even in Europe, fully mechanized silk-reeling was mostly a 20th century phenomenon. Therefore, the major distinction between hand and machine-reeling in the 19th century East Asia was the use of centralized steam heating.

Entrepreneurs in East Asia had selectively adopted various features of this bundle to suit their needs. For example, the traditional silk-reelers

encountered little difficulties to insert the first two features of European reeling technology – cogwheels and crossing systems – into their household based production. However, the adoption of the third and fourth technical innovations required the use of a centralized location, a first step towards the rise of modern factories. But even there, as will be shown below, various technological and organizational compromise had evolved in different periods that the distinction between household and factory production could be blurry at times in the 19th century East Asia. In comparison with other modern industries, silk-reeling factories remained relatively small in scale, low in capital intensity and dispersed in location.

The evenness and uniformity of the machine-reeled raw silk found favour with the weavers in Europe and particularly the U.S, who were growing increasingly in scale and capital intensity. It commanded a price premium over the hand-reeled silk in the international market. Throughout the 19th and early 20th century, average price for machine-reeled raw silk were about 40% higher than hand-reeled and 25% higher than the so-called improved hand-reeled raw silk, which adopted an additional process of hand-re-reeling (*LTES*, vol. 11, p.167).

Yet despite the price premium, the diffusion of machine-reeled silk did not lead to the immediate displacement of hand-reeled silk in exports. Table 1 shows that exports of hand-reeled silk in China and Japan rivalled that of the machine-reeled before 1900. Even after the 20th century that machined reeled began to dominate only in Japan and Guangdong but not the Lower Yangzi. It is interesting to note from figure 1 that Guangdong, partly due to its relatively small level of hand-reeled silk exports, had the highest share of exports in machine-reeled silk, followed closely by Japan. On the other hand, machine-reeled silk exports from the Lower Yangzi, the world's long-time leading high quality silk producing region, were so puny that they were

not even separately counted in the 1893 trade statistics. Even towards the 1920s, machine-reeled silk counted only about half of the total exports from Shanghai.

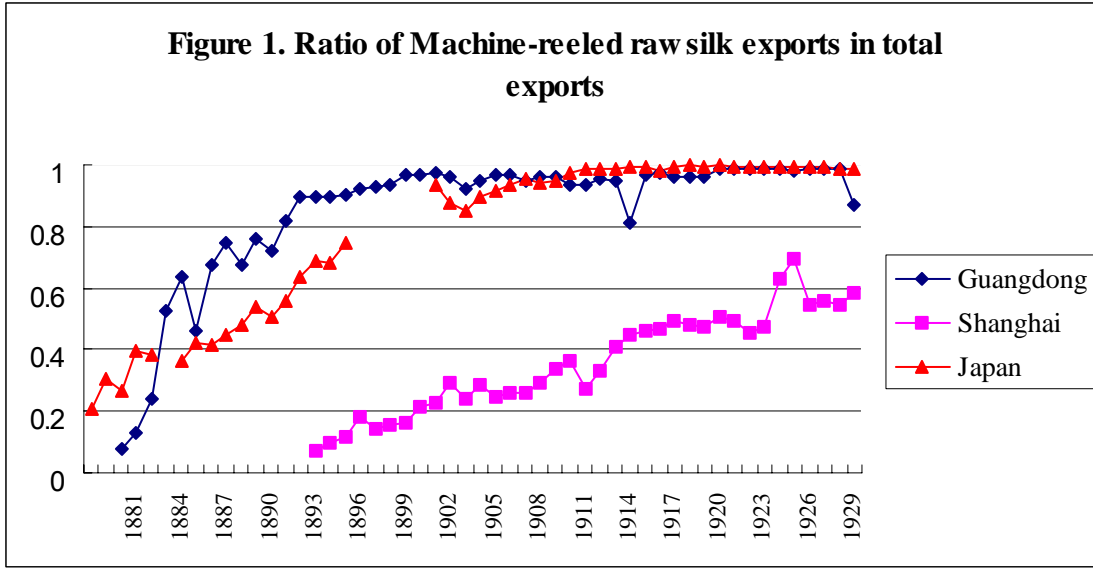
Table 1. Raw Silk Exports of China and Japan by Types (in Metric Tons)

Years	Hand-Reeled Silk			Machine-Reeled Silk		
	Lower Yangzi	Guangdong	Japan	Lower Yangzi	Guangdong	Japan
1880-90	2370	345	1074	-----	360	728
1890-1900	2576	160	1010	484	1349	2358
1900-10	1715	93	549	834	2097	5344
1910-20	1320	127	153	1609	2206	11825
1920-30	742	37	164	2306	2877	23989

Source Notes:

Chinese raw silk data from Chen, *Jingdai*, p.170, Xu, et al, *Zhongguo*, pp. 688-707, Guangdong hand-reeled silk from Wong, Cho Yee, *Proto-Industrialization*, pp.290-1. Amount for machine reeled raw from Shanghai before 1894 were insignificant and not separately reported in the Maritime Customs Reports.

