Pierre-Yves Donzé

Canon catching up with Germany: The mass production of «Japanese Leica» cameras (1933 until 1970)

ABSTRACT:

This article aims at contributing to a better understanding of the root causes for the competitiveness of the Japanese camera industry on the world market before the electronics revolution. It takes the example of the company Canon, one of the main camera manufacturers in Japan, and focuses on technological issues. The main result of this article is to demonstrate that Canon was able to establish itself as a competitive firm on the world market thanks to a particular production system, which incorporated the design of high-quality 35mm cameras and mass production methods. The technological facilities developed during World War II for manufacturing armaments (training of engineers in universities, optical instruments made by Nikon for the Navy) played a key role in the development of Canon after 1945.

Introduction

While the German camera industry dominated the world market from the end of the 19th century onwards, its Japanese rival caught up in the 1960s. During this decade, Japan indeed overtook Germany in terms of the production (1962) then the export (1964) of cameras (value). This is a typical example of Japanese industry’s success on the world market after World War II and of the emergence of industrial nations in Asia, which sometimes challenged the deeply rooted domination of Western enterprises, as seen in other manufacturing sectors.

In the particular case of the camera industry, Japan’s success has led to various works which have essentially emphasized both product innovation and specific socio-economic conditions as the most important factors. Even though the overwhelming majority of studies concern the post-1970 period and stress the adoption of electronic technologies and the globalization of the production system, product innovation appears to be at the heart of the few works focusing on the period before 1970. For example, Windrum explains the success of the Japanese camera industry in the years 1955 to 1974 by the development of a new product, the single lens reflex (SLR) 35mm camera, which, albeit launched by the German firm VEB Zeiss Ikon (Contax model, 1949) was...

1 In this paper, the names of persons appear following the usage in Japan, that is, with the family name preceding the first name.
2 Nihon kamera kogyo shi, Tokyo 1987, 32.
copied, improved and diversified by several Japanese manufacturers (Asahi-Pentax, Canon, Nikon, Minolta). Windrum is also quick to mention the mass production method adopted by Japanese firms, but does not dwell on it. Thus, product innovation seems to be the key success factor for Japan. Finally, other authors, mostly Japanese, have emphasized the impact of the State and industrial associations on the development of the technological level in this industry; improvements in terms of product quality; and export promotion.

As for the difficulties encountered since the 50s by German camera companies and their failure to withstand Japanese competition, these issues have generated very few academic works. In particular, Fengler sheds light, through the case study of Agfa-Gevaert Co., on the inability of German managers to move away from the innovation management model which was introduced in the 30s and which was designed to meet the different needs of consumers with specific cameras. The segmentation of German production between specialized goods was reflected first by a proliferation of camera types, then by the impossibility of rationalizing production. The pursuit of this production system, driven by self-pride and contempt for Japanese competitors, led in the 60s to a loss of competitiveness of German camera makers. Nelson has also showed the existence of unfavorable socio-economic factors, such as high wages in Germany, but this perspective is discussed by Windrum. As for Oberthür and Albach, they stressed the product development strategy (mass production of high-quality SLR cameras) and the low price policy (due to lower wages, employment of women, mass production methods, and small profit margins) to explain the success encountered by Japanese camera makers since the late 50s. Although German makers, especially Rollei, the firm specialized in SLR camera manufacturing, later became aware of increased Japanese competitiveness they were hamstrung by their high price policy.

While all these works give a general understanding of the basis for the competitiveness of the Japanese camera industry after World War II, there is a need to highlight those analyses focused on the industry level with arguments largely based on macroeconomic data. Yet such approaches make it difficult to understand why some Japanese camera makers became able to compete effectively on the world market. A business history approach, which examines such issues as product development, process innovation and marketing strategy, makes it possible to shed fresh light on this question. This

8 Windrum, Heterogeneous preference (cf. n. 4).
paper argues that the root causes for the success of Japanese camera companies on the world market can be traced to the mass production of high-quality, general-purpose cameras. Socio-economic conditions usually stressed in literature, such as low wages or easy access to the American market, were of course key for supporting the growth of a competitive camera industry in Japan, but they were insufficient on their own. Product innovations, as emphasized above, are also commonly taken as an important factor in this story. After World War II, Japanese camera makers developed many different products, with continuous incremental innovation and integrated electronic technology from the late 60s onwards, even though this was not enough for Japanese companies to become No. 1 on the world market. Process innovation, that is, the mass-production of high-quality goods, as it could be seen in other sectors of the Japanese manufacturing industry at the time, appears to be a key factor in this development.

