ENTREPRENEURSHIP AND INNOVATIONS IN JAPAN: AN IMPLICATION OF THE EXPERIENCE OF TECHNOLOGICAL DEVELOPMENT IN THE TEXTILE INDUSTRY

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I. EXISTING STUDIES OF JAPANESE ENTREPRENEURS

1. *Significance of human resources*

No one can deny that entrepreneurs are required to play a leading role in promoting the industrialization of a capitalist economy. This was certainly true in the case of Japan's economic development. Despite the decisive role of entrepreneurship in Japan, studies of it have been limited so far, as compared with studies of other aspects of the Japanese economy. This does not, however, imply that research in this field is less advanced. Rather, a consensus concerning the main features of Japanese entrepreneurship in the prewar period appears to have already emerged from several pioneer studies which are based mainly upon personal histories of various managers as well as promoters.

Our primary aim in the present paper is to reexamine the widely accepted understanding of Japanese entrepreneurship from the viewpoint of technological innovations. A weakness in the study of entrepreneurship consists in the difficulty of conceptualizing entrepreneurship into objectively measurable concepts from which certain basic characteristics can be extracted. It is, therefore, our contention that a different viewpoint may possibly reveal different features of entrepreneurship in Japan.

As is well known, Japan was a natural-resources-scarce country from the beginning of her industrialization. For a long time, domestic infant industries were not protected from foreign competitors by tariffs due to Japan's lack of autonomy. Nevertheless, industrialization steadily proceeded, and the factory system in the manufacturing industry came rapidly to prevail.[1] Although the

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[1] For example, S. Kuznets demarcates the beginning of Japan's sustained growth in 1874–79, in terms of his concept of "modern economic growth." See S. Kuznets, *Modern Economic Growth: Rate, Structure and Spread* (New Haven: Yale University Press, 1966). K. Ohkawa and H. Rosovsky differ slightly, locating it in 1886–1905. See K. Ohkawa and H. Rosovsky, "A Century of Japanese Economic Growth," in *The State and Eco-*

government actively took the initiative in various economic activities, its power and investment capacity were not so great as in the less developed countries of today. Hence it appears to be quite reasonable for economic historians to have sought the most fundamental source of economic development in Japan in the relative abundance of her human resources. As is often claimed, the early establishment of the educational system, the adequate supply of disciplined labor, the flexible social value system, etc., must have contributed greatly to her rapid growth. But of all these human factors, entrepreneurship, we would like to maintain from the economics viewpoint, should be regarded as the most significant direct factor in the promotion of industrialization through arranging various socioeconomic conditions.

2. *The managerial class and education*

Prior to reviewing the existing studies of Japanese entrepreneurship, it may be helpful to confirm briefly the main findings in the studies of the social background of the managerial class. Relatively early in the study of the modern Japanese economy, it has been broadly accepted that the leadership in the industrial world of Meiji Japan was overwhelmingly conducted by managers with samurai origins, particularly ex-samurai with middle and lower class backgrounds.[2] In fact, the ex-samurai class, which accounted for only 6 per cent of the total population, occupied a great number of top management positions in well-established business firms, as well as senior government posts.[3] This fact is apt to lead us to an assertion that their samurai-origin social background was undoubtedly useful in developing managerial qualities in regard to discipline, responsibility, loyalty, and so forth.

No one can deny that samurai-origin managers contributed greatly, as a matter of fact, to the development of the industrial world. Yet whether their competence and active role originated from their origins or not is another problem. Whether or not such personal characteristics as their responsibility, loyalty, and discipline can be attributed to their samurai origins alone, rather than to other factors,

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nomic Enterprise in Japan, ed. W. W. Lockwood (Princeton: Princeton University Press, 1965). W. W. Rostow similarly defines Japan's take-off period as 1878–1900. See W. W. Rostow, *The Stages of Economic Growth* (London: Cambridge University Press, 1960).

[2] See, for instance, as typical studies in the prewar period: H. Tsumuraya, *Wagakoku shihonka-kaikyū no hattatsu to shihonshugi-teki seishin* [Development of the capitalist class and entrepreneurship in Japan] (Tokyo: Mita-shobō, 1920); W. Kanno, *Nihon no kaisha-kigyō hasseishi no kenkyū* [A study of the origins of enterprises in Japan] (Tokyo: Iwanami-shoten, 1931); E. Honjō, *The Social and Economic History of Japan* (Tokyo: Maruzen, 1935); and Y. Horie, "An Outline of the Rise of Modern Capitalism in Japan," *Kyoto University Economic Review,* Vol. 11, No. 1 (July 1936). See also T. Tsuchiya, *Nihon shakaikeizaishi no shomondai* [Essays on the socioeconomic history of Japan] (Tokyo: Heibonsha, 1937), and his various articles.

[3] We may be easily reminded of the names of such distinguished industrialists as Tomoatsu Godai, Takashi Masuda, Hikojirō Nakamigawa, Heigorō Shōda, Toyoji Wada, Zenjirō Yasuda, Keiichirō Yasukawa, etc. According to the first statistical yearbook, 91 per cent of senior government officials, i.e., *chokunin-kan* and *sōnin-kan,* were of samurai origin in 1880. See [*Nihon teikoku*] *tōkei nenkan* [Statistical yearbook], 1st edition (1882).

should be examined in further detail. In fact, subsequent studies of the social background of managers uncovered new features of Japanese managerial resources which indirectly answer these questions. More specifically, the statistical data on the origins of managers disprove the above impressionistic conjecture concerning the significance of their samurai origins.

H. Mannari's study discloses that even in the early Meiji period the proportion of samurai-origin managers in relatively big enterprises was only a fourth, whereas that of merchant-origin managers accounted for more than a half.[4] Similarly Y. Aonuma's research for the year 1900 endorses Mannari's result. What is more, both studies reveal that the majority of samurai-origin managers were highly educated. This fact is a matter of great importance, since both researches confirm the early appearance of a prominent feature of the Japanese managerial class: that the great majority of it was composed of professional employee-managers with higher education as early as the 1920s. In other words, the evidence suggests that ex-samurai elites were eagerly welcomed by enterprises because of their education, not because of their origins, since the enterprise as a new social system had to obtain an enormous amount of new knowledge to adapt itself to the abruptly forced-open economic system, i.e., the international market.

3. *The features of Japanese entrepreneurship*

In prewar Japan it was already true that higher education was a prerequisite to climb the managerial ladder. However, in considering the experiences of the less developed countries of today, top management with higher education is not a sufficient condition at all for active entrepreneurship (see, for example, [5] [12] on the educational background of Indian managers). What is indispensable to rapid industrialization is entrepreneurship itself, not the receptacles of it. Analyses of the managerial function or of the managerial class in conventional business history studies, therefore, are inclined to be insufficient to clarify the source of entrepreneurship, as they implicitly presuppose the existence of entrepreneurship among homogeneous managers.

To understand the active entrepreneurship in Japan, a slightly different viewpoint might thus be required. For instance, the study of managerial behavior such as the analysis of motivations for an enterprising decision, the private reasoning behind risk-taking, the value judgments concerning some initiating activity, etc., may cast a new light on the spirit of enterprise, i.e., entrepreneurship. A typical example of this is the so-called entrepreneurial history studies that were started in the 1940s by the Research Center in Entrepreneurial History at Harvard University, and that focused particularly on the sociocultural aspects of managerial behavior.[5] Major research on Japanese entrepreneurship was

[4] H. Mannari statistically confirmed the dominant share of commoners, particularly of merchants, in the managerial class of Meiji Japan [9].

[5] The reader may find more detailed information about the entrepreneurial studies conducted mainly at the Research Center in Entrepreneurial History in: R. Crandall, *The Research Center in Entrepreneurial History at Harvard University, 1948–1958: A Historical Sketch* (Cambridge, Mass., 1960); J. E. Sawyer, "Entrepreneurial Studies: Perspectives and Directions, 1948–1958," *Business History Review*, Vol. 32, No. 4 (Winter 1958);

conducted under the influence of this school in and after the 1950s. That is to say, the initiative and main contributions were brought at first by foreign scholars.