Japanese raw silk data from Fujino et al, *LTES*, Vol.11 Tables 4-4 and 63, Hand-reeled silk 1879-1896 based on Ikawa, "Seishi" p.252; and 1860-67 based on Ishii, *Nihon*, p.41, table 4.



Same as Table 1

To analyze the persistence of hand-reeled silk and the differential rate of diffusion of machine-reeling across these three regions, I construct a simple partial equilibrium model. As demand side of raw silk is set in the international market, we can treat the prices of machine-reeled and hand-reeled silk, denoted as P_M and P_H respectively, as parameters. For the supply side, we posit that the output of machine and hand-reeling silk output (Y_M and Y_H respectively) are produced by two constant returns to scale technologies, each using three inputs: Labour (L), Reeling Machines (K) and Cocoons (Q). We assume that the total quantities of cocoons produced for each year are fixed and shared by machine and hand-reelers. That is $Q = Q_M + Q_H$. It is also reasonable to assume that machine-reeled technology has higher total factor productivity (A_M) than that of the hand-reeled (A_H), that is $A_H = \alpha A_M$ where $0 < \alpha < 1$. We can write them out as:

$$Y_M = A_M F(L, K, Q_M);$$

$$Y_H = \alpha A_M F(L, K, Q_H).$$

The corresponding cost equations for these production functions are:

$$C_M = wL + (1+r)(P_{KM}K_M + P_QQ_M) + TY_M;$$

$$C_H = wL + (P_{KH}K_H + P_QQ_H) + \phi TY_H;$$

where w , r , P_Q , P_{KM} , P_{KH} , T are wage rates, interest rates, cocoon prices, prices of machine-reel tools and hand-reel tools, transaction costs per unit of output respectively. For machine-reeling sector, we use the $(1+r)$ term as we assume purchase of cocoons and reeling machines are externally financed, while these purchases are self-financed for hand-reeling. As machine-reeling tools are more expensive than that for hand-reeling, we have $P_{KM} > P_{KH}$. I assume ϕ is a coefficient between 0 and 1, which means per unit output transaction cost is higher for machined reeled silk than that of the hand-reeled.

The two cost identities are standard except for the addition of the per unit transaction cost T . Transaction cost here denotes two broad categories of costs facing a silk-reeler. The first and the most straightforward is costs incurred in various market transactions that involved the marketing and moving of silk, the recruitment of labour, the procurement of inputs, particularly cocoons. The second category pertains to the public and government sector, in which the external legal environment, contract enforcement mechanism, securities of properties and government taxation policies are all likely to impact transaction costs. It is quite reasonable to expect that a machine-reeled firm, with larger capital investment concentrated in a centralized location, would likely incur higher transaction cost per unit of output than a hand-reeling unit in both categories.

Combine the output price, production function and cost identities, we can derive the following two profit functions machine and hand-reeled silk respectively. The intuition of the equation is that although machine-reeled

silk can be produced with higher total factor productivity and fetches a higher price than that of the hand-reeled silk, it also requires more expensive machines, additional interest costs and higher per unit transaction cost.

$$\Pi_M = (P_M A_M - T) Y_M - [wL + (1+r)(P_{KM} K_M + P_Q Q_M)];$$

$$\Pi_H = (P_H A_H - \phi T) Y_H - [wL + (P_{KH} K_H + P_Q Q_H)];$$

With CRS technology, perfect competition and relatively inelastic cocoon supply, profit maximization with respect to inputs could yield a unique equilibrium ratio of machine-reeled silk to hand-reeled (Y_M^*/Y_H^*) at which the optimal per unit output profit for machine and hand-reeling silk are equal given certain parameters restrictions. Comparative statistics would show that optimal output of machine-reeled silk would rise relative to that of hand-reeled silk if there is an increase in P_M, A_M, w , or a decline in r and P_{KM} . Note that a decline in T , the per unit transaction cost, will lead to an increase in both Y_M^* and Y_H^* , but will increase Y_M^* proportionately more than Y_H^* (because $\phi < 1$) so that in the end, Y_M^*/Y_H^* will rise.

This model aims to capture several important aspects of the transfer of European reeling technology and organization in traditional East Asia. Despite the relatively high profitability and higher productivity of the machine-reeling technology, the viable transplantation and diffusion of the new European technology required substantial learning efforts, and more importantly, vigorous adaptation of a relatively expensive modern machine to the labour-abundant, capital scarce economy of 19th century East Asia. Moreover, to produce in a centralized location and later modern factory compelled substantial reorganization and realignment on the existing social and economic structures of traditional East Asia. Being fundamentally rural-based, the success of modern silk reeling industries hinges on the existing capacity of grass-root rural communities and agrarian structures to respond

to these challenges and opportunities. As machine-reeling was often in direct competition to the traditional handicraft interests, our analysis of its differential patterns of diffusion would have to be placed in the larger political economy background of these two nations at this critical junction which saw unprecedented political and economics shocks.