Here, the company Canon (Canon Camera Co. since 1947; Canon Co. since 1969) is taken as an example to shed light on the way Japanese camera makers were able to acquire and develop the technologies necessary for this production and implement a successful marketing strategy. This firm is very representative of the major Japanese camera makers after World War II, which succeeded in competing with German rivals thanks to the mass production of high-quality cameras. Given that other camera makers used processes quite similar to the one examined here, Canon should be viewed not as an exception but rather as a representative of the Big Five Japanese camera makers (Canon, Minolta, Nikon, Olympus and Pentax).10

This article is divided into three parts. First, a brief presentation of the Japanese camera industry from its beginnings to the 60s maps out the main trends for this industry, in order to further understanding of the general framework in which Canon developed and the domestic background. Next, the focus is placed on Canon’s beginnings up until World War II. Third, the period 1945 to 1970 shows how the firm was able to internalize new technologies and incorporate them into a given production system. The analysis carried out here is mainly based on the corporate history published by Canon in 1987,11 together with other published material (annual reports, lists of engineers, patents, etc.). The use of such sources makes it difficult to examine in detail the process of decisions and strategies adopted by the firm, as there is no direct access to primary sources. Anyway, as is often the case in Japan, the corporate history edited by Canon consists of a two-volume publication full of rough data (statistics, product development, organization of the company, etc.) enabling business historians to examine the growth process of such a company.12

10 Minolta, 45 nen no ayumi, Tokyo 1973; Olympus, 50 nen no ayumi, Tokyo 1969.
12 On the use of corporate histories by business historians in Japan, see Business History Society of Japan (ed.), Nihon kaishashi kenkyu soran, Tokyo 1996.
The beginnings of the Japanese camera industry

The camera industry appears to be a classic case of an import substitution industry, as can be seen in most manufacturing sectors in Japan. Until World War I, the Japanese camera market was dominated by imported goods, mostly from Germany and the United States. The first trading houses specialized in this business emerged shortly after the Meiji Restoration, especially with the opening in Tokyo of Asanuma (1871) and Konishiya (1873). While Asanuma primarily imported Kodak products since 1890, Konishiya assembled its own cameras with imported parts, launching in 1903 the first amateur camera made in Japan (the Cherry model). Other assemblers were also set up, such as Fujimoto Works (1913) and Kuribayashi Camera Works (1919).

The growth in the production of cameras in Japan occurred in two phases. First, in the 20s, domestic production increased sharply, from 344,000 yen in 1920 to 747,000 yen in 1930, accounting for 2.5 percent of imports in 1930. Yet apart from the Japan-German Camera Co. (1928, Minolta brand since 1947), no lasting companies were created during this decade. Domestic production still relied on the assembly of imported parts.

Subsequently, the 30s were characterized by an increasingly independent supply of parts. Domestic production of lenses took off following the creation, in 1918, of Japan Optical Industry (Nikon). Other companies, such as Tokyo Optical Industry (Topcon), Fujioka Optical Machine (Kyocera) and Takachiho (Olympus), also began to produce lenses. Moreover, domestic production of shutters was also introduced, thanks to the involvement of watchmakers in this field (Hattori, 1930). This process of national production of camera parts was firmly backed by several R&D institutions, in particular in the field of lenses. The 30s therefore appear as a high-growth period for production, the value of which jumped to 19.1 mn yen in 1940, an increase marked by military demand and a weak share of exports (a paltry two per cent of production in 1940), as well as the overtaking of imports by domestic production in the second half of the decade. Measured in terms of volume, production increased from 36,700 cameras in 1930 to 218,700 units in 1940. Moreover, this growth was based on not only the development of existing firms but also the emergence of newcomers, such as Asahi Optical (1931), Elmo (1933), Seiki Optical Instruments Laboratory (Canon, 1933) and Mamiya Optical Machine Works (1940). During World War II, these various companies engaged in arms production.

The camera industry was supported by a protectionist custom policy after Japan recovered its autonomy from unequal treaties (1899). Duties on imports of complete cameras were indeed raised from 15 per cent in 1899 to 30 per cent in 1905 then 50 per cent in 1911. Moreover, to facilitate the reconstruction of camera workshops destroyed
by the Great Kanto Earthquake (1923), customs were even raised to 100 per cent in 1924 to 1925 before they were cut to 50 per cent until the war. As for duties on parts, a very flexible policy was adopted, namely, to avoid overtaxing some key parts not yet produced in Japan. Finally, in September 1937, the authorities decided to ban the import of luxury cameras altogether.