A pioneer study by G. Ranis [14] maintains that Japanese entrepreneurs were never auto-centered entrepreneurs, viz., entrepreneurs in the Schumpeterian sense. Japanese community-centered entrepreneurs, who were so named by Ranis, had to establish, by their own hands, the basic preconditions for economic development in close cooperation with the government, as is often seen in the late-coming countries. Hence, their managerial decisions were, whenever conflicts appeared, apt to give priority to the national interests over their private interests. This viewpoint of Ranis's is basically supported by the subsequent researches of J. Hirschmeier [4], B. Marshall [10], and K. Nakagawa [13], among others.[6] It is to be noted that many of these studies consider their state-interests-first behavior, i.e., business nationalism, as the essential feature of Japanese entrepreneurship.

J. Hirschmeier emphasizes the discontinuity of economic development from the previous social conditions under Gerschenkron's proposition, whereas B. Marshall claims the continuity of the social value system with that of the pre-industrialized society. K. Nakagawa presents a highly persuasive notion of "organized" entrepreneurship on the premise that Ranis's and Hirschmeier's views are not to be rejected.[7] Although we may find these differences of emphasis among them, they commonly assert the significance of business nationalism in arriving at a rational understanding of the "irrationality" or noneconomic rationality discernible in the behavior of Japanese entrepreneurs.

In Japan these views are widely accepted,[8] or at least are not faced with any strong objection except that some economic historians point out their nationalistic speeches and behavior were more for public consumption than an actual determinant of their business policy.[9] We ourselves do not on the whole disagree that the decision-making by Japanese entrepreneurs went frequently, in its outward appearance, beyond so-called profit motivations in the short run, and that the entrepreneurs were in general highly concerned about the government's guidance and public esteem. Yet it is quite questionable, for the following two reasons, whether their nationalistic behavior can be regarded as a specific characteristic of Japanese entrepreneurship.

First, the evidence concerning nationalistic speeches and behavior in the above-

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and J. H. Soltow, "The Entrepreneur in Economic History," *American Economic Review*, Vol. 58, No. 2 (May 1968). The journal *Explorations in Entrepreneurial History* was published for 1949–58 by the Center.

6 See also Sumiya [18, Vol. 2, pp. 79–110, 157–94] and Morikawa [11].

7 Nakagawa's notion of organized entrepreneurship, which is applicable among Japanese entrepreneurs, should not be identified with the more generalized concept of entrepreneurial organization in late-developing countries by F. Harbison (see [2]).

8 The patriotic property of entrepreneurship in Japan was originally extracted from the research of large firms in the above-mentioned studies. Nevertheless, this proposition is over-generalized, and appears to be applied to all entrepreneurs of the whole economy. See, for example, Sumiya [18, Vol. 2, pp. 79–110, 157–94].

9 K. Yamamura's view is one of the few exceptions (see [22]). A bibliography on Japanese entrepreneurship written in English is available, see Rosovsky and Yamamura [15].

mentioned studies is adopted exclusively from the biographies of well-known entrepreneurs. Accordingly, those people were without exception successful top managers in major, large-scale enterprises. Anyone successful enough to make his business a representative firm of the nation would, as a matter of course, tend to reflect the consciousness of his status in nationalistic speeches and behavior. Furthermore, such social-interests-oriented behavior and lip service might well have been profitable in the long run as a means of obtaining government aid and social prestige. At any rate, the nationalistic or patriotic feature of entrepreneurship, it appears to us, is the case only for top management in major enterprises. What remains to be demonstrated is whether it is of any significance among the entrepreneurs of smaller firms.

Secondly, it also remains to be demonstrated whether the nationalistic inclination was a characteristic peculiar only to entrepreneurs. In other words, it could have been a feature of Japanese culture in those days, not a peculiarity inhering in certain specific people. Since nationalist sentiment was inflamed by various means such as government policy, education, journalism, etc., and prevailed all over the nation from the early period of her industrialization (just as is observable in many less developed countries of today), it seems unreasonable to cite it as a distinguishing characteristic of entrepreneurs. Further, the close cooperative relations between enterprises and the government are a typical feature of the latecomers.

By these reasons, we consider that the widely accepted view of entrepreneurship in Japan should be reexamined from a slightly different angle. That is, entrepreneurial behavior in smaller firms, based on the nonbiographical information, has to be analyzed for confirming the relevance or applicable range of the patriotic feature of Japanese entrepreneurship. Thus we should like to adduce a counterexample against the over-generalized view on entrepreneurship in Japan from the experience of the prewar textile industry, in which innovators selected from the patent information satisfy the above requirements of ours.

We begin Section II with giving a more appropriate definition to entrepreneurship in the late-industrializing countries. Although an explicit definition of entrepreneurship was often lacked in the previous empirical studies, the operational concept and definition of entrepreneurship are crucial in this kind of study area. The main purpose of Section II is to confirm, under the definition, the existence of entrepreneurship for the six major innovations in textile technology. In Section III, we summarize from a macro viewpoint various characteristics of such entrepreneurs' behavior as discussed in Section II. Beyond providing a counterexample, we should like, if possible, to draw any common feature of entrepreneurs observable in the textile industry, vis-à-vis the so-called patriotic feature of Japanese entrepreneurship derived in the previous studies.

II. MAJOR INNOVATIONS IN TEXTILE TECHNOLOGY AND THEIR PROMOTERS

Our viewpoint

In these circumstances, it may be helpful to come back to the orthodox concept

of the entrepreneur proposed by J. Schumpeter. He defines the entrepreneur as an innovator who carries out "new combinations," viz., the setting up of a new production function either in terms of new products, new methods of production, new markets, new sources of supply of materials, or the new organization of an industry.[10] As was typically seen in the earlier stages of Western capitalism, this entrepreneurial function is usually realized by risk-taking managers, technological innovators, promoters of new enterprises, and so on. Schumpeter, therefore, draws a sharp line between the entrepreneur and the average manager. Furthermore, irrationality in the initial motivation of the entrepreneur is often emphasized by him to explain the entrepreneurial function as a type beyond the functions embodied in the *homo economicus*.

Such a rigorous Schumpeterian specification is instructive in helping us to understand the essence of entrepreneurship, yet it is of limited effectiveness in the analysis of the entrepreneurial function itself, since Schumpeter's entrepreneurship appears to be defined as an autonomous variable of the individual's behavior with almost no social interaction. We would like, thus, to loosen slightly his definition and shift emphasis more to an adaptive macro aspect of entrepreneurship, an aspect which provides a fuller reflection of the social environment. For instance, some decisions might appear irrational according to the standards of individual behavior, but could still be rational when considered market deficiencies in the real world of aggregated macro behavior. Often in the case of a latecomer's industrialization, it is the ability to adapt and modify, rather than creative potential, which is indispensable in the situation of transplanting great amount of highly advanced technology.[11]

Thus, it is better to widen the concept of the entrepreneurial activity for achieving a shift of the production function, particularly in the case of late-industrializing countries. This provides also a justification for us to use the information on patents and utility models in our analysis, since it cannot be denied that the essence of a great number of patents and utility models in Japan consisted in the adaptative or imitative modification of foreign or some other domestic models. Nevertheless, many of those activities can be regarded as important innovations in the situation of late-starting industrialization.

Another important modification of the conventional concept of entrepreneurship is found in our intention of grasping the concept of entrepreneurship on a macro level. A few remarks on implications of this understanding are best added. To some extent, individual's economic behavior must reflect the social environment, but it is much easier for us to distinguish reflections of the social condition, e.g., the patriotic ethos, from purely personal motivation, when their

[10] See J. A. Schumpeter, *The Theory of Economic Development* [16, pp. 65–66]. As the new combinations include the case of changes in production coefficients on the same production function, this term is abandoned in his *Business Cycles* [17].

[11] H. Leibenstein, A. O. Hirschman, and some others also suggest, it appears to me, that the concept of entrepreneurship in late-developing countries should be widened for more appropriate analyses. In particular Leibenstein's concept of "N-entrepreneurship" appears to be very instructive. See Leibenstein [8] and Hirschman [3].

behaviors are aggregated to a macro level. In other words, the concept of entrepreneurship on an aggregated level may help us discern the entrepreneurial features due to the market or social condition in the late-industrializing countries, since entrepreneurs in those countries can be considered to behave frequently as gap-fillers of market deficiencies in Leibenstein's sense.

Furthermore, it should be noted that this macro concept of entrepreneurship is also a basis to support our unique view on technological innovations. That is, any major innovation is best considered to appear as a result of a collection of various minor innovations. Or a shift of the production function is frequently realized as a result of serial minor innovations. This is a main reason why we use the time-series data of all related patents and utility models. What is more, this analysis presumes also our implicit contention that the existence of the production function is justifiable only on an aggregated level.

