

From Public to Private:  
Technology Transfer in Meiji Japan's Silk Reeling Industry

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As Japan underwent transformation from a semi-feudal state to a modern nation in the mid-nineteenth century, the new Meiji government stepped up as “national entrepreneur” to create a “modern” industrialized state with a variety of industries considered strategic for building the nation and economy. One industry that stands out in this regard is silk reeling. Rather than following what I would call a traditional business model where an entrepreneur would evaluate and seek a balance between the market, start-up costs, labor, and potential profit, the Meiji government had “non-traditional” concerns when developing the Tomioka Silk Filature. As such, its entrepreneurial activities must be evaluated and judged in a different light than most other private or public ventures. This is especially true when examining choice of technique and technology transfer to this industry under state and later private ownership.

Among the earliest of the Meiji government’s industrial ventures, the Tomioka Filature stands as an example of the difficulties of creating a multi-purpose enterprise. Typically considered a failure by many economists and economic historians, Tomioka failed to operate in the black for much of its time as a government-owned facility. Exactly why this was the case is at the heart of the government’s entrepreneurial dilemma—what technologies to use and defining a clear purpose for the filature. I should note that technology does not simply refer to artifacts, i.e., the “machines,” but includes physical spaces, methods, and organization of technological systems.

Tomioka had multiple functions. Essential for many officials, Tomioka—its technologies and physical manifestation—served as exemplars of Japanese “civilization and enlightenment,” proof positive that Japan was a “modernizing” nation. Being “modern” was the overriding criterion for choice of technique. As a result, government officials ordered their foreign silk reeling adviser to build a large Western-style filature that was powered by steam and equipped

with the latest cast iron, French machinery. Tomioka was also supposed to be a model factory where private sector entrepreneurs could see a modern, Western-style silk mill theoretically housing the latest and most advanced technologies. Adding to the complexity of the situation, government officials wanted Tomioka to serve as a training facility for silk reelers from all over Japan. The idea was that women would come to Tomioka and train on the latest machinery. They would eventually take their new knowledge back to their home filatures as instructors. If all this was not enough, the government intended for Tomioka to be a functioning filature producing high quality raw silk. And somewhere along the way this exemplar of “modernity,” model factory, training grounds, functioning filature was also supposed to turn a profit!

Confounding this multifaceted situation is the fact that the Meiji government had neither clear goals nor realistic expectations for the mill. It was built following meetings in 1869 between then Vice Minister of Finance Itō Hirobumi and Freiderich Geisenheimer, representing the foreign merchant community, which was deeply troubled over the declining quality of Japan’s raw silk. The government too, was concerned because raw silk was Japan’s leading export commodity and a valuable source of revenue. It was obvious that something had to change in the silk reeling industry because a variety of laws aimed at improving the quality of Japan’s raw silk had failed to motivate the private sector. Unwilling to allow foreign merchants to build Japan’s first modern filature, the Meiji government assumed the mantle of entrepreneurship, assuming significant risk to the nation’s finances and reputation in an industry where officials lacked expertise and experience.

The government hired a foreign adviser, Paul Brunat, who surveyed the state of Japan’s raw silk industry with Odaka Atsutada, the man eventually responsible for Tomioka’s day to day operations. After visiting numerous filatures, including Hayami Kenzō’s recently constructed

Maebashi Filature that relied on hybridized Japanese–Italian machinery, Brunat and Odaka presented their recommendations for a modestly-sized filature based on Maebashi’s technologies to the new government. The two were thanked for their efforts and Brunat was ordered to essentially buy, ship, and build a fully functioning French-style filature in Gunma prefecture.