2. European Technology in 19th Century East Asia

The Lower Yangzi

Thanks to the detailed archival records of East Asia's most powerful trading firm, Jardine, Matheson & Co. we are able to learn the dramatic details of the first European silk reeling technology transfer to East Asia (Brown 1979, Ishii 1998). In 1859, Jardine employed a British subject John Major, who, with 15 years of operating silk filature in Naples, Italy, was eager to construct such a factory in China employing "Italian and French methods." In January 1860, factory construction began in Shanghai, a treaty port opened to Western trade since 1843. To construct a modern style factory complete with one hundred mechanized, steam-power driven machines and warehouse was no simple task in the then largely primitive "frontier" environment of Shanghai. The construction was finally completed after a protracted and trouble-ridden seventeen months.

Industrial capital and factory construction proved to be the easier part of this modern factory, named as Ewo Silk Filature. To develop a stable corps of labour force with skill and discipline, in 1861 Major managed to recruit four female French skilled reelers directly from Lyon on a five-year contract basis. Despite some initial set-backs and with all the French girls having eloped with French soldiers within the next two years, a reasonably skilled Chinese female labour force, consisting mostly of refugees from the

Taiping rebellion ravaged Nanjing, turned out products of quality comparable to the European standard. The size of the factory also doubled to include an additional 100 reeling basins in 1863.

But the real problem seemed to lie outside the factory or even Shanghai. The treaty port status of Shanghai provided Westerners and their business extraterritorial protection. But the Ewo filature was set up with the presumption that Shanghai's hinterland, the Lower Yangzi delta, could be relied on as a supply base of cocoons, the raw materials for mechanized silk-reeling. This presumption, however, turned out to be fatal.

Worldwide, most reeling factories located near cocoon producing regions as transporting finished raw silk is far cheaper than shipping fresh cocoons – it takes six times the amount of fresh cocoons to produce one unit of raw silk. Clearly, the choice of Shanghai – located more than a hundred miles away from the sericultural regions - as a site for Ewo filature was political as foreign direct investment outside the treaty port was prohibited. To transport fresh cocoons out of the rural markets, Ewo, besides the issue of higher transportation cost, encountered the immediate technical difficulty of killing the chrysalis inside and drying the cocoons in the rural area.

But this technical problem, which was solved partially and gradually, paled in comparison to the political and social obstacles that Ewo encountered in the Chinese countryside. It was only until 1868 that Major, through the repeated attempts and even bringing the weight of British diplomatic pressure to bear on the local government officials, managed to set up a stable cocoon purchasing and drying station in the countryside. The fiercest resistance came from the organized silk handicraft and commercial guilds that feared for their loss of source of cocoon supply.

In 1864, Major recalled after his cocoon purchase trip to the rural Yangzi: “I plainly saw that we must get rid of the Shanghai middleman and have a place up country to collect and kill cocoons. In following this up I had deadly opposition from these people and their friends up country, who for many years had been making a good thing of it and indeed from the whole silk guild. The mandarins were bribed to oppose me, people and brokers, more or less in the hands of the silk hong[s] frightened from me, suitable houses were refused me or set fire to, and what I actually built was pulled down and the Chinamen that did assist me were put in chains...”³

In the summer of 1869, it seems that Major for the first time was able to buy all the high-quality cocoons he required. But in another trip to the rural Lower Yangzi a couple of months later, he died of heat apoplexy. Soon after that, Jardine decided to close down the Ewo filature as soon as the current inventory was unwound. By the May of 1870, the Ewo, East Asia’s first mechanized silk reeling plant came to an end after ten years of operation. The reality behind the rise and fall of the Ewo filature, which seemed so intricately bound with the tough-minded and single-willed personality of John Major, was that the factory had been incurring a constant loss throughout its years of operation. It is clear that the fixed cost of setting up an entire infrastructure to support a single factory was simply too high.⁴

The next ten years after the closing of Ewo went by with no more new attempts at mechanized silk-reeling in Shanghai. By the late 1870s, a new technological innovation of drying and storing fresh cocoons at the site of purchase was discovered (Xu, p.129). This began to stir up new interest in establishing filatures. In the early 1880s, an American trading firm, Russell &

³ Brown, “The Ewo Filature,” p.561-2.

⁴ The narrative on the Ewo Filature was based Brown 1979 and Ishii 1998, chapter 5.

Co., and two other Western trading firms constructed new filatures respectively. By 1882 the Jardine's also came back to business by erecting a new Ewo filature factory in 1882. An important shift in strategy of the new Ewo filature was their enlisting the Chinese cocoon merchants as subscribers to stocks and board members (Suzuki, p. 324).

Most noticeably in 1882, a Chinese comprador of Western silk trading firms, Huang Zhuoqin, started the first Chinese owned filature, marking the beginning of a trend where the entire Shanghai silk industry was to come into the hands of Chinese capital.⁵ This wave of construction increased the nascent Shanghai silk industry to about 800 reeling basins (Suzuki, p. 323-4).