Now, to consider the Japanese features of entrepreneurship in the loose Schumpeterian sense, we examine the entrepreneurial function in connection with the most important innovations in textile technology in prewar Japan. The textile industry is selected here because of its great significance, viz., it was the largest manufacturing industry and displayed the most rapid technological progress. As a typical example, it may provide us with fruitful suggestions for understanding a relationship between Japanese entrepreneurship and the competitive market. Entrepreneurial activities will be discussed at an aggregated level from the viewpoint of different technological innovations, rather than from the level of individual behavior. More specifically, the innovations of three indigenous and three imported technologies will be examined; all of these innovations in textile technology are well known as marking own epochs in the increase in productivity.[12]

A. *Innovations in Indigenous Technology*

1. *The gara-bō spindles*

For the first two decades after the start of her industrialization, Japan suffered extremely from enormous amounts of cotton yarn imports. The foreign yarn was machine-made with better quality, and cheaper than the hand-spun yarn prevailing then in the country as a whole. Hence, traditional products for the weft, without mentioning the warp, were rapidly replaced by the foregin yarn, and *han-kara*, or half foreign yarn, and *maru-kara*, or all foreign yarn, cotton fabrics became very popular even in small villages and local up-country towns. It was thus an urgent necessity to find some means for reviving the hand-spinning or for establishing the modern spinning mills in order to compete with the foreign yarn in price and/or quality.

It was under these circumstances that the *gara-bō*, or "rattling" spindle, was

[12] These six innovations in textile technology were selected from the list of major inventions in Japan and the name-list of the Blue Ribbon Medal awardees related to those inventions, in Tokkyo-chō (Patent Office), ed., *Tokkyo seido 70-nen-shi* [Seventy years of the patent system] (Tokyo, 1965) [21].

invented by T. Gaun in a small village of the mountainous Nagano Prefecture. An improved model was completed by around 1876, and Gaun immediately started to produce it on a commercial basis in his tiny workshop using power from a waterwheel, the Renmen-sha Co. This technology can be considered a kind of intermediate technology, or a very primitive spinning machine on a line of the development of hand-spinning. Yarn is spun directly from a sliver by a spindle of the simpler flyer type. That is to say, the machine adopts a one-process-spinning of simultaneous drafting with twisting, the counts and the twist being adjusted respectively by the leverage principle and the revolving speed of a cap spindle.[13]

The machine having 50 spindles could spin around 1.9 kg of 5's–10's per worker per day (ten hours). This implies productivity six to eight times as high as the productivity of hand-spinning. The machine was usually made of tinplate and wood, and operated by waterpower. Its price was merely 35 yen, which was almost equivalent to one-month's salary of a supervisor or a skilled male-worker in a modern cotton spinning mill. Owing to the poor quality of domestic cotton and the crude structure of the machine, the yarn produced by the *gara-bō* spindle was much inferior to imported yarn. Nevertheless, the former could compete for a while both with the latter and with Japanese machine-made yarn of the newly established mills mainly because of its extremely low price.

The *gara-bō* spindle established the basis for its rapid diffusion as early as 1877, when it obtained nationwide fame by winning the first prize at the first National Industrial Exhibition held in Tokyo. Gaun thus expanded his business to Yamanashi, Tokyo, Shizuoka, and Toyama prefectures, by setting up new workshops and employing agents with financial aid from his fellow provincials. Yet he soon had to meet a difficulty resulting from the appearance of various imitation machines. This was predictable for two reasons: first, the patent law had not yet been established at that time; secondly, the structure of the machine was rather simple and hence slightly modified but similar types of machine were easy to design, no matter whether the *gara-bō* spindle had been patented or not. Consequently, despite his initial success, Gaun's subsequent life was a hard struggle to find financial sources to back his various innovations.

At any rate, the so-called *gara-bō* spindles, including Gaun's, were rapidly diffused after the first Industrial Exhibition. The superb *gara-bō* yarns produced in various districts were then usually displayed at different sample fairs, or *kyō-shinkai,* which were frequently held in various towns and villages throughout the country. From the reports on those sample fairs we can realize how swiftly the diffusion took place. For instance, by 1880, at least more than 250 cottage industry workshops with the *gara-bō* spindles had already been built in such prefectures as Aichi, Tokyo, Osaka, etc.[14] It was around the year 1887 that

[13] For the mechanism of the *gara-bō,* see S. Nakamura, *Nihon gara-bō shiwa* [A history of *gara-bō* in Japan] (Tokyo: Keiō-shuppansha, 1942), pp. 71–75; S. Okumura, *Gijutsushi o miru me* [Viewpoints for the history of technology] (Tokyo: Gijutsu-to-ningen-sha, 1977), pp. 230–34; and others.

[14] See *Meiji-13-nen men-tō kyōshinkai hōkoku: dai-4-gō* [Report on sample fairs for cotton and sugar in 1880: no. 4] (Tokyo: Kannō and Shōmu-kyoku, 1880), pp. 89–98.

the highest production of the *gara-bō* yarn from domestic cotton was recorded. Particularly in the Mikawa District of Aichi Prefecture, a typical domestic cotton cultivation area, the yarn production amounted to as much as 1,160 tons by 131,000 *gara-bō* spindles; the number of spindles was almost equal to the total number of imported spindles which existed in modern mills in nearly the same year (1888).[15]

However, the prosperity did not last for a long time. As the *gara-bō* yarn quickly lost its competitive power to yarn made with the more sophisticated, imported machinery, the nature of the *gara-bō* cottage industry changed. After around 1892, it became complementary to the modern cotton spinning industry, rather than a competitor. That is, the *gara-bō* cottage industry became the *de facto* waste spinning industry by using the waste cotton from the modern mills for its raw material. This result followed inevitably from the following two facts: (1) the modern spinning industry drastically improved its factory system after 1890; and (2) domestic cotton production declined sharply after the same year and was replaced exclusively by imported cotton. We may thus regard the *gara-bō* spinning as having accomplished its original mission until then and having survived subsequently by fulfilling a different function.

Although the life of the *gara-bō* spindle was in fact short, that does not diminish its significance in the history of cotton spinning technology in Japan in the least. How great the importance of the *gara-bō* spinning was at the initial stage of Japanese industrialization is also suggested by the fact that Gaun was decorated with the Blue Ribbon Medal, or *ranju-hōshō,* as early as 1882.[16] He was born of a family of a small coarse-yarn dealer and died poor in contrast to his brilliant innovations. As the patent law was finally enforced in 1885, Gaun patented as well his improved *gara-bō* spindle (Pat. 752; 1889), but it was of no help at all in his raising money. What was left to him was solely a reputation, since his toil for inventions in poverty was applaudingly taught to school children in the textbook on morals. Finally it should also be pointed out that the advancement of *gara-bō* spinning technology was promoted as well by S. Nakano, I. Itō, T. Kōmura, and other local artisans, and that the simple scutcher and twister for the exclusive use of *gara-bō* spindles were developed in subsequent years to raise greatly the productivity and quality of *gara-bō* yarn.

2. *Cocoon-cooking machines*

Among textile industries, it was the silk-reeling industry which contributed most to the expansion of exports in Meiji Japan. In fact it provided more than a third of the foreign currency reserve required to import the advanced technology of Western countries. The silk-reeling industry itself also modernized its production system very swiftly after encountering the French and Italian steam-filature technology. Since the technological gap between the imported

15 See Nihon-wabō-kyōkai, ed., *Wabō* [Indigenous spinning] (Tokyo: Nihon-wabō-kyōkai, 1949).

16 The Blue Ribbon Medal (after 1955, the Purple Ribbon Medal) was then the most glorious decoration for inventors and technological innovators. The first medal was given to T. Gaun in 1882.

and the existing "core technologies" was not so great, the development of the industry was realized particularly by reorganizing its mode of production into the factory system, rather than by introducing new technology.

In other words, although some improvements for mass production such as waterpower winding, steam boiling, and the European croisure system were partly introduced, the fundamental system of technology for silk reeling did not differ so much from the previous indigenous type. This therefore implied that, to advance a step ahead of competitors in the world market, the Japanese silk-reeling industry had to develop its own appropriate technology by itself, rather than to imitate other countries' technology. The time had come by around 1905, since Japan had, by then, deprived China of her hegemony in the international raw silk market through active marketing and reorganization of the production system.