As a model factory, Tomioka stood head and shoulders above any filature in Japan. Built from brick with rows of cast iron reeling machines powered by a massive, centrally located steam engine, Tomioka was an ideal. It was something to which the private sector could aspire but not achieve for decades. Whether the government truly expected the private sector to adopt Tomioka’s technologies is unclear but doubtful. On one level, the Meiji government as entrepreneur self-identified as the innovative force which brought new techniques to the market place. It is unlikely that the government intended to be Schumpeter’s “creative destructive” force. Officials who oversaw the project and chose Tomioka’s technologies clearly ignored viable alternatives that would have been more technologically “appropriate” for Japan and more likely to supplant extant technologies. While it is clear that the government intended to change the system and perhaps disseminate the latest reeling technologies throughout the country, the “national entrepreneur” may have overestimated the private sector’s willingness to assume risk and its ability to change.

There was no local “technological revolution” in the immediate wake of Tomioka.<sup>1</sup> Gunma prefecture’s silk reelers were in a perfect position to benefit from the presence of Tomioka filature. Gunma had been at the technological forefront of the silk reeling industry for decades. One would think that when presented with the latest technology, Gunma’s entrepreneurs would jump at the opportunity to increase output and profits by adopting Western

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<sup>1</sup> Technological revolution in the sense of a Kuhnian scientific revolution.

methods.<sup>2</sup> The Meiji government even made large sums of money available to Gunma's reelers, something it did not do in other prefectures.<sup>3</sup> Despite these incentives, Gunma prefecture became a hotbed of Luddism. The vast majority of reelers rejected the new technologies, so much so that as late as 1889, 85 percent of the raw silk produced in Gunma was produced on *zaguri*, traditional reeling machines invented during the Tokugawa Era.<sup>4</sup> The fact that Gunma had a tradition in silk reeling and innovation seemed to work against change. Very few reelers believed altering existing patterns of production would be advantageous despite the presence of Tomioka and Maebashi filatures.

There were, however, a few Gunma entrepreneurs who followed the government's lead and sought to mechanize the silk industry. One businessman set up a filature supposedly based on Tomioka's technologies directly across the street from the government's mill. Hayami Kenzō, often considered the father of Japan's modern silk reeling industry, inspected it in November 1878 and found it to be shabby at best; it was out of business by the end of the decade.<sup>5</sup> There were a few mills built based on Hayami's Maebashi Filature's hybridized technologies that did succeed and influenced others to adopt mechanized reeling. The two most successful, the Kengyōsha and Mizunuma Filatures, were visited and copied by numerous entrepreneurs interested in mechanization. Ironically, none of the visitors were from Gunma prefecture. The pressure to resist change in Gunma precluded significant technological advancements in its silk reeling industry until the turn of the century.

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<sup>2</sup> Steven McCallion, *Silk Reeling in Meiji Japan: The Limits to Change*, (PhD dissertation, Columbus, Ohio, 1983), 311-312.

<sup>3</sup> McCallion, 311.

<sup>4</sup> McCallion, 309.

<sup>5</sup> Ōtsuka Ryōtarō, *Sanshi*, 2 vols., mae-hen, (Tokyo: Fusōen, 1900) 1:415.

The majority of Gunma's reelers did not believe that mechanization was worth the risk, either financially or to established patterns of production. They continued to reel by traditional methods because demand for raw silk largely trumped issues of quality. As Chinese and European filatures began retaking their share of the market, however, the price gained by Gunma's inferior silk reflected its quality. Despite the drop in revenues, Hoshino Chōtarō, the founder of the Mizunuma Filature, was unable to convince Gunma's reelers that mechanization was in their best interest. In 1877, however, he managed to persuade 40 reelers to start re-reeling their silk on locally made Western-style machines. This process helped improved the silk's uniformity and luster and more importantly, gave it the appearance of machine reeled silk.<sup>6</sup> Combined with a new cooperative organization that facilitated direct sales to foreign markets, Gunma's traditionally reeled silk increased in value. The technology, however, remained largely the same.