These developments soon alarmed the traditional silk merchants in the Lower Yangzi. Through petitions and publications, they mobilized the local governors of Shanghai, and the provinces of Jiangsu and Zhejiang to issue a closure order for the two Western silk reeling factories in Shanghai in September 1882. Their order, although rejected by the local British and American authorities that had jurisdiction over their areas of international settlement in Shanghai, sent the stock prices of these two factories plunging and caused the closure of their rural cocoon station.

In 1883, Li Hongzhang, China's most powerful bureaucrat at the time, made a compromise and allowed the existence of these two Western silk reeling factories in Shanghai. Subsequently, other Chinese owned filatures in Shanghai were also ordered to register with the authority. Part of the consideration for the compromise was the government's levying of a transit tax, known as the likin tax, on cocoons the filatures purchased in the rural

⁵ It is important to note that Chinese capital preferred to invest in filatures registered in the name of Western firms for their extraterritorial protection. Even later, entirely Chinese

area. The opening of cocoon stations, like the silk hong, would also be subject to official license fees and taxes (Suzuki, p.329-332). By the mid-1880s, as revealed by Suzuki's careful research, there was a subtle but clear governmental policy shift towards an unofficial recognition of private silk reeling firms (pp. 432-440). The industry began to recover and grew modestly that by the mid-1890s, there were a little over ten factories with about three to four thousand reeling basins.

The mid-1880s policy shift did not constitute a major ideological change in the Self-strengthening movement that discriminated the private sector. In cotton spinning, for example, the government continued to prohibit private involvement largely because the government itself had been planning a mechanizing spinning plant. Similarly, attempts by Shanghai silk reelers and merchants in the same year to introduce steamships into inner rivers were also thwarted by local officials who were protecting the interests of traditional shippers. The major ideological shift only came after China's defeat by Japan in 1896, which eventually led to the full lifting of legal constraints against private enterprise.⁶

In contrast to the difficulties of machine-reeling in Shanghai, the response of the traditional hand-reeling sector in the rural Lower Yangzi to the new foreign demand seemed to be far more successful. To meet the European, particularly the American demand for evenness and uniformity, a new type of merchant firms, the so-called Jinsihang, centred in Huzhou, Zhejiang province, emerged in the 1870s to organize a re-reeling process where the hand-reeled silk collected from peasant household or silk hong

owned and operated reeling firms registered as Western firms. Xu, *Zhongguo*, p.188, Suzuki, p.324.

⁶ Steamship companies were allowed to ply the Yangzi river and the coast under the treaty system, but not in the inner rivers or canals. The government only compromised until 1889 to grant the use of steamers in towing traditional boats. Suzuki, p.347.

was first sorted by type, colour, and grade. Then on a putting-out basis, these sorted silks were redistributed to the peasant households for re-reeling using newly invented re-reeling tools. The Jinsihang then packed these re-reeled silk for the export market (Furuta, pp.126-130, Zhu xinyu, p.142-145). Although still an imperfect substitute for machine-reeled silk, it did not require technical and institutional change beyond the traditional framework. The re-reeled silk was a clear improvement over the traditional silk in the overseas market and was important in explaining the resilience of hand-reeled silk exports from Shanghai in the 19th century.

Guangdong

A few years before John Major arrived in Shanghai to start his ill-fated filature, a poor and struggling part time school-teacher named Chen Qiyuan, left his native county of Nanhai in Guangdong province for Southeast Asia. For the next ten years in Vietnam, Chen seems to have not only amassed a small fortune from his retail trade, but also discovered the French style filature operating in Vietnam. It was said that Chen travelled extensively in Vietnam and Thailand to carefully observe the machines, marking down their sizes and structure, often surreptitiously, using his body as a frame of reference. In 1871, Chen returned to his native town with an elaborate plan to start a modern filature.

But unlike Major, Chen knew China or at least his hometown. Beware of the kind of possible interference from the local government and guilds, he decided against such conspicuous location as the city of Guangzhou (or Canton) for his factory site. Instead, he set his factory in his familiar hometown, the Nanhai County.

To fit a modern mechanized filature into a rural setting, Chen had to solve a series of technical problems. He reproduced the French style reeling machine with the two most crucial innovations of the European filature, the double-twisting mechanism and steam-heated oven. But he largely replaced the iron structures with locally available materials such as wood, bamboo and china. He used the foot-powered treadle to replace steam power and, to add a Chinese touch, used all-purpose Chinese chopsticks to pick out cocoons from the boiling basins (Wong, pp. 270-80).