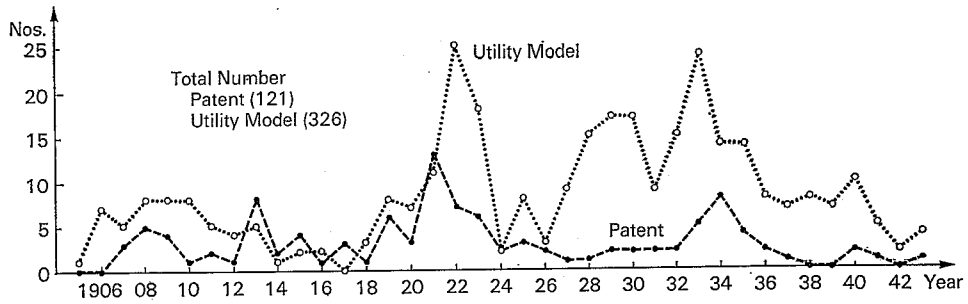
Among the various processes of raw silk production, both reeling and cocoon cooking are considered to be of greatest importance.[17] We discuss first the innovations in cocoon-cooking technology which significantly controls the quality of products, particularly in the case of mass production. In the standard system of production, cocoons were individually boiled in a heated basin either by a reeling hand or a cooking assistant, synchronized with the progress of reeling. Yet, if reeling efficiency was to be increased, the setting up of a specialized section for cocoon cooking was an unavoidable course of development, since controlling the cooking time and temperature required to achieve uniform finish is a complicated and delicate process, depending on the condition of the dried cocoons.

As a first step towards machine-cooking, various types of machines with a rather simple structure were rapidly developed in the first decade of this century, as is shown in Figure 1. A rotary system developed by S. Nakahara, an innovating filature-owner, was the most popular among them (Pat. 13882; 1908). But a door towards more sophisticated cooking technology was soon opened by the discovery of a permeation cooking method based upon water temperature difference (by M. Mori in 1916). This principle was immediately applied, and various utility models of permeation cooking machines with different systems (e.g., high, low, or steam osmotic pressure methods) were competitively commercialized around 1922.[18]

[17] For the cocoon "boiling" process, we use a term "cooking" according to standard technical handbooks, since the latter reflects the actual treatments more exactly. That is, this process includes not only boiling but also cooling by cold water, giving steam pressure and/or giving acetone gas or ammonium gas.

[18] The first Japanese Patent Law was enforced in 1885, whereas the Utility Model Law following the German system was first put into force in 1905. The present system of patents and utility models was established through revisions of these laws in 1921. The patent right protects for fifteen years an invention which should include some originality or new devices. On the other hand, the utility model right of ten-year protection is given not to an invention but to a contribution as a new model or a new structure for practical purposes. While the patent number given here is a registered one, the utility model number is an announcement number in each year.

Fig. 1. Numbers of Patents and Utility Models Registered for Cocoon-cooking Machines



Sources: Tokkyo-chō, ed., *Tokkyo bunruibetsu sōmokuroku* [The classified list of patents] (Tokyo: Gihōdō, 1958) [19]; and Tokkyo-chō, ed., *Jitsuyō-shin'an bunruibetsu sōmokuroku* [The classified list of utility models] (Tokyo: Gihōdō, 1958) [20].
Note: Classification code nos. (40)–211, 212, 213, and 214 are adopted.

On the other hand, as for the machine structures, a fully mechanized type of the so-called *shinkō-shiki*, or horizontal shifter system, was developed for mass cooking in large filatures, and began steadily diffusing after 1919. This horizontal shifter system and the permeation principle were unified by J. Chiba, a winner of the Royal Invention Association medal, and his best-known cocoon-cooking machine, using the automatic steam-osmotic-pressure system, was perfected by 1927 (Utility Model 14298; 1927). This innovation fitted in, much more than the previous types, with the sunk or half-sunk reeling method, as well as with massive pretreatment of the cocoons. In other words, it prepared, as a matter of fact, a prerequisite for the broad introduction of multi-end reeling machines which will be discussed next.

Many variants of Chiba's horizontal shifter type were developed by different small textile-machine makers and rapidly diffused to various regions.[19] Particularly with the entry of the two greatest filature companies, Katakura and Gunze, which supplied also the multi-end reeling machines to their own branch filatures, market competition in the production of cooking machines intensified after 1930, leading to further innovations. Besides, the vertical shifter system was developed in subsequent years and, because of its space-saving feature, led to the diffusion of the cooking machine into smaller filatures as well. Here it should be noted that the basic research on cocoon cooking carried out by local industrial experimental stations in Nagano, Gumma, and other prefectures contributed considerably to the small makers' producing different types of cooking machines embodying various new devices.

The cocoon-cooking machine was thus developed through improvement after

19 On the technical differences between the many variants of the cocoon-cooking machine, the following materials include some information: Ministry of Agriculture and Forestry, ed., *Seishi-kikai ni kansuru tokkyo-hatsumei oyobi jitsuyōshin'an tekiroku* [An abstract of patents and utility models of silk-reeling machines] (Tokyo: Nōgyō-to-suisan-sha, 1934); S. Ogiwara, *Shakenron* [A theory of cocoon cooking] (Tokyo: Meibun-dō, 1934); and F. Nakagawa, *Shakengaku* [Principles of cocoon cooking] (Tokyo: Meibun-dō, 1927).

improvement not by a single innovator but by a great number of different innovators with a competitive spirit. Around 1935, for instance, more than forty different brands of cooking machines were actually available, and each of them claimed its own uniqueness, whether in regard to function, structure, or utility, as was endorsed by its patent or utility model registration. It is well known that such innovations were typically conducted by S. Nakahara, S. Naganuma, S. Yajima, Z. Wataya, Y. Kinoshita, J. Chiba, K. Masuzawa, and other innovating textile-machine makers, although many new models were developed as well by technical experts in experimental stations. The development of cocoon-cooking machines was a typical example of innovating activities in the Japanese economy in the sense that new ideas were competitively commercialized in swarms by many innovators.

3. *Multi-end reeling machines*

As was already mentioned above, another most important technology in a silk-reeling filature is the reeling process which requires the highly delicate and intensive work by reeling hands. Just as the reelability of cocoons depended upon appropriate cooking treatments, so too reeling efficiency and the quality of the raw silk are greatly affected by the structure of the croisure system. In Japan, the prevailing system of croisure was the so-called Italian Tavelette system with three to five ends, whereas the French Chambon system was adopted only in a limited number of filatures at the initial stage of transplanting Western steam-filature technology. This reflected the fact that the former was a much more appropriate system for a coarse-thread-producing industry like the Japanese silk-reeling industry.

The long-standing prevalence of the standard Tavelette system was broken in the 1920s by the appearance of an epoch-making new reeling technology, the multi-end reeling machine. The original idea for this had already been applied by N. Minorikawa as early as 1903, and his various models of multi-end reeling machines were awarded many prizes at such exhibitions as the fifth National Industrial Exhibition (1903), the Tokyo Industrial Exhibition (1907), the Peace Memorial Exhibition (1922), etc. Yet it was not until 1925 that the multi-end reeling machine was commercialized in real earnest by the Minorikawa Factory with the cooperation of the Katakura Raw Silk Co. This realization was eagerly promoted by G. Imai, vice-president of Katakura, who had had a strong crisis-consciousness in response to the drastic shift of demand for raw silk in the U.S. market.

After World War I, in America the newly-risen rayon industry began to supply a large amount of weft yarn at an extremely low price, steadily depriving the Japanese raw silk industry of its market share. Accordingly, to avoid the competition with rayon, raw silk had to shift its main market for use from fabrics to stockings. But the raw silk normally required for stockings is of a relatively fine size and much higher quality than for fabrics, e.g., finer than 15^{D} and above grade A. Thus, to produce such a thread satisfying these qualities without any

loss of labor productivity, the Japanese reeling technology required fundamental improvements to its croisure system.