The Ministry of Public Works (Kōbushō) also opened a filature at the same time that the Ministry of Finance opened Tomioka. This, the Akasaka or Kankōryō filature (together with the Maebashi filature), had greater immediate influence on Japan's silk reeling "technological revolution." Like Maebashi it used hybrid Japanese–Italian technologies that were within the grasp—financial and technological—of many private entrepreneurs. In fact, many entrepreneurs who visited Tomioka and claimed to base their methods on the government's premier mill had actually adopted Akasaka's and Maebashi's methods.<sup>7</sup> More than a dozen entrepreneurs from Fukui, Niigata, Ishikawa, Yamanashi, and Kanagawa prefectures visited the short-lived Akasaka

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<sup>6</sup> Ōtsuka, *Sanshi*, mae-hen, 1: 413.

<sup>7</sup> **Error! Main Document Only.** Nakamura Naofumi, "Kōhatsu koku kūgyōka to chuo-chihō: Meiji Nihon no keiken" in Tokyo Daigaku Shakaikagaku Kenkyūjō ed., *20 seiki shisutemu: 4 kaihatsushugi*, (Tokyo: Tokyo Daigaku Shuppankai, 1998) 241–75.

mill and adopted its technologies.<sup>8</sup> As Hayami predicted, it would take decades for Tomioka's technologies to disseminate to an appreciable degree.<sup>9</sup>

Tomioka's greatest transformative effect on the silk industry can be seen outside of Gunma prefecture, and more in terms of expanding silk reeling into areas not previously known for silk production, southern Nagano prefecture for example. In 1869 and 1870, southern Nagano was literally overlooked in F.O. Adams' survey of Japan's silk reeling districts. By the end of the decade, however, this area was producing 40 percent of Japan's machine reeled silk and had 395 machine filatures, a full 60 percent of the nation's total.<sup>10</sup> Impetus for this change came indirectly from Tomioka, Maebashi, Kengyōsha, and Mizunuma filatures and directly through technologies transferred by another modern filature which belonged to the Ono-gumi or House of Ono.

Ono had long been involved in silk reeling by traditional methods but after a visit to Tomioka decided to expand operations. That is, the marketplace reacted to a new profit making opportunity. Although having lucrative ties to the government, Ono lacked the government's wallet and was less concerned with prestige than profitability. It relied on the same hybrid Japanese–Italian technologies as the Akasaka and Maebashi filatures. Built in the Tsukiji section of Tokyo, Ono's filature only lasted a few years but that was because of circumstances of real estate not shortcomings of the technology.<sup>11</sup> Prior to its demise, Ono gumi provided the capital and Western reeling technologies for 14 of southern Nagano's 19 mechanized filatures. And

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<sup>8</sup> **Error! Main Document Only.** Kannōkyoku, Shomukyoku, *Kyōshinkai hōkoku, kenshi no bu*, (Tokyo: Yūrindō, 1880) 24, (hereafter *KH*)

<sup>9</sup> Tomioka Seishijōshi Hensan Iinkai, ed., *Tomioka seishijōshi*, 2 vols., (Tomioka: Tomioka-shi Kyōiku Iinkai, 1977) document 187, 1:401-403 (hereafter *TSS*).

<sup>10</sup> McCallion, p. 242.

<sup>11</sup> Tsukiji was originally farmland with ample Mulberry for sericulture. As the Tokyo building boom spread, however, the land around the Tsukiji Filature became too valuable to use for farming.

although most of the filatures established by Ono were small by Western standards (30 basins), there were several larger 96 basin mills established at this time.

Prior to Tomioka and Ono's activities in southern Nagano prefecture, all of the region's silk was produced on *zaguri*. The onset of mechanization in the 1870s however, brought about a paradigm shift, Schumpeter's 'creative destruction,' so that by the early 1880s nearly all of Nagano's silk was produced on Western-style reeling frames in factory settings. The days of by-employment home reeling were over.