Table 1: Production, import, and export of cameras in Japan, thousands of yen, 1900 to 1940

<table>
<thead>
<tr>
<th></th>
<th>1920</th>
<th>1925</th>
<th>1930</th>
<th>1935</th>
<th>1940</th>
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<tr>
<td>Import</td>
<td>1,475</td>
<td>423</td>
<td>1,423</td>
<td>2,583</td>
<td>337</td>
</tr>
<tr>
<td>Production</td>
<td>344</td>
<td>302</td>
<td>747</td>
<td>2,571</td>
<td>19,132</td>
</tr>
<tr>
<td>Export</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>379</td>
</tr>
</tbody>
</table>

Source: Dainihon gaikoku boeki, 1920-1940 (import and export); Kojo tokeihyo, 1920-1940 (production).

After 1945, the Japanese camera industry experienced high growth and once again benefited from custom protectionism to recover. Until 1960, camera imports were subject to quotas and official authorizations. Three phases can be highlighted in the post-war development of this industry.

First, the years 1945 to 1950 were a period of reconstruction. American occupation authorities and the new Japanese Government attached strategic importance to the camera industry against the backdrop of the country’s reconstruction, as this was an industry with high added value that was not overly dependent on imports of raw materials and was capable of bringing in much-needed foreign currency. Moreover, this sector made it possible for numerous former arms manufacturing firms to convert to civilian industry. As a result, there were many new entrants immediately after the war: indeed, there were some 40 camera manufacturers by 1950. During this first phase, the camera industry took advantage of the support of the State and universities to raise its technological level. Production volume rose from 24,000 cameras in 1946 to 260,000 in 1951. These were essentially cameras for US military and civil servants in Japan, who purchased half of overall production in 1948 and some 85 per cent in 1949.

Second, the high-growth period continued and accelerated during the Korean War (1950 to 1953), with the production volume reaching 590,000 cameras in 1953. Above all, the main feature of this period was the boom in terms of new enterprises: there were more than 80 in 1953, most of which were small workshops specialized in assembling. The range of products was also very wide, but what should be mentioned is the launch of the first twin lens reflex cameras (Ricohflex, 1950) and single lens reflex 35 mm cameras (Asahiflex, 1952).

22 These numbers include parts but not lenses alone. Camera exports are mentioned only since 1937.
23 Seki e.a., Kamera – firumu (cf. n. 14), 27.
24 Sawai, Kogaku kogyo ni okeru kyodo kenkyu no hakai (cf. n. 5).
25 Seki e.a., Kamera – firumu (cf. n. 14), 26.
26 Ibid., 27f.
27 Nihon kamera kogyo shi (cf. n. 1), 17.
Third, the end of the Korean War led to a new period characterized by the progressive concentration of production within some enterprises, which invested heavily in production equipment and established themselves as leaders in this business. In addition, during the 60s, R&D activities tended to be concentrated within firms. Consequently, many small companies were not able to survive in this new environment, as a result of which there were only some 30 camera companies by the mid-60s. Moreover, the concentration of production within the three largest firms (Canon, Nikon, Minolta) went from 35.0 percent of the overall volume of national production in 1955 to 46.1 percent in 1965.

Given the above, when camera imports were liberalized in 1960, the Japanese camera industry was competitive enough not to suffer from the influx of foreign products. In fact, imported cameras primarily consisted of some models not produced in Japan, such as the compact cameras of the American company Kodak. Even if the value of imports increased almost tenfold in the 60s, it amounted to only 1.1 per cent of production in 1970, against 0.7 per cent in 1960 (see table 2). The design of high-quality cameras combined with considerable investments in production equipment in the 50s enabled Japanese camera companies to not only be competitive on their domestic market but also export worldwide. Exports were growing fast, and their share of production jumped from 15.9 per cent in 1950 to 32.5 per cent in 1960 and 47.1 per cent in 1970. This growth made it possible for Japan to catch up with Germany and overtake the historic leader of the world camera industry in the first half of the 60s.