To construct the machine and especially to adapt and install the steam boiler (for heating up the reeling basin) in the village, Chen engaged an ingenious traditional artisan in Guangzhou, who later became a main supplier of reeling machines in the area (Wong, p. 280). The modified machines not only can be locally supplied but also much cheaper, at only about one fifth of the value of a Shanghai style machine.⁷

Mobilizing the lineage and village organization, he successfully recruited female workers in the neighbouring areas.⁸ Using credit advance and other tools, Chen managed to procure cocoons from the neighbouring markets. To market his raw silk, Chen set up special trading firm to sell his raw silk directly to Western merchants. Modern filatures in Guangdong benefited from the multivoltine silkworms reared there, which would hatch four to six times a year in contrast to only one or two times from the uni- or bi-voltine silkworms in Japan and the Lower Yangzi. Although somewhat inferior in

⁷ Chen, Yao-Min, "Qing Mu."

⁸ According to Suzuki's research, female workers of a particular factory were usually recruited from the same lineage-based village community sharing a common family name. Hiring from outside the lineage was discouraged by the elders. See Suzuki, p. 473 and p.480. For the important role of lineage as social and economic organization, see Faure (1989) who emphasized the corporate nature of Chinese lineages. For the role of common lineage property and capital in the Guangdong silk reeling industry, see Ye Xianen.

quality, multivoltine silk production saved the finance cost of cocoon purchase and allowed the year-around operation of modern filatures.

The factory was started in 1874 after almost a year of preparation and construction. Unlike the Ewo in Shanghai, Chen's factory was said to have turned out profits even in its first year of operation. The filature product, much more smooth and even than the traditional silk, was well received, fetching a price a third higher than the hand-reeled (Xu, p.114).

Within a couple of years, Chen's factory expanded to about 800 basins. More remarkably, Chen was keen to diffuse this technology, receiving, as he claimed, over a thousand visitors during the first three years of operation (Chen, p.2). As a result, modern reeling factories spread quickly in Nanhai and in the neighbouring Shunde County. By 1881, there were already about 11 factories in Nanhai and 6 factories in Shunde, with the total of reeling basins exceeding 4000 (Xu p.116).

Understandably, China's first factory encountered various resistances from both the vested interest and traditional-minded locals. But Chen, through provision of local charities and participation of public projects, managed to pacify the discontent and win the trust of the village elders. The growth of filatures occurred in Guangdong largely under China's characteristically ambiguous legal environment, which Chen Qiyuan took full advantage of using his social network. That ambiguity, however, came back to haunt the industry.

On October 5th of 1881, a sacred day of sacrifice for the Nanhai silk weaver guild, more than a thousand weavers marched to destroy and loot a filature in the Nanhai County. On their way to Chen Qiyuan's factory, they broke into violent clash with the local villagers defending the factory. The violence was said to have claimed two lives and wounded hundreds. Although the weavers had long harboured anger towards the filatures, their

Luddite violence was triggered by a particularly bad year of business that they blamed on the filatures for taking away their source of cocoon supply.

Eventually, local county militiamen had to be mobilized to put down the riot. The magistrate, while punishing the weavers for the violence, also ordered all the filatures in the county to shut down immediately. The magistrate's ruling, backed also by the provincial leader, was in line with the ruling ideology of the Self-strengthening movement that discouraged private initiatives in modern industry. Appeals by Chen Qiyuan and others against the ruling failed. In 1882, Chen had to move his factory to the Portuguese colony of Macao. Interestingly, filatures in the nearby Shunde County survived under the protective wings of the local gentries there (Xu, pp. 121-123).

Fortunately, the mid-1880s policy shift of the Self-strengthening movement towards private modern reeling firms came in the right time for Guangdong. Around 1886, the Qing government began to levy taxes on the sale of machine-reeled silk, which is tantamount to an unofficial recognition of these enterprises. Three years after the forced departure out of Nanhai, Chen's factory was allowed back in Nanhai County. But by then the Shunde County was already on its way to become the center of growth. By 1894, Guangdong exported ten times the amount of filature raw silk in 1880.⁹

At the time Chen Qiyuan designed the steam-heated reeling machine, he also made a model complete with the French Chambon double crossing system, but used charcoal stove instead of centralized steam boiler for heating. This model, which did not require concentration of equipment in a centralized location, was an instant success. It diffused quickly among

⁹This narrative is largely based on Suzuki, 419-447, Xu, xinwu, p. 127. For a model linking agricultural seasonality with slow transition from cottage to factory production, see Sokoloff and Dollar.

individual peasant households and was later adopted by merchants in a variety of organizational forms that included putting-out and “manufactories” system. Part of these “improved” hand-reeled silk went for export but the bulk of them supplied the domestic market partly (Xu, p. 126-7).