It was the multi-end reeling machine which was developed to meet the above requirements. Its unique principle is to be found in the following points: (1) To preserve the quality of cocoon fiber, reeling was conducted in relatively low temperature hot-water and under very slow reeling-up speed; (2) To offset the decrease in labor productivity due to slower reeling, fifteen to twenty ends could usually be attended by one reeling hand on a standing-type machine with various new semiautomatic devices.[20] All of these fresh ideas had already been embodied in Minorikawa's original model, which came to be highly appreciated in later years.[21]

Once such a so-called multi-end reeling machine had been commercialized, similar types of machine were successively developed by various textile machinery makers (including large raw silk companies, e.g., Gunze and Kanebō) in each major sericulture region. For instance, more than forty different brands were available around 1930, but each of them was equipped with its own patented apparatus for the end-feeder, reel-stopper, etc.[22] Among them, the established models of Minorikawa, Gunze, Masuzawa, S-O, Taisō, and C-M were rapidly diffused to various parts of Japan. On the other hand, it is well known that the small machine shops satisfied only local demand with their modified machines benefiting from the technological advice and patents of sericulture experimental stations.

Prices of these multi-end reeling machines were generally ¥150–250 which amounted to roughly three to five times the price of a traditional reeling machine. This, however, was not in the least expensive when we take into account that: (1) the labor productivity on the former was 50 per cent greater, and (2) the quality product from the former could be sold at a price 30–50 per cent higher than the product from the latter. Consequently, the diffusion of multi-end reeling machines was rapid and they accounted for more than 40 per cent of all reeling units in the mid-1930s.[23] It should be noted, finally, that the way for this rapid

20 A standard twenty-end reeling machine would have been equipped with at least an end-feeder, an end-groper, and an automatic reel-stoppage system. All of these were quite effective in raising labor productivity, and also in obtaining high scores in the seriplane test, particularly in the evenness-variation test.

21 His contributions to the development of the multi-end reeling machine, together with his sixty-four patents, were reevaluated again, winning the Blue Ribbon Medal in 1928, the Grand Prix from the Royal Invention Association in 1929, and the Imperial Prize from the All Japan Raw Silk Association in 1930.

22 In other words, the multi-end reeling machine was a machine combined with a reeling table, an end-feeder, an end-groper, a filament guide, a croisure, a reel, and so on. Hence, patent and utility model information provides useful information on different devices for each part, but not on the multi-end reeling machine itself. S. Katō, *Nihon seishi gijutsushi* [A history of silk-reeling technology in Japan] (Ueda: Seishi-gijutsushi-kenkyūkai, 1976) includes some fragmentary information on different brands of multi-end reeling machine.

23 For more detailed discussion on technology and diffusion of multi-end reeling machines, the reader may refer to Y. Kiyokawa [6].

diffusion had also been prepared by the broad introduction of cocoon-cooking machines and the first filial hybrid silkworms in the preceding period.

B. *Innovations in Imported Technology*

1. *Automatic power looms*

The invention of a power loom by E. Cartwright in 1785 brought a revolutionary increase in labor productivity into the weaving industry. Subsequently the labor productivity of power looms relative to that of hand looms steadily increased from five times to ten times over the next hundred years. Further drastic progress in weaving technology was realized at the end of the nineteenth century, when the so-called automatic power loom was patented and commercialized in 1894 by an Englishman, J. Northrop, and an American firm, the Draper Co. In the case of this automatic power loom, one weaver may attend as many as ten to thirty looms, so its labor productivity is said to be three to six times that of the power loom, where one weaver generally attends three or four looms.

The automatic power loom is normally considered to be a power loom with an automatic weft supplier and a warp stopping motion (without mentioning a weft stopping motion). And for the weft supplier there exist two types of mechanism, viz., shuttle-change and cop-change systems. These kinds of power loom were already studied in and after the 1830s by J. P. Reid, T. Johnson, C. Parker, and many other machinists in England. Although nearly fifty patents for automatic power looms had been registered in Great Britain up to 1890, it was in America that an automatic loom, Northrop's cop-change type, was first commercialized.

In Japan, one hundred and fifty Northrop automatic looms were introduced in 1900 for experimental purposes. But this trial, it is said, ended in failure for the following three reasons: (1) Japanese cotton yarn of those days was not strong enough to use on the automatic loom; (2) The workers' motions were not fully systematized because of unfamiliarity; (3) The real necessity for automatic looms was not sufficiently realized yet by the industry. This experiment, however, appears to have indirectly given a great incentive to a prominent loom-innovator, Sakichi Toyoda, who had already perfected his own improved domestic power loom in 1898.

Toyoda on the one hand continued to improve his power looms from half-wooden to all iron, and from indigenous narrow types to international broad types, and on the other hand he repeated experiments of various weft suppliers and completed his first shuttle-change automatic loom (Pat. 6787; 1903) in 1903. This model was greatly improved by new devices of a shuttle-pushed-out system and a warp stopping motion, and renovated into an almost new automatic loom (Pat. 17028; 1909). The latter's patent right was extended ten years by an exception clause because of the unique and important ideas it embodied. Yet it was still not considered to be a first-grade loom from international standards.

While his improvement of automatic looms steadily progressed, S. Toyoda

often had to face financial difficulties to realize it. In the earlier years the Mitsui Trading Co. from time to time offered financial cooperation, but it was insufficient to satisfy Toyoda's insatiable innovating activities. Fortunately, by around 1900, the quality of Toyoda power looms (not automatic) came to be considered as nearly comparable to that of foreign looms, and they began to be adopted broadly by major cotton spinning and weaving companies in Japan. S. Toyoda, hence, decided to raise the funds for studies of the automatic loom by managing mills for himself. Thus the Toyoda Automatic Loom Weaving Factory was established in 1911, the Toyoda Spinning & Weaving Co. in 1918, and another spinning and weaving mill in Shanghai in 1921. All of these mills contributed greatly to his aims not only by providing enough funds but also by producing special high-quality yarn for experiments with automatic loom operations.

After World War I, the weaving industry became very keen on introducing automatic looms, as a result of the rapid increase in wages the Japanese economy experienced during the war boom, and also of the scheduled prohibition of night work by female workers starting in 1926 in accordance with the 1916 Factory Law.[24] Consequently, the import of foreign automatic looms sharply increased in the 1920s. They were in general quite expensive, however, and inconvenient as well for obtaining additional spare parts or for combining with domestic parts. Thus the home supply of cheap automatic looms with quality equivalent to that of foreign ones was eagerly awaited by many weaving mills.

Under these circumstances, the Toyoda automatic loom, G-model (Pat. 65156; 1925) was finally perfected by Sakichi and his son Kiichirō Toyoda in 1924.[25] This G-model and the other related patents they registered between 1923 and 1926 were highly appreciated in the world of automatic loom makers. For instance, Platt Bros. made a market-partitioning agreement with the Toyodas by purchasing a part of their foreign patent-rights in 1929. On the other hand, it should equally be noted that two important cop-change automatic looms invented by K. Sakamoto (Enshū) and Y. Nogami were completed in 1927, soon after Toyoda's automatic loom was perfected.

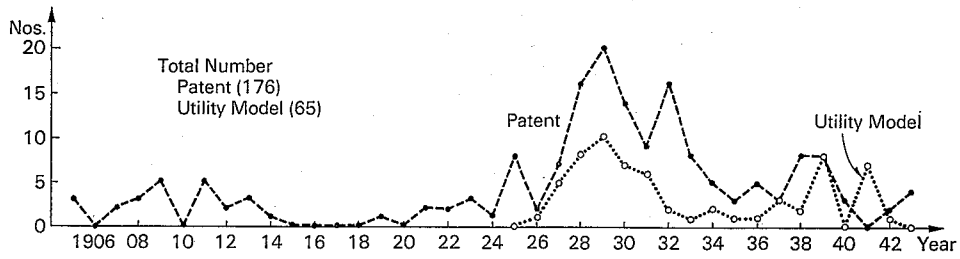
As is shown in Figure 2, induced by the success of these automatic looms, various new patents were eagerly developed, particularly after 1926, by other makers as well, such as Osaka Machinery, Hirano, Harada, etc., alongside the development of the machine tool industry in the 1920s.[26] As most of these automatic looms satisfied the requirements of the weaving mills with regard to

[24] The Japanese Factory Law was promulgated in 1911 and enforced from 1916. Yet the prohibition of night work by female and child labor was postponed fifteen years up to 1926 (and later a further three years, i.e., to 1929). In Japan, almost all weavers were female workers.