Table 2: Production, import, and export of cameras in Japan, thousands of yen, 1950 to 1970

<table>
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<tbody>
<tr>
<td>Import</td>
<td>0.2</td>
<td>28</td>
<td>124</td>
<td>129</td>
<td>1,046</td>
</tr>
<tr>
<td>Production</td>
<td>1,567</td>
<td>10,087</td>
<td>17,961</td>
<td>47,225</td>
<td>97,148</td>
</tr>
<tr>
<td>Export</td>
<td>249</td>
<td>1,680</td>
<td>5,836</td>
<td>18,872</td>
<td>45,747</td>
</tr>
</tbody>
</table>


Canon’s roots: making a «Japanese Leica» (1933 to 1945)

Canon was one of the main enterprises that enabled Japan to establish itself as a world leader in the camera industry in the early 60s. When founded in 1933, Canon’s objective was to design and manufacture products able to compete with the best cameras of the day, that is, Leica’s models. At the beginning of the 30s, German makers indeed launched several new luxury cameras on the market, notably focal-plane shutter 35 mm cameras equipped with rangefinders, considered as the top cameras at the time, and suc-

28 Sawai, Kogaku kogyo ni okeru kyodo kenkyu no hakkai (cf. n. 5).
29 Nihon kamera kogyo shi (cf. n. 1), 58.
30 Yoso Yabe/Masao Kogure, Seisan taisei no saihensei, in: Yabe/Kogure, Nihon kamera sangyo (cf. n. 3), 49.
31 Nihon kamera kogyo shi (cf. n. 1), 40.
32 Import includes parts but not lenses alone.
cessively marketed by the companies Ernst Leitz (models Leica I-III, 1930-1933) and Zeiss Ikon (model Contax I, 1932), as well as twin lens reflex cameras by Rollei-Werke (Rolleiflex Standard, 1932). The conception of a «Japanese Leica» by Canon occurred in two phases: design (1933 to 1937) and production (1937 to 1945).

**Product design by Seiki Optical Instruments Laboratory (1933 to 1937)**

The company which would become known as «Canon» was originally a small R&D enterprise, the Precision Optical Instruments Laboratory (Seiki kogaku kenkyujo), opened in Tokyo in 1933. Its creation was made possible by the combination of a young technician and investors. The technician at the origin of this laboratory was Yoshida Goro (1900 to 1993), a self-educated craftsman born at Hiroshima. After settling in Tokyo, he worked for the emerging film industry – repairing, improving and making movie cameras. Convinced that domestic production of high-quality cameras could become a reality, he dismantled Leica cameras in order to produce some copies, in a typical reverse engineering process. In 1933, he obtained financial backing from an employee of Yamaichi Securities Co., Uchida Saburo, who invested in his workshop, which was then renamed Precision Optical Instruments Laboratory. It was, however, still a small business, with only twelve employees in 1935. In autumn 1934, Yoshida left the company for unknown reasons.

Yet Yoshida’s departure had no impact on the firm’s development. Among the people hired in the first years, two technicians played a key role in product design. The first was Kaneko Tomitaro, an engineer at Japan Optical Industry Co. (Nihon kogaku kogyo, brand name Nikon), who was poached by Canon around 1934 to 1935 to take responsibility for designing lenses. The second was Fukusawa Tamotsu, a technician who graduated from the Watch Industrial School and was snapped up by Canon at the end of his training in 1935. He drew up blueprints based on Leica cameras and conceptualized Kaneko’s advices into drawings.

In this way, between 1935 and 1937, Kaneko and Fukusawa performed reverse engineering on Leica’s cameras. The key parts for ensuring camera quality, namely lenses and rangefinders, were supplied by Nikon. It became Canon’s supplier of lenses until 1948, enabling the latter to use outstanding quality pieces. Nikon’s focus on military optical instruments led it to strongly limit its involvement in civilian products such as cameras.

Reverse engineering efforts hit the mark in 1935, when the first prototypes of high-quality 35 mm cameras were rolled out in Japan. The brand Canon was registered the same year and used for the first models launched on the market. As the magazine Asahi Camera wrote in 1935, «Canon is the Japanese copy of Leica models». Apart from a utility model obtained for a viewfinder in 1936, Canon held no intellectual property
rights during this period, a fact which underscores the fact that its products tended to be copies. Besides, these cameras were expensive: the unit price amounted at 275 yen, about half the price of a Leica. In any event, it was a luxury good for the Japanese market, as the daily salary for a male worker in the cotton weaving sector was about 1.3 yen in 1936.