Japan

Japanese modern filature started exactly where the first Shanghai Ewo filature left off. Jardine trading firm were considering to set up a modern filature in Japan in the late 1860s. Meanwhile in 1869, the Maebashi han sent an official, Hayami Kenzou, to Yokohama to investigate the foreign raw silk market demand. Visiting the Swiss embassy, Hayami was shocked to find that Japanese raw silk was selling at half that of the price of the Italian and French raw silk in London. This brought to home the urgency of improving the quality of Japanese raw silk adopting European methods (Furuta, p.138)

In 1869, the year Major died in the rural Lower Yangzi, Maebashi han officials visited the Yokohama office of the Jardine and soon after started the negotiation of transferring the reeling machines of the ill-fated Shanghai Ewo filature for starting up a joint-venture in Maebashi. The negotiation did not fall through. The han officials decided to independently start a modern filature with the purchase of Italian style machinery from a Swiss trading firm in Yokohama. Approved by the newly established foreign ministry of the Meiji government, the officials employed a Western technical supervisor recommended by the trading firm (Mayako Ishii 1998, p. 182, Furuta p. 139).

Hence, Japan’s first modern filature started in 1870 with 12 filature machines. The machinery was initially set up in the middle of Maebashi in June. But it encountered stiff resistance from the local officials and merchants who feared for the loss of their handicraft interest. Three months

later, the filature had to be relocated to the isolated village of Iwagami with Hayami himself having endured threats of assassinations in the process. The machine adopted the Italian self-crossing Tavelle system (also referred to as “kenneru” in Japan) and centralized steam-heating, but was greatly modified to suit the local conditions - wood replaced metal for the reeling basin, human and later water-power rather than steam power was used. During the four-months when the technical advisor, Casper Mueller, was under contract, Hayami and a few other people worked around the clock to grasp the technology (Furuta, p. 139-140, Dai Nihon, p. 50-51).

The Maebashi filature never truly became a viable business. With the abolishment of han officialdom under Meiji’s centralization policy in 1872, it was taken over by the Gunma prefecture and later sold to a merchant house, the Ono-gumi. But in 1871, the Ono-gumi already launched a sixty filature reeling factory in Tsukiji of urban Tokyo, partly because, Mueller, who was hired again as its technical supervisor, feared going to the rural countryside (Furuta p.76). This urban-based private operation was even more short-lived and closed down in June 1873 partly due to the disappearance of mulberry fields and cocoon supply in a rapidly urbanizing Tokyo (Furuta p.76).

These two early acts of introducing European reeling technology were followed by the third and the most well-known effort by the Meiji government itself: the erection of Tomioka silk reeling mill in Gunma prefecture in Oct. 1872. This government-owned-and-operated factory, with 300 all iron-made reeling machines, driven by steam power and housed under a specially constructed Western style red-brick building, became an imposing structure set in rural 19th century Japan. It also brought in Paul Brunat as the French head advisor along with 11 French experts, viz. 2 foremen, 3 assistants, 4 female reeling supervisors, 1 machinist and 1 doctor (Kiyokawa 1987, p.29).

Despite its government sanction, the construction of the factory met with local xenophobic resistance. When the factory started recruiting workers in March of 1872, few people actually applied. It was only through government's repeated assurances that the factory managed to employ female workers on a two-year rotation basis from various parts of Japan. The Tomioka's transfer of the full bundle of European technology, irrespective of local conditions, was reminiscent of John Major's Ewo filature backed by Jardine's financial capital. And like Ewo, the Tomioka factory was a financial failure and was sold-off in the 1880s by the government at a value below the original investment.¹⁰

The trajectory of Japanese reeling technology and organization was to follow the path pioneered by the Maebashi and the Tsukiji type of filatures rather than that of the Tomioka. In August 1872, even before the closure of its urban-based Tsukiji filature, the Ono-gumi launched a new filature in the rural upper Suwa area of Nagano prefecture with some technical supervisors transferred from the Tsukiji plant. The Ono-gumi also engaged in financing several other filatures in the rural Nagano. In 1874 when the Ono-gumi itself went bankrupt, family based filatures were already multiplying in Suwa, which was soon to become Japan's centre of silk reeling industry (Furuta, p. 77-78, Dai Nihon, p. 52-53).

However, most of these family based filatures were fairly small in scale and often produced an amount of raw silk below the minimum order from the retail merchants based in Yokohama. To overcome this problem, these rural based filatures organized "Sha," a type of village or sometime lineage based cooperative, each usually consisting of between 10 and 20

¹⁰ The idealized French filature proved to be unrealistic for the relatively primitive state of the Japanese economy. Japanese cocoons rarely met the quality standard required by

individually owned and operated filatures. The members of the cooperative would supervise each other's production to ensure homogeneity and standards in raw silk quality and jointly market their finished raw silk to Yokohama bearing their "sha" label. They also coordinated the purchase of cocoons and employment of female labourers. Moreover, the cooperatives were units of what we now know as joint-liability lending, through which they acquired direct credit advance mostly for cocoon purchase from the silk retail merchants in Yokohama.¹¹ By the second half of the 1880s, most of these cooperatives were equipped with a joint re-reeling plant that specialized in sorting and re-reeling raw silk produced by the individual member filatures to achieve greater standardization for shipment to Yokohama.