[25] Both Sakichi and Kiichirō Toyoda were awarded the Blue Ribbon Medal in 1912 and 1950 respectively. K. Sakamoto received his in 1951.

[26] Our data include foreigners' patents as well, particularly in the earlier period. But their proportion is on average quite small. The registered number of utility models is in general much greater than of patents because of the relative ease of obtaining the former. But, in the case of automatic looms, the number of the latter is greater due to the complexity of their mechanism. This is also to some extent the case for chemical fibers.

Fig. 2. Numbers of Patents and Utility Models Registered for Automatic Looms



Source: The same as for Figure 1.
Note: Classification code nos. (46)–53, 54, and 112 are adopted.

price and quality, their diffusion was rather rapid. In the case of Toyoda, for instance, more than twenty thousand automatic looms were already adopted in major mills by 1932. Finally it is to be mentioned that a great number of automatic looms were also exported to Asian markets, particularly to China, because of their much cheaper prices than other foreign ones.

2. *Chemical fibers*

In Europe, the studies of the so-called artificial silk, i.e., rayon, were commenced from very early years. For instance, as early as the 1880s, Chardonnet in France patented a new production method of nitro-cellulose silk and commercialized it after 1891. Yet this innovation dropped away from the market competition before World War I, since other much cheaper and simpler methods of production were commercialized around the turn of the century. That is, cuprammonium rayon and viscose rayon were both developed in the 1890s and began to be produced on a commercial basis, respectively, by a German firm, Glanzstoff, in 1899 and a British firm, Courtaulds, in 1904. Thus the production of artificial silk in Europe had a long history and an advanced technology.

In contrast, the first experiment of rayon production in Japan was conducted as late as 1915 by two engineer-innovators, S. Kumura and I. Hata of the Teikoku Jinken Co. Following this experience in the period up to the mid-1920s, a number of small venture firms tried to enter the rayon-producing market by their own techniques. All but two of them could not, as a matter of course, survive in the market, since the rayon production technology required a great deal of advanced chemical knowledge and a huge capital investment, both of which were utterly short in those firms.

The two which narrowly survived, Teikoku and Asahi, had been backed up by large firms, the Suzuki Trading Co. and the Nihon Chisso Co. More specifically, they were respectively supported by the private enthusiasm of two entrepreneurs, N. Kaneko and S. Noguchi. Despite such firm support from newly-risen big companies, the two had to depend on foreign rayon production technology. That is, Asahi introduced a complete plant from Glanzstoff, whereas Teikoku struggled at first to develop its own technology, but eventually got on to a smooth track only after installing Courtaulds machines. These facts appear

to have distinctly reflected the technological level of rayon production in Japan at that time.

Rayon production technology in foreign countries was greatly improved in the 1920s. The rayon industry, hence, began to massively supply quite cheap artificial silk with reasonable quality, and the genuine silk was rapidly replaced by it. In Japan, once a fair prospect of stable demand and the rapid improvement in rayon technology had similarly been established, major cotton-spinning companies poured into the rayon-producing market. That is, such rayon companies as Nihon, Kurashiki, Tōyō, Shōwa, and others were all established during 1926–28 as affiliates of cotton-spinning companies.[27] Thus the oligopolistic market was immediately reorganized into a very competitive one.

It is worthwhile to mention here a Japanese characteristic of technology transfer, viz., the competitive introduction of different foreign technologies. More specifically, in the case of the rayon industry, Shōwa, Nihon, and Tokyo rayon companies adopted the German viscose technology of the Oscar Kohorn Co., whereas Asahi introduced both the viscose and cuprammonium methods of Glanzstoff and Bemberg in Germany. Teikoku, Kurashiki, and Nihon Keori started with British, French, and Czech technologies, respectively. In introducing foreign technology into Japan, it was thus not uncommon that different companies adopted different countries' technologies and competed with each other.

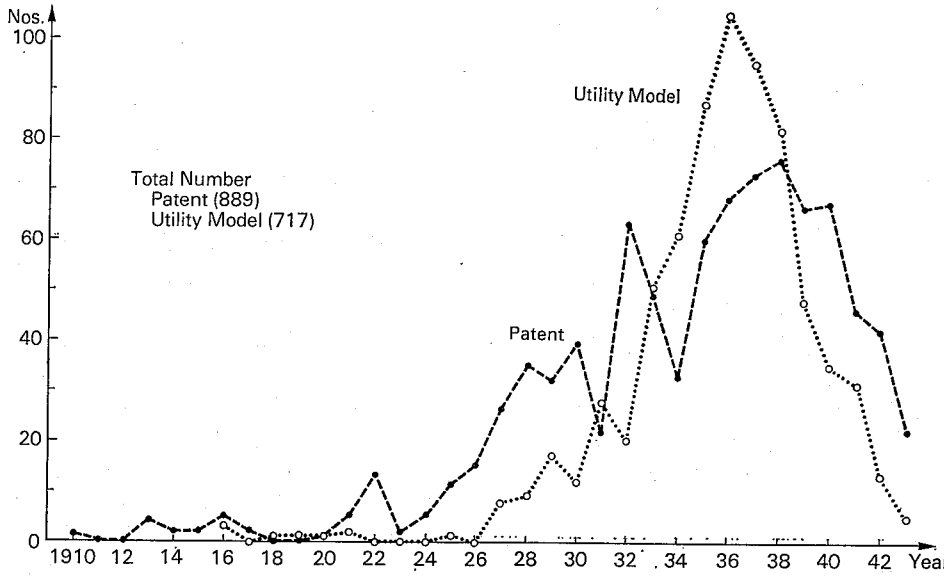
After the completion of market entries by major spinning companies, namely, around 1928, their own adaptations and development of rayon technology were finally commenced in Japan, as is also indicated by Figure 3. Two different fields of improvement in rayon technology may then be discernible in Japan. One consisted of modifications or minor improvements in the machinery of the production process. For instance, various improved models of the dialyzer, the crystallizer, the vacuum kneader, and the pot (centrifugal spinning machine) were developed by Japanese textile-machinery makers under the guidance of rayon companies.

Another greater development was found in improvements in the product quality of rayon yarn. As such an example, high tenacity rayon, delustered multifilament, and some others can be pointed out. But this kind of product betterment, such as crimped rayon, high polymerized rayon, etc., was more typically developed for rayon staple fiber, production of which increased explosively after 1936.[28] Finally it might be worth mentioning that, among many contributors to the development of rayon technology, the two pioneers, Kumura and Hata, received Blue Ribbon Medals in 1928, as did E. Munakata (cuprammonium method) in 1952 and T. Saitō (viscose kneader) in 1954.

[27] Their entries were connected with the steep increase in import tariffs on rayon in 1926 which, it is said, was realized under strong pressure from cotton-spinning companies and others.

[28] The term "chemical fiber" normally means fiber made from cellulose. In other words, it includes both regenerated fiber, e.g., rayon, and semi-regenerated fiber, e.g., acetate. Rayon covers two types of rayon filament and rayon staple fiber. The production of acetate fiber was negligible in Japan. Synthetic fibers made from synthetic materials developed mainly after World War II.

Fig. 3. Numbers of Patents and Utility Models Registered for Chemical Fibers



Source: The same as for Figure 1.
Note: Classification code nos. (42)–A, B, and C are adopted.

3. *The high-draft system of spinning*

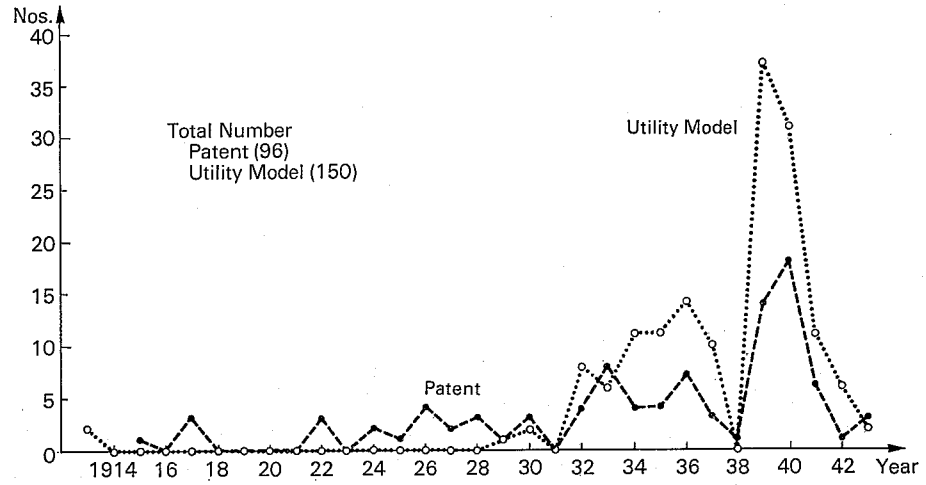
For the cotton spinning technology, much of the fundamental technological progress, such as the ring spindle, the revolving flat card, the precision winder, etc., had been realized in the nineteenth century. In the present century, slightly less-important innovations for increasing efficiency and also the development of production system as a whole were strongly in evidence. Among them the high-draft spinning system was one of the exceptional greatest innovations in the first half of the century. And it was also the first spinning technology with which Japan participated in the "innovation race" in cotton textile technology. In other words, up to the 1920s, almost all spinning machines in Japan except for some simply-structured ones had been imported from foreign countries because of the backwardness of her textile machinery industry.