**Industrialization of the production of high-quality cameras: Canon Co. (1937 to 1945)**

Aiming at implementing the mass production of high-quality 35 mm cameras, the small workshop founded in 1933 was transformed into a joint stock company in 1937, the Seiki Optical Industry Co. (Seiki kōgaku kōgyō), with a capital of one mn yen. Uchida was the main shareholder (23.3 per cent of capital) and was entrusted with the post of Chairman of the Board of Directors. The purpose of this new company was to invest in the in-house production of all camera parts and to become autonomous for the manufacturing of complete products. The technical staff was strengthened by the arrival of several engineers: four were indeed engaged in 1936 to 1938 and others followed obviously until the end of the war. In 1945, the company had 156 employees. In addition, from 1937 onwards Canon benefited from the support of a technological advisor, Fujii Ryuzo, a member of the Nikon Board of Directors who specialized in lens production technology. The cooperation with Nikon was still at the core of Canon’s industrial project.

There was no real change in product design. The camera developed in 1935 to 1936 was the basic model for other cameras launched until the end of the war. Moreover, Nikon continued to supply Canon with lenses. However, as it shifted increasingly towards the production of armaments and instruments for the Navy, Nikon was not able to meet the growing demand from Canon. In 1939, both companies signed an agreement whereby Nikon agreed to transfer its lens production know-how to Canon. It sent two engineers specialized in this technology and sold special machine tools. In September 1939, Canon completed its first lens prototype then opened a lens division which engaged in production in 1940. In return, Nikon obtained an unknown amount of Canon shares. In 1946, Nikon still held 10.4 per cent of Canon’s shares and was the second-largest shareholder, but it withdrew from the company’s capital in 1947. Canon’s engineers also worked on designing and producing other parts, a large share of which had hitherto been outsourced up until 1937. Here as well, Nikon’s engineers seem to have played an important role. For example, their advice made it possible to improve rangefinder quality. By the end of the war, Canon had registered 28 patents and utility models relating to various mechanical parts.

The gradual internalization of know-how relating to the production of 35 mm cameras led to an attempt to streamline production with the opening of a new plant in 1937-1938.

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42 Ibid, 10.
44 *Kiyanon shi* (cf. n. 10), 11.
46 Ibid., 369.
48 *Kiyanon shi* (cf. n. 10), 16.
50 *Kiyanon shi* (cf. n. 10), 11.
51 Ibid., 24.
Meguro (Tokyo) in 1936. The company’s balance sheets point to a strong expansion of equipment between 1937 and 1941, the value of the category «machines, tools» being estimated at 188,188 yen in 1937 and at 332,308 yen four years later, corresponding to growth of 76.6 per cent (some 35 per cent using deflated values).\footnote{Seiko kogaku kogyo kabishiki kaisha, Eigyo hokokusho, 1937-1941. Inflation calculated on the basis of the price index published by Miwa e.a., Kingendai nihon keizaishi yoran (cf. n. 48), 3.} However, assembly was a handmade operation, carried out by trained workers.\footnote{Kiyanon shi (cf. n. 10), 28.} In 1941, Canon reached a maximum annual production of some 70 cameras.\footnote{Kiyanon shi (cf. n. 10), 14.}

Towards the end of the 30s, Canon switched over to producing military goods. Even if the war put a temporary end to the expansion of the production of 35 mm cameras, it was not a break. First, the plant specialized in camera production, which had been moved to Yamanashi Prefecture, was not affected by US bombing.\footnote{Ibid., 19.} Second, design and production know-how remained intact, as engineers hired in the 30s pursued their career within the firm. As a result, the equipment and human capital established before and during the war provided the basis for Canon’s return to camera production a few weeks after the war ended.

Implementation of mass production of high-quality cameras (1945 to 1970)

Canon quickly resumed production of cameras after the war. The first batch, which was completed in October 1945, was intended for US troops in Japan, in order to provide foreign currency to supply the country with food and raw materials. For example, in February 1946, the Supreme Commander for the Allied Powers (SCAP) ordered 10,000 cameras from Canon.\footnote{Price list of ACME Company, 5 December 1949, in: National Diet Library, Tokyo, GHQ-SCAP papers, ESS (B) 10492.}

The American orders jumpstarted growth at Canon, with gross sales shooting up from 367,000 yen in 1946 to 205 mn yen in 1949 and the number of employees doubling during the same period to 611 in 1949. Moreover, whereas numerous firms were trying to entering this business, Canon immediately established itself as a high-quality goods producer. Its cameras were luxury items. In 1949, according to an official price list of cameras destined for export to America, among the six 35 mm cameras on offer, Canon’s was the most expensive (70 US dollars).\footnote{Ibid., 29.}