After the collapse of the House of Ono 1874, mechanized silk reeling in Nagano continued to expand, theoretically under the influence of Tomioka's technologies. Rokkōsha, a filature established in 1874 by samurai in Nagano, claimed to be based on Tomioka's methods and technologies. Dozens of other entrepreneurs established filatures making similar claims. While most claims were spurious, including Rokkōsha's, steam reeling and a Western factory system reminiscent of Tomioka became a staple of southern Nagano prefecture's silk reeling industry. The most obvious transfer of Tomioka's physical technologies came in the form of a device known as a *chambon*, the part of a reeling frame responsible for *croisure*, a process that cleans, dries, and strengthens the silk thread as it is reeled. Filatures which followed Ono's or Maebashi's technologies relied on a device that performed the same function known as a *tavelette*. It is Italian in origin unlike Tomioka's French *chambon*. Following Rokkōsha's lead, many post-1874 filatures adopted the use of *chambon*. Although in many ways technologically inferior, the *chambon* produced a finer denier thread that was attractive to the French who purchased the majority of Japan's silk in these early days.

Private sector silk entrepreneurs followed a process of discovery more in line with what economist Israel Kirzner describes.<sup>12</sup> Filature owners responded to the government's offer and visited Tomioka. They stood in awe of the factory but realized they could not recreate to any extent what the government had built. None had the government's finances and could ill afford the ¥200,000 investment in machinery and infrastructure. They did, however, incorporate bits of Tomioka's technologies into their factories—ones which were appropriate for their individual circumstances. Even though the vast majority of private filatures bore no resemblance to the government's mill, they still claimed to reel silk by Tomioka's methods or in Tomioka-style. Embracing the mystique of the government's filature, the marketplace reacted to a new profit making opportunity that was within its grasp. Unable to assume the government's level of entrepreneurial risk, however, the private sector was able to profit from the minimal adaptation of some of Tomioka's Western technologies—which included methods and factory organization.

By consciously choosing advanced Western technologies over more practical domestically-produced alternatives, the Meiji government actually hindered the dissemination of the technological artifacts it thought would improve the quality of Japan's raw silk. What is often cited as the genius of Japanese entrepreneurs, their substitution of wood, wire, and clay for iron, copper, glass, and brick, was in fact the modification of Tomioka's technologies to suit local circumstances and a private sector entrepreneur's budget.<sup>13</sup> Steam reeling techniques, which supposedly spread throughout Japan following Tomioka's opening, were limited to the use of steam for killing silkworms or heating water, not powering mill machinery. A survey of filatures

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<sup>12</sup> Israel M. Kirzner, *Competition and Entrepreneurship*, (Chicago: University of Chicago Press, 1973) 81.

<sup>13</sup> Wada Ei, *Tomioka nikki*, (Chuō Kōronsha, 1978) 21-22.

established by 1879 with at least 30 basins reveals that none were steam powered. All relied on waterwheels and this includes filatures that claimed to use Tomioka's methods.<sup>14</sup>

Between 1881 and 1884 nearly all of the government's non-strategic industries were sold to the private sector in what is called the Matsukata Deflation. Named for Minister of Finance Matsukata Masayoshi, this economic policy was intended to end the inflationary spiral that threatened to destroy the Japanese economy. Selling the government's "model factories" was one way to raise needed capital and end the destructive practice of simply printing money when faced with declining revenues and increasing debt, something the Meiji government had been doing since at least 1877 following the Satsuma Rebellion. Despite Tomioka's prestige, when it went up for sale in November 1880, the government failed to receive a satisfactory bid and decided to continue operating the mill for the unforeseeable future.

As the years went by and the government was forced to deal with mounting expenditures at Tomioka, its function as model factory and training grounds faded as the desire to turn a profit moved to the fore. Still, prestige was always Tomioka's saving grace. By 1885, Tomioka was in the black. Mill girls were required to sign a minimum three year contract which counteracted the earlier problem of Tomioka's transient, largely unskilled workforce. Under Hayami, what Kiyokawa Yukihiro called an "idealized Western factory management system"<sup>15</sup> was replaced by a more stringent system. Eight hour work days were extended by as much as two hours a day and wages were cut in half. The women no longer had Sundays off; they were permitted two or fewer holidays per month depending on the season.<sup>16</sup>

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<sup>14</sup> Katō Sōichi, *Nihon seishi gijutsushi*, (Seishi Gijutsushi Kenkyūkai, 1976) 105-109.