This system of production, combining indigenous social organization with borrowed intermediary technology, supported the rapid growth in exports of machine-reeled silk in the 19th century. By the 1890s, there are signs that this system may have outgrown itself. In 1895, the filature group under the Katakura family withdrew from Kaimeisha, the largest cooperative in Suwa, and independently started its own reeling factory with 360 basins, marking the beginning of the rise of independent manufacturers. With the growth of filatures, it became increasingly difficult for cooperatives, with their disparate production units sometimes employing different power source, to rely only the final process of re-reeling for standardization. In the case of Katakura factory that had consistently produced relatively high-quality silk,

Tomioka. The machines, their spare parts and repairs were extremely costly. See Kiyokawa, "Transplantation, p.34-36, Tsurumi, *Factory Girls*, chap. 2.

¹¹ For the important role of rural-based industrialization in Asia and an analytic expositions of contracting and organizational issues related to small-scale rural industries, see Yujiro Hayami (1998).

there was strong incentive to strike out on its own to fully capture the quality premium.

Equally important to this Japanese transition to independent manufacturers was the surge of filatures in Shanghai following the lifting of legal constraints against private capital in modern business in 1896. These relatively large-scale, independent filatures in Shanghai were turning out machine-reeled raw silk with a good reputation in the international market. Hence, the rise of modern factory is a direct response to overseas competition (Nakabayashi, chapter 4).

It is important to recognize that the divisibility of the bundle of European technology could, as in the case of Guangdong, also exert transformational effect on Japan's hand-reeling industry. In the 1870s, Japanese reelers already began to improve their traditional hand-reeling machines through the addition of the foot-treadle, the cogwheel and the crossing system (mostly the Italian Tavelle style) (*LTES*, vol.11, p.167). Without the use of steam-heating and inanimate power source, this improved hand-reeling machine (referred as improved Zaguri) did not require operation in a centralized location and hence, diffused rapidly among individual peasant households.

To satisfy the Western demand for uniformity, traditional hand-reelers and merchants also adopted the re-reeling process. While organizational forms such as putting-out was adopted on a fairly substantial scale, the prevalent institution of production was the cooperative (Sha, or Kumi) system similar to that of the machine-reeled sector. Ironically, it was in Gunma prefecture - the region where Tomioka was located - that rose to become the centre of cooperative-based hand-reeling production. Each cooperative, like in the machine-reeling system, shared centralized joint-re-reeling plants but the initial reeling process was done usually at the

individual household rather than the filature level. They also coordinated in the hiring of workers, marketing and credit procurement. In comparison with machine-reeling production, their scale was smaller and their production more self-sufficient, with cocoons often raised domestically. In spite of the above, the improved hand-reeling production proved to be a viable and important system of production for the 19th century Japan.

3. The Determinants of Regional Differences: a Summary Hypothesis

As demonstrated in the narrative, innovative technological and institutional adaptations of European technology to the local physical and social environment ensured the rapid diffusion of machine-reeling in Guangdong and Japan in the late 19th century. This success, contrasted by the laggard diffusion of machine-reeling in Shanghai due to the absence of technological adaptation, reveals the important role of creative technical learning for the growth in silk exports. This is consistent with our model prediction that a reduction in price of machine-reel tool will lead to higher output of machine-reeled silk relative to that of hand-reeled.

Differentiation at other levels of technological diffusion also existed in the three regions. Shanghai, through foreign direct investment, and Japan, through the efforts of central and local governments and private entrepreneurs, have been exposed to the most advanced Italian silk reeling technology. In contrast, Guangdong, through a private individual like Chen Qiyuan, learnt of the French technology through a second-hand or a third-hand source. There is a possibility the Western reeling technology in Vietnam witnessed by Chen may have been indirectly transferred from Western experiments in Bengal, India. The cogwheel mechanism, which could have been dropped in the Bengal adaptation, was conspicuously

absent in Chen's drawings. More importantly, the French chambon system adopted was relatively outdated compared to the Italian Tavelle system, but Guangdong was to stick with it all the way into the 20th century. Apparently, the channels through which knowledge was transferred had long-term productivity implications.

However, machines were only part of the story. Machine-reeling has shifted the reeling process out of individual peasant household. In comparison with traditional hand-reeling, modern filatures are far more dependent on market transactions. Cocoons consisted of 60-80% in the valued-added of raw silk. As is true throughout China and Japan, modern filatures relied heavily on short-term finance. The growth of silk-reeling in Suwa, Nagano, for example, was a tale of financial expansion. In the 1870s and early 1880s, a financial network based on credit advance linked the Yokohama silk retail merchants with reeling cooperatives in the mountainous Nagano. This system of credit provision relied on the use of bills of exchange and the network of national banks set up and diffused across rural Japan since the Meiji. By the late-1870s, the issuance of insurance contracts by the domestic land-transportation corporation further reduced the risk of lending. In the mid-1880s, the Yokohama Species Bank and later the newly established Bank of Japan provided low-interest indirect finance to the silk reelers through rediscounting bills held by Yokohama merchants and local banks (Nakabayashi, chap. 7).