In the 50s and the 60s, Canon experienced two decades of high growth and became one of the world leaders in the camera industry. Trends for gross sales and its share of overall national production feature two main phases as far as this growth is concerned. At first, in the 50s, Canon experienced a constant but slowly growing increase, with gross sales rising from 378 mn yen in 1950 to 2.8 bn yen in 1959. The steep decline in its share of the national production, which plummeted from 25.2 percent in 1951 to 12.3 percent in 1959, reflects the intensely competitive nature of this market. This was a reconstruction phase during which Canon created the conditions for high growth and invested heavily in equipment. Subsequently, rationalization of the production system...
led to a high-growth decade in the 60s, with gross sales skyrocketing from 4.3 bn yen in 1960 to 44.8 bn in 1970. Moreover, the race for investments boosted Canon’s competitiveness and clout within the Japanese camera industry: the firm’s gross sales amounted on average to 26.6 per cent of national production in the 60s.

Canon’s rapid growth after World War II was due to a desire to pursue and implement the strategic objective set in the mid-30s, namely, the mass production of high-quality cameras. This was made possible by the arrival of a new generation of engineers and cooperation with various R&D centres. The technological capabilities developed after the war enabled the design of new products and the rationalization of work – two necessary steps for implementing a new production system.

**Figure 1: Gross Canon sales and share of national production 1950 to 1970**

![Graph showing Gross Canon sales and share of national production from 1950 to 1970.](image)

*Source: Own calculations on the basis of Kiyanon shi: gijutsu to seihin no 50 nen, Tokyo 1987, 368-369; Nihon kamera kogyo shi, Tokyo 1987, 375.*

**Technological capabilities**

Even though there are no data for changes in the number of engineers employed by Canon, the importance of the arrival of numerous production engineers after World War II must be stressed. They came from three main channels: Nikon, the Army and Navy arsenals, and engineering faculties.

First of all, immediately after the war, Nikon was the benchmark for lens production technology. Consequently, precisely in order to internalize this know-how, Canon
poached several engineers, such as Kuroki Masana, who was entrusted with the task of designing lenses similar to those used in Leica cameras. As for Yoshikawa Ryozo, who was dispatched by Nikon to Canon at the end of the 30s, he pursued his career after the war as a lens designer employed by Canon.58

Second, the arsenals of the Army and the Navy were a major reservoir of engineers, not only for Canon but also for the entire Japanese precision machine industry after 1945. They provided civilian firms with their knowledge of mass production techniques and played an essential role in implementing the new production system (mass production of high-quality goods). Kawaguchi Hiroshi was one such figure. A graduate of the Department of Arms Production of the University of Tokyo in 1927, he worked in a shipyard before entering Canon in 1946, where he was tasked with rationalizing production.59 Suzukawa Hiroshi graduated from the same department in 1940 and began his career as an engineer in the production of torpedoes – a weapon considered at the time to be the most complex precision machine – and pursued it at Canon, where he designed cameras suited to mass production, filing many patents. Finally, one could mention Mitsui Matao, who graduated in 1931 from the Department of Chemistry of theFaculty of Physics of the University of Tokyo, worked in a Navy explosives research division, then went on to head up Canon’s Chemicals Division after the war.60

Third, engineering faculties churned out a great number of production engineers. This was especially the case for engineers from the University of Tokyo, which produced Numata Minoru (Department of Arms Production, 1944), Koyama Seijun (Department of Arms Production, 1944), Ito Hiroshi (Faculty of Physics, 1948), and Nemoto Satoshi (Department of Precision Engineering, 1951).61

These engineers were working in several research divisions set up after the war. In 1948, Nikon’s decision to halt lens deliveries to Canon made R&D on lenses a key strategic challenge. As a result, the following year Canon opened a Chemicals Division, which focused on developing new materials for lenses,62 which was renamed the R&D Division in 1958.63 In 1962, a second research division was created, the Product Research Division, which worked on product design. These two divisions merged in 1966 into a R&D Division, renamed the Central Research Laboratory shortly thereafter (1969). Moreover, R&D activities were supported by a Patent Division, opened in 1958, specialized in the legal protection of innovation.64

Even though Canon organized some in-house facilities from 1949 onwards to back the development of R&D activities, it also relied on joint R&D with universities or national institutes to sustain its technological progress. Sawai Minoru has shown that the Japanese camera industry benefited after 1946 from several institutions supervising joint R&D, involving private companies (among which Canon), universities, and public institutes related to MITI. They played a key role as a platform for exchanges and diffusion of technical information and tacit knowledge among camera makers, thereby contributing to the overall improvement of their technological level. In the mid-60s, R&D