<sup>15</sup> Kiyokawa Yukihiro, "Transplantation of the European factory System and Adaptations in Japan: The Experience of the Tomioka Model Filature," *Hitotsubashi Journal of Economics*, 28:1 (June, 1987) 30.

<sup>16</sup> Kiyokawa, 32.

With Tomioka turning a modest profit and the government looking in new directions, the finance ministry announced in May 1893 that it was accepting bids for its filature. Five bids came in but only one, Mitsui's, exceeded the minimum ¥105,000 set by the government. With the winning bid of ¥121,450, Mitsui took control of Tomioka in October 1893. Four months later, the last government official assigned to Tomioka left the mill.<sup>17</sup> Traditional histories claim that Mitsui bought Tomioka at a bargain basement price and that the government lost money on the deal. At first glance knowing that more than ¥80,000 of the purchase price went to cover the cost of Tomioka's cocoon inventory, it appears that the government sold the facility for a mere ¥40,000; truly a loss on its ¥200,000 initial investment. In reality, under Hayami's draconian management, the government managed not only to recoup all of its investment; it earned a profit of ¥13,000.<sup>18</sup>

In 1893, Tomioka's technologies were more than twenty years old. Silk reeling in Japan had changed and Mitsui was prepared to re-outfit the mill with new machinery. When it did, the new reeling frames were outfitted with *tavelette* which although producing a somewhat coarser thread, allowed for greater productivity. By 1905, following Mitsui's lead and the principle of quantity over quality, 80 percent of the *croisure* devices in Japan were replaced with *tavelette*. Steam filature still meant the use of steam to heat water and kill cocoons. The vast majority of Japan's filatures relied on waterwheels and locally produced wooden machinery; technologies within the financial grasp of most entrepreneurs. Tomioka still dwarfed its nearest competitors with its 300 reeling frames, but many entrepreneurs at this time realized that large filatures were more profitable and mills of 100 frames or more started to become common. Under new

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<sup>17</sup> TSS, document no. 258, 1:617.

<sup>18</sup> TSS, document no. 258, 1:617-8.

management, Tomioka's technologies were becoming more accessible to the average entrepreneur and its management system more appealing.

Mitsui bought a filature that still held a great deal of prestige in the Japanese and international markets, although this was not their concern. The company's focus was on profit. The mill finally served a single purpose and as such, its technologies—including management—changed accordingly. Following in Hayami's footsteps, the workday continued to lengthen, dormitory life became less comfortable and working conditions more arduous. The European factory system that came to Japan in a very much relaxed French form at the government's mill, was adapted to local conditions and was informed by a profit-first mentality. Steam filatures all over the country, ones theoretically based on Tomioka's technologies, regularly had their mill girls working between 10 and 15 hours a day, adjusted seasonally, with 40 minutes off for lunch.<sup>19</sup>

By 1902 Mitsui moved on and sold Tomioka to Hara Gomei Kaisha (Hara Partnership Corporation). Silk reeling had entered a new era and so too, had Tomioka. Under private ownership both Mitsui and Hara invested in infrastructure, technology, and staffing needs. In addition to new machinery, Mitsui added a second reeling plant, dormitories for the workers, and residences for management. Hara likewise expanded the mill. They too, added dormitories, but the real changes were technological. Hara separated several reeling processes to rationalize production. Importantly, they introduced a new type of multi-end reeling machine, and built a sericulture laboratory and experimental station whose efforts would revolutionize sericulture and silk reeling in Gunma prefecture and beyond.