High-draft spinning is a special drafting system to give roving greater drafts by additional rollers or leather bands on the spinning frame.[29] In the 1920s, the ordinary draft system had a draft of five to nine times, whereas the high-draft system could succeed in realizing a draft of thirteen to thirty.[30] Hence, the adoption of a high-draft system may eliminate at least one of the three

[29] A "draft" refers here to the attenuation of roving, or the ratio between length of roving fed into and the length delivered from the spinning frame.

[30] More specifically, the drafting ratio depends generally on the quality of raw cotton and yarn size. For instance, in the case of 20's with standard raw cotton in Japan, the ordinary draft was 6.5, and the high draft 16. See for greater detail S. Mori, *Bōseki* [Spinning] (Tokyo: Daiyamondo-sha, 1949).

Fig. 4. Numbers of Patents and Utility Models Registered for High-draft Spinning



Source: The same as for Figure 1.
Note: A classification code no. (43)–201 is adopted.

(viz., slubbing, intermediate, and roving) frames in the roving process (usually the last). The high-draft system thus saves about 10 per cent of the fixed capital investment and labor.

The idea of high-draft or better-draft spinning was first studied by a Spaniard, F. Casablanca, as early as 1904, and his roller high-draft innovation was patented in European countries around 1913. It may be pointed out that his first patent (Pat. 28107; 1915) was registered in Japan as well in 1915. In the initial stage of high-draft spinning, the quality of yarn spun by it was said to be inferior to that spun by the ordinary draft system. In the mid-1920s, however, the quality of the former had completely caught up to the latter owing to the development of various different systems, particularly Casablanca's new apron (leather bands) system in 1921.[31]

In Japan, the first high-draft system of the four line-roller type was introduced from various foreign makers around 1925, and subsequently the three line-roller type came to be rather popular up to the end of the 1920s. As a result of the great influence of Casablanca's improved system, studies of the apron-type high-draft spinning system were competitively begun by many Japanese textile-machinery makers and also cotton-spinning companies after 1929. Figure 4 shows that this research began to bear fruit swiftly from 1932.

Various systems, such as the Eikō, O-M, Nittō, T-N, Kanebō, etc., were developed mainly for their own and affiliated spinning mills. Among them the O-M system, which was perfected by K. Honda (Pat. 114590; 1936) in 1934, was the most popular and was said to have been of superior quality.[32] As

[31] See, for example, R. Pickard, ed., *Research in the Cotton Industry* (Manchester: British Cotton Industry Research Association, 1927).

[32] K. Honda was awarded the Blue Ribbon Medal in 1951. T. Nakamura was awarded one

Japanese high-draft machines were in general more appropriate than European ones for poor quality raw cotton, the replacement of imported machines by the former and their diffusion were quite rapid. More than 70 per cent of the spinning frames were equipped with the high-draft system in the 1930s, although nearly half of them were remodeled from existing frames. After 1937, a great number of spinning frames with the high-draft system were also exported to China, particularly to the Japanese-owned cotton-spinning mills in China.

III. IMPLICATIONS OF INNOVATING ACTIVITIES FOR ENTREPRENEURSHIP

1. *A summary of the above-discussed innovations*

So far we have examined the significance of six great textile technological innovations and the basic facts on innovating behavior for each technology. We should like now to summarize them from the macro viewpoint as regards entrepreneurial activities so as to derive some implications for Japanese entrepreneurship. The main features of the innovating activities discussed above are stylized in Table I, where a little subjectiveness might appear since some of the evaluations are based implicity upon my rough comparisons with other countries' experiences.

A few comments concerning Table I are to be in order. An outstanding pioneer is as a rule to be found for each technology, except in the cases of the cocoon-cooking machine and high-draft spinning. T. Gaun (A-1), N. Minorikawa (A-3), S. Toyoda and his son (B-1), S. Kumura (B-2), and I. Hata (B-2) are precisely the examples, whereas K. Honda (B-3) may be on the borderline. The innovations of two indigenous technologies, i.e., the *gara-bō* spindle and the multi-end reeling machine, appear to have contained a greater amount of originality, compared with the other innovations.

When we consider the problem of entrepreneurship, the motivation for innovating activity must be one of the worthy factors to be examined. However, the subjective motivations of innovators, we would like to claim, are not so much crucial, since the private reasons for economic decision-making are not completely independent of economic conditions in the society as a whole. Rather it is the motivation common to all innovators involved in the same technological development, or the economic consciousness commonly held by them in achieving the innovation, that should be analyzed. In other words, the macro economic forces or incentives driving them to take action are considered to be of greater significance than subjective ones.

Whether the main promoter of some innovation was an individual or a firm depended chiefly upon the level of capital investment required for realizing that technological innovation. The dispersion of localities in which innovators emerged

in 1954 due to the development of his T-N high-draft system. The patent for a production method of the high-draft apron leather band by Nihon Hikaku (Pat. 126029; 1938) was also said to be important.

TABLE I

STYLIZED CHARACTERISTICS OF THE SIX GREAT INNOVATIONS

	(1) Outstanding Pioneer	(2) Originality	(3) Motivation or Incentive	(4) Main Promoters	(5) Regional Dispersion	(6) Competitive Development	(7) Diffusion Speed
A. Innovations in indigenous technology:							
1. *Gara-bō* spindles	found	great	foreign technology	individual	high	less active	high
2. Cocoon-cooking machines	not found	moderate	domestic competition	indiv. & firm	high	active	high
3. Multi-end reeling machines	found	great	foreign competition	indiv. & firm	high	active	high
B. Innovations in imported technology:							
1. Automatic power looms	found	moderate	foreign technology	indiv. & firm	low	less active	high
2. Chemical fibers	found	moderate	foreign competition	firm	low	active	very high
3. High-draft spinning	not found	moderate	domestic competition	firm	low	active	very high

was in principle dominated by the regional distribution of its user industry, i.e., the dispersion of customers who demanded the innovation. Finally, the active competitive development of similar innovations and the high speed of their diffusion are to be regarded as specifically a Japanese characteristic of technological innovation.

Now the features found in Table I may be generalized a little more to draw further implications concerning entrepreneurial activities. First, the patent and utility model data on the above six major innovations appear to support our previous conjecture that a large number of small innovations or improvements may often prepare the way for the birth of more important innovations and, conversely, a major innovation usually induces a great many marginal innovations around it. In such cases, the originality of all the innovations is normally guaranteed under the patent or utility model system, even if they are minor ones. These various kinds of innovation as a whole can thus bring about a shift of the production function.

In other words, it is not true in our cases that a unique entrepreneur acting alone carries out such a shift. Rather the shift can practically be attained solely by a large collection of minor innovations developed by many innovators, since even major innovations can neither be produced abruptly, nor be completely independent of other innovations. In this sense, adaptive innovations or imitating followers are equally important in realizing shifts in the production function. They are of particularly great significance in such late-starting countries as Japan.

Secondly, as is shown in Table I, Japanese innovating activities were directly or indirectly very much market-oriented. That is to say, this market consciousness on the part of innovators implies that their underlying motivation was essentially based upon profitability. This view is also endorsed by the following findings made earlier: (1) the existence of distinct peaks, viz., rushes to exploit the innovation, in the course of patent and utility model development (see Figures 1 to 4); and (2) the high-speed diffusion of similar innovations. The existence of peaks and rapid diffusion are the competitive results of profit-motivation whenever innovators felt their entry into the "innovation market" would still be profitable or had to protect their market shares from rivals, even though their innovations were adaptive ones or minor improvements.