58 Kiyanon shi (cf. n. 10), 32.
59 Kaiin shimei roku, Tokyo 1956.
60 Ibid., Tokyo various years.
61 Kaiin shimei roku, Tokyo 1956.
62 Kiyanon shi (cf. n. 10), 44.
63 Ibid., 63.
64 Ibid., 98–99.
activities tended to be concentrated within private companies, as was the case at Canon, a factor which weakened joint R&D activities in the industry.\textsuperscript{65}

New products and new markets

After the war, Canon resumed production of cameras, aiming to launch high-quality products that could catch up with and overtake Leica. The German maker was indeed still the reference for product design and development. For example, in 1946, Canon marketed the 35 mm SII model, a copy of a Leica model. This camera was designed by a former Nikon engineer hired by Canon at the end of the war, Taguchi Hidehiko.\textsuperscript{66}

Like this product, most of the cameras developed by Canon after 1945 were based on the model produced in the mid-30s and marketed as the JII model. Thus, the focal shutter rangefinder 35 mm cameras were the main products brought out by Canon in the 50s. Subsequently, the firm introduced many innovations destined to improve precision, offer new functions or simplify use of these products. Table 3 shows clearly a shift in management’s focus from rangefinder cameras to single lens reflex (SLR) and shutter cameras in the 60s. The main reason for this change was a desire to expand production, and rangefinder cameras were too specialized for mass production and mass distribution. Subsequently, new models were developed on the basis of technologies internalized during the 50s.

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<tbody>
<tr>
<td>Rangefinder camera</td>
<td>6</td>
<td>33</td>
<td>2</td>
</tr>
<tr>
<td>Single-reflex camera (Canonflex)</td>
<td>-</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Shutter camera (Canonet)</td>
<td>-</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Half-shutter camera</td>
<td>-</td>
<td>-</td>
<td>9</td>
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\textit{Source: Kianon-shi, Tokyo 1987, vol. 2, 305-318.}

Even though Canon launched more than 30 new models in the 60s, this was not inconsistent with the implementation of the mass production system, as most of these models were new varieties of former models (e.g. shutter speed or lens size), so that standardization of the basic model was possible. For example, in 1959 Canon launched a new SLR camera (model Canonflex) and incorporated in its models the automatic diaphragm (models FL and FX, 1964), followed by electronic shutter control (Canon Ex Auto, 1969). In this connection, Canon developed a compact rangefinder camera for the general public, launching it under the brand Canonet in 1961.\textsuperscript{67} This model,
which had the technical quality of Canon’s first 35 mm models, targeted the mass market through its cheap price and simplified use. It soon scored a real hit, helping drive Canon’s growth on the world market in the 60s, and was produced in different varieties in the 60s (Canonet Junior 1963, Model S 1964, Model QL17 1965, Model QL19 1965, Model 28 1968, etc.). There are no statistical data available on the different products made by Canon. The corporate history of this company mentions that the production of the Canonet model between 1960 and July 1963 amounted at some one mn cameras.68 A comparison with the domestic total production of cameras (10.4 mn units in 1960 to 1963)69 sheds light on the importance of this product, as it accounts for some ten per cent of all Japanese cameras during these years. For Canon, manufacturing this model gave the management an opportunity to adopt mass production methods. Offering mass consumers a high-quality camera required this kind of radical change to the production system, a path not followed by either German manufacturers (high-quality cameras for a niche market) or American camera makers (basic quality for mass market).

The change in products observed at the end of the 50s was accompanied by a change in markets. Whereas rangefinder cameras were aimed at professional users, especially abroad (Canon’s exports amounted at 42.2 per cent of gross sales in 1950 to 1959), the expansion of sales and production from the 60s onwards relied on new mass markets. The SLR and shutter cameras developed from 1959 onwards were initially geared to the domestic market (exports dropped to 29.9 per cent in 1961 to 1964) before being exported (38.1 per cent of sales in 1965; 55.4 per cent in 1970).70