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<sup>19</sup> Suzuki Jun, "Two Time Systems, Three Patterns of Working," *Japan Review* (2002) 14: 88.

Under Hara, Tomioka entered into agreements with local silkworm producers, providing silkworm eggs and guarantees to purchase high quality standardized cocoons in 1906. At the same time, Tomioka's sericulturists succeeded in their work with the F1 (first filial) hybrid silkworm. In 1911, Hara formed partnerships with silkworm growers in Gunma, Nagano, and Saitama prefectures that standardized the rearing of the hybridized silkworm. This was a boon for the industry. F1 hybrids produced cocoons with more usable silk more quickly than other varieties. Propagation and use of F1 silkworms became the Japanese standard shortly thereafter.<sup>20</sup> Likewise, the multi-end reeling machines that Hara chose to replace Tomioka's older technologies were soon adopted in filatures throughout Japan's silk reeling districts.

In some ways, Tomioka finally functioned as the government had intended—to disseminate the latest reeling technologies to the private sector. What the Tomioka model demonstrates are the limitations of a top-down approach to technological change and entrepreneurial risk. The Meiji government, as public entrepreneur, had the wherewithal to conceive, build, and operate a mill that was an ideal. The private sector could not assume such risks. Even when presented with the opportunity for incremental change, successful entrepreneurs refused to modify existing production patterns. This can be seen with Gunma prefecture's silk reelers, who steadfastly rebuffed all efforts to mechanize their industry. They eventually changed part of their organizational structure by re-reeling their silk and forming reelers' cooperatives, but this was a method by which they could pass off their hand reeled silk as a higher quality, machine made product for greater profit.

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<sup>20</sup> Kiyokawa Yukihiro, "The Diffusion of New Technologies in the Japanese Sericulture Industry: A Study of the Experience of Hybrid Silkworms," *Japanese Experience of the UNU Human and Social Development*, series 46 (1984)

Southern Nagano prefecture presents a different story. Not known for silk production, southern Nagano businessmen jumped at the opportunity to build and operate Western-style mechanical filatures. There were no existing production patterns to disrupt and by starting small, Nagano's entrepreneurs assumed little risk. Over time the filatures grew in size and number until Nagano assumed the mantle of leadership in the silk reeling industry. It was only then that neighboring Gunma prefecture's reelers began replacing their out of date technologies with newer, Western-style machines. Ironically, many of Gunma's "new" machines were Nagano's cast offs.<sup>21</sup> Regardless, by 1895 the vast majority of raw silk was produced on Western-style machines. Only two percent of exported silk was reeled on *zaguri*.<sup>22</sup>

By the twentieth century, the model Tomioka established had fundamentally won acceptance in the marketplace. The majority of Japan's raw silk was produced in large, mechanized mills. And while there was a technological revolution of sorts, even a "creative destructive" force present in the industry, the revolution was incremental. There were a few "spectacular innovations" such as the adoption of cast iron reeling machines, steam engines, electric motors, and the F1 silkworm hybrid, but the majority of innovation was incremental and adopted in a controlled manner. Modifications to *croisure* devices or the materials of their construction, different methods of drying and boiling cocoons, even reeling at slower speeds allowed for increased production and better quality raw silk with minimal entrepreneurial risk.<sup>23</sup> Ono Akira has argued that these types of innovations were brought about by a high level of competition in the silk reeling industry, a point with which I concur.<sup>24</sup> What this also indicates is

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<sup>21</sup> McCallion, 310.

<sup>22</sup> Ono Akira, "Technical Progress in Silk Industry in Prewar Japan—Types of Borrowed Technology," *Hitotsubashi Journal of Economics*, 27: 1 (June 1986) 5.

<sup>23</sup> Ono, 1-3.

<sup>24</sup> Ono, 5.

that the private sector, while benefitting from the government's entrepreneurial activities and financial programs, would not or could not assume the same level of risk. Regardless of incentive, private entrepreneurs were more cautious in accepting new technologies.