This highly sensitive market-oriented innovating activities, on the other hand, may explain the existence of a great number of imitative innovations among Japanese patents and utility models. Particularly for utility models, the imitative property has been stressed. But each of our four figures shows the similar pattern of peaks between patents and utility models. That is, the response pattern of utility models to some breakthrough innovation was almost the same as of patents, viz., a peak being usually induced immediately after the appearance of a breakthrough innovation, as was discussed in Section II. Conversely speaking, this fact suggests us to include the utility model as well into entrepreneurial activities, even though many of them were imitative minor innovations. Thus, we should like to emphasize again the significance of adaptive and imitative innovations in the late-industrializing countries.

2. *Japanese entrepreneurship reconsidered*

As we pointed out in Section I, it has been maintained by many business historians that state-interests-first or nationalistic behavior was the common feature of Japanese entrepreneurs. Is this proposition equally applicable to our cases? As most of their studies were based mainly upon the biographies of entrepreneurs selected according to their own criteria, we also examined the biographies and speeches of our entrepreneurs to see if the same character of nationalism could be found. Yet our answer is inclined to be negative.

Biographies or speeches are available for our engineer-origined entrepreneurs, T. Gaun, N. Minorikawa, S. Toyoda, K. Toyoda, K. Sakamoto, S. Kumura, I. Hata, and K. Honda.[33] But it is difficult, except in the case of Sakichi Toyoda, to find in these materials evidence of patriotic motivation underlying their distinguished innovations. Almost all of them emphasize either an indomitable spirit, a challenging mind, or a competitive spirit as the most important motivation driving them towards innovating activities. What then can account for the difference between this finding and that of the previous studies?

First, the entrepreneurs mentioned here were originally engineers, and without exception had strong pride in their technical skills. Secondly, their enterprises were not so large from a national perspective, although the Teikoku Jinken Co. and Toyoda Automatic Loom Weaving Factory were of reasonable size. Hence they themselves had little consciousness of being entrepreneurs of firms representing Japan. Furthermore, their connections with the government were generally not strong.

However, it should be noted that even where the firms were large or government connections strong, patriotism was not always in evidence as an entrepreneurial motivation. Even in the cases of N. Kaneko and G. Imai, for example, warm supporters of Kumura and Minorikawa respectively, and S. Noguchi, a worthy rival to Kaneko, nationalistic sentiments do not abound in their bio-

[33] Many of the following biographies are published privately, and edited by special committees for each biography (all in Japanese). Only in case helpful, the information and translation will be provided. K. Sakakibara, *Gara-bō no shiso Gaun Tatsumune ō denki* [A biography of T. Gaun: an originator of *gara-bō*] (Aichi, 1949); M. Murase, *Gaun Tatsuchi* (Tokyo: Yoshikawa-kōbunkan, 1965); *Minorikawa Naosaburō ō jiden* [An autobiography of N. Minorikawa] (Tokyo, 1922); S. Niwa, ed., *Minorikawa Naosaburō ō to sono jiseki* [N. Minorikawa and his legacy] (Tokyo, 1960); *Imai Gosuke ō den* (Tokyo, 1949); M. Yora, *Hatsumei monogatari—Toyoda shokkiō* [Power loom king Toyoda: a story of invention] (Tokyo, Kōfū-shoin, 1931); T. Tanaka, ed., *Toyoda Sakichi den* (Nagoya, 1933); M. Kajinishi, *Toyoda Sakichi* (Tokyo: Yoshikawa-kōbunkan, 1962); M. Ozaki, *Toyoda Kiichirō shi* (Tokyo: Jiken-sha, 1955); F. Niwa, *Kumura Seita* (Osaka, 1955); F. Niwa, *Hata Itsuzō* (Osaka, 1955); T. Shiraishi, ed., *Kaneko Naokichi den* (n.p., 1950); K. Takanashi, ed., *Noguchi Shitagau ō tsuikai roku* [Memories of S. Noguchi] (Osaka, 1952); K. Yoshioka, *Noguchi Shitagau* (Tokyo: Fuji International Consultant, 1962); *Honda Kikutarō den* (Kyoto, 1962). Short biographies of K. Toyoda and S. Noguchi are available in *Nihon no kigyōka* [Entrepreneurs in Japan], Vol. 3, ed. H. Morikawa et al. (Tokyo: Yūhikaku, 1978). Speeches by K. Honda, K. Toyoda, and K. Sakamoto are available in *Nihon hatsumeika 50-ketsu-sen* [Fifty great inventors in Japan], ed. K. Matsubara (Tokyo, 1952).

graphies in spite of their big-business activities and tight connections with the colonial government of Korea and/or Taiwan. On the other hand, we also lack definitive evidence that the entrepreneurial decision-making in such large companies as the *zaibatsu* were never state-interests-oriented under their close relationships with the government. In short, some entrepreneurs might have been nationalistic, but many others were not, as is distinctly suggested by our counter-examples.

At any rate, it cannot be denied that Japanese culture in the prewar period was strongly tinted by patriotism and chauvinism.[34] Similarly, we do not hesitate to acknowledge that some entrepreneurial activities were, as a matter of fact, well-organized so as to achieve the common long-run interests of both the industry and individual firms. Such examples may typically be found in the coordinated behavior in the cotton textile and sericulture industries under the leadership of the All Japan Cotton Spinners' Association or the All Japan Raw Silk Association. Nevertheless, taking all these facts into consideration, it is clearly inappropriate to conclude that some patriotic entrepreneurial behaviors can be generalized and identified as an essential feature of all Japanese entrepreneurs.

In fact, compared with Western countries' experiences, major Japanese entrepreneurial activities might have had a much stronger connection with the government. This, however, is a common feature in the industrialization process of late-starting countries, where the government is required to play a more decisive role than in the early-starters. Furthermore, in the late-starting countries, state-interests-first behavior may often guarantee the long-run profit maximization for individual firms. What is of importance thus is to distinguish the Japanese features of entrepreneurship from the general characteristics of late-starters.

So far almost all studies of Japanese economic history have unfortunately lacked the comparative viewpoint with the industrialization problems in other late-developing countries. In other words, seeing nationalistic behavior as the essence of Japanese entrepreneurship, we would like to claim, is partly due to this defect of the viewpoint, viz., lack of comparison. As was confirmed by our examination of technological innovations, the real character of entrepreneurship in the textile industry can be sought along the line of orthodox Schumpeterian entrepreneurship. That is, as far as entrepreneurial behavior in the textile industry is concerned, we may call it "competition-oriented entrepreneurship."

This characterization is evident from our investigations concerning entrepreneurial behavior in the textile industry, where technological innovation can be systematically interpreted under the rubric of competition-first behavior. For

[34] Accordingly, the publication dates of the biographies should be analyzed as well in the biographical studies, since an author of a biography is easily dominated by the social value judgments of his own times. We may easily point out many cases in which the biographies of the same person written in different days convey completely different tones and evaluations. Some reservations, hence, are in order regarding biographical studies for which detailed examinations of the social value judgments of the publication period are not provided.

instance, as is typically shown in a mushroom-patenting phenomenon, an entry-rush into the innovation market was frequently observed immediately after some breakthrough innovation was developed. Furthermore, the great significance of adaptive and imitative innovating activities in Japan was equally appreciated in our characterization. Although our analysis covers only the experience of the textile industry, the derived feature appears to be more instructive, since the source of this competition-oriented entrepreneurship can be found on a grass-roots level almost everywhere in Japan. Precisely, the decisive difference between the economic development of Japan and of the less developed countries of today must be sought in whether this kind of extended Schumpeterian entrepreneurship broadly exists in the nation or not.

To explore the origins of such entrepreneurial behavior in Japan is beyond the scope of our present paper. But it must definitely be related to the unique characteristics of Japanese society. For instance, Japan's flexible culture may have helped to foster the adaptive and imitative abilities useful in absorbing Western technology. The homogeneity of the society, while not necessarily inducing a democratic and individualistic society, might have provided a rich soil for social mobility and market competition.[35] At any rate, further detailed empirical studies in these areas are really long overdue.

[35] For the problem of entrepreneurship and technological innovation in an almost opposite society, see, for example, Kiyokawa [7].

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