As consistent with our model predictions, general decline in interest rates would lend itself to higher level of machine-reeling production. But the interest rate story is also part of the transaction cost explanation posited in our model. An essential element supporting the expansion of Japanese reeling industry in the nineteenth century was the rapidly improving external infrastructure built up in the Meiji period. Newly built modern communication

system such as telegraph between Tokyo and silk-producing regions reduced the power of local silk merchants and enhanced the interests of silk-producing cooperatives.¹² Infrastructure construction or improvements in roads, shipping and particularly railroads, which went on continuously throughout the 1870s and 1900s, not only served to link the rural silk producing regions with Yokohama, but also helped filatures to extend their cocoon purchase to locations farther away from their immediate surroundings (Nakabayashi, chap. 3).

In the Lower Yangzi, a dense financial network composed of foreign banks, trading firms and native banks clustered in the treaty port of Shanghai, but financial intermediaries beyond Shanghai were far and few until after the 1920s. At each cocoon purchase season, silk-reelers had to organize shipments of bulky silver ingots guarded by military boats to the rural Lower Yangzi for cocoon procurement. The building of railroads had to wait until the early 20th century in the Lower Yangzi. It was even later in Guangdong.

To fully understand the differential rate of decline in transaction costs, one cannot avoid the large political economy story. Both Guangdong and Lower Yangzi turned out to be hazardous and sometimes dangerous environment for capital investment in concentrated locations. Due to the insecurity of private investment in machine-reeling, location wise, Shanghai had become a centre of reeling industry for all the wrong reasons, enduring high transaction costs almost from the beginning to the end.

¹² Before modern telegraph reached rural Japan, local silk merchants in Maebashi used to hire runners to acquire price information in Yokohama. Such activities of profiting from price differential between Maebashi and Yokohama lost their ground very soon after telegraphs were installed in the late-1870s. Besides the government policy stated earlier, this is a major reason that accounted for the decline of local silk merchants. Kanji Ishii 1972, p. 100-101.

In the clash between traditional handicraft and factory interests, Qing's initial stance in favour of the traditional was not merely ideological. In the latter half of 19th century, public finance in Qing China deteriorated rapidly and government revenue grew dependent on commercial taxes such as the likin tax. Merchants suffered increasing squeeze. In return for tax revenue, merchant guilds, through tax-farming, extracted the government for monopoly power, a process where both parties ended up being captives of vested interest.

In this regard, the retreat of Japanese mercantile control in the 19th century was highly illuminating. In 1873, in order to arrest the trend of quality deterioration in raw silk export, the Meiji government promulgated the Regulation on Raw Silk Production, which stipulated that all raw silk bound for export would have to bear government printed labels and all silk merchants were required to obtain license issued by the Ministry of Finance. Subsequently, the government organized a national Aratamei Kaisha (Raw Silk "Corporation") with branches all over the major silk producing regions. It became clear later that the licensed silk merchants entrusted with raw silk quality inspection and distribution of government labels soon dominated the local levels of Aratamei Kaisha.

The Aratamei Kaisha, designed for quality control and possibly also as a blocking device against the intrusion of Western trading firms into rural Japan, had however, inadvertently led to the rise of privileged merchant group who, backed by government power, was beginning to exercise monopsony control over silk trade in Japan. In 1876, Hayami Kenzo, then an official in the government industrial promotion bureau, voiced to the government about his concern of Aratamei Kaisha becoming a hindrance to the development of the still nascent machine-reeling filature in rural Japan. In 1877, the government officially abolished the Regulation, but it took

another four years for the entire system of Aratamei Kaisha to whittle away. During this period, the government ministry stood firm against repeated attempts by local silk merchants to regain their trading privileges and their attempts to include the machine-reeled raw silk under their monopsony control. It was in the weakening of local merchant monopoly that paved the way for silk-reeling cooperatives and later factories to start direct trading relationships with the retail merchants in Yokohama (Ishii, pp. 96-115).

The study of the evolution of the silk industries offered us important insights not only into the impact of political change on economic growth but also shed new light on the nature of traditional East Asian society. It is important to recognize that the transaction costs modelled in this paper largely existed beyond the control of individual firms or households. Thus, to overcome them required coordination on a local and, in many cases, national level. This case study of raw silk exports is thus an interesting counter test to the burgeoning literature spawned by the 1989 Murphy, Shleifer and Vishny article on industrialization and the big push which emphasized the crucial importance of coordinated investment through demand-side spillovers in domestic market. The “big push” idea, originally formulated by Rosentein-Rodan in the 1940s, became the intellectual foundation for the post-War import substitution policy pursued by many developing countries.

This paper presents a case where, given the demand side (from the international market), “big push” on the supply side matters too. Often times, it is what leads economies from the vicious circle to a virtuous circle. It is this “supply side” big push since Meiji Japan that constituted the historical origin of the export-orientation policy in East Asia.

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