Besides, Canon reorganized its worldwide sales organization in the second half of the 50s in order to keep a tight grip on the distribution of its products. A first contract with a foreign company had been signed with the British trading firm Jardine Matheson & Co., which obtained exclusive rights to export Canon cameras around the world (1951). It was a powerful distributor of optical goods, not only in its traditional markets (Asia and United Kingdom) but also in the United States. Jardine’s distributor in America had access to a network of some 8,000 camera retailers. But this was still too few in comparison to Eastman Kodak (3,500 specialized retailers and around 60,000 drugstores under contract).71 The strengthening of the sales network in America was made possible thanks to a common policy adopted by the Japanese camera industry, which organized market surveys and joint initiatives during the 50s.72 In 1955, Canon cancelled its contract with Jardine and set up a branch in New York to directly control sales in the United States. This subsidiary was responsible for marketing surveys and advertising, whereas retailing was outsourced to domestic companies which owned a wide sales network (Scorpus Photographic in 1958 to 1961, then Bell & Howell in 1961 to 1973).73 Subsequently, Canon also directly took over its exports to Europe, where it was, together with Minolta, the first Japanese company to open a sales subsidiary in Switzer-
land (1957). It was later transferred to the Netherlands, to gain direct access to the European market (1968).\footnote{Yushutsu kyoten (cf. n. 80), 142,146.}

Finally, a reference should also be made to Canon’s commitment to developing other products than high-quality cameras. Two phases of diversification strategy can be observed up until 1970. They were adopted in different socio-economic contexts, but both aimed at reducing the risks related to the manufacturing of specialized production. First, when the production of cameras resumed in October 1945, the management set up two subsidiaries at Camera’s main plant in Tokyo, one for the production and the sale of radios (Akatsuki Musen) and the other for the sale of medicine (Kashiwa yakugyo). These two small businesses were not profitable and were closed down in 1949.\footnote{Kiyanon shi (cf. n. 10), 30.} Subsequently, during the 50s, Canon focused on cameras. Diversification was limited to optical products and was considered as a way to make profits from technological convergence. For example, the firm launched eight mm movie cameras in 1956, equipment for TV cameras in 1958, and microfilm readers in 1959.\footnote{Ibid., 58ff.} However, Canon really began to diversify actively outside optics in the 60s. A desire to limit the risks inherent in over-specialization led it to adopt in 1962 a first five-year development plan with the clear objective of diversifying outside the camera industry, ideally reaching 20 per cent of gross sales in new businesses by 1966.\footnote{Ibid., 79.} Management wanted to found the growth of the firm on the development of new high-quality goods rather than an extension of the range of cameras. There was a clear objective to make good use of the brand Canon, associated with quality and reliance, for other products, and the company changed its official name from Canon Camera Co. to Canon Co. in 1969, to emphasize this desire to become a general maker of precision apparatuses and instruments. The main field of diversification at the time was office machines, such as calculators (1964) and photocopiers (1966).\footnote{Ibid., 80ff. For the case of photocopiers, see Teruo Yamanouchi, Breakthrough: The Development of the Canon Personal Copier, in: Long Range Planing, 22 (1989), 11-21.}

However, cameras accounted for more than 80 per cent of gross sales until 1967, a proportion which then dropped rapidly to a mere 49.5 per cent by 1970.\footnote{Kiyanon shi (cf. n. 10), 368.} The integration of electronic technologies in the 70s and 80s was the key driver for diversification (cameras plunged to 23.5 per cent of gross sales in 1985). Nevertheless, even though Canon became a diversified enterprise in the 70s, it established itself on the world market essentially as a camera manufacturer in the previous decade.

Implementation of the mass production system

The production engineers engaged by Canon after the war worked not only to design new products but also to organize work in such a way as to allow for the mass production of such goods. When viewed from this perspective, one key point was the use of completely interchangeable parts, in order to rationalize assembly work. Mass produc-
tion of high-quality cameras relied on three main elements: control of the supply of parts, acquisition of high precision machine-tools, and workflow organization.

For Canon, controlling the supply of interchangeable high-quality parts was critical for the implementation of the new production system. The goal was to internalize production of all parts for 35 mm cameras. Up until the war, Canon had depended largely on an external supply network to source such key components as lenses, shutters and rangefinders. In 1948, however, Nikon, which had been supplying most of these parts, decided to halt deliveries to Canon.\textsuperscript{80} Indeed, Nikon’s abandonment of military production led the company to convert to civilian optics, mainly cameras – a strategic choice which meant the end of supplies to rival firms.

In-house production of all parts was a major challenge for Canon’s engineers, as can be seen from statistics for patents filed in Japan up until 1960 (see figure 2). Whereas Canon filed only a single patent prior to 1945, it filed 85 for the period 1948 to 1960, with a sharp increase from the mid-1950s onwards, which led management to open a new division dedicated to patents in 1958. Moreover, even though patents were filed for all camera parts, there was a special focus on shutters (20 patents, 23.5 per cent of the total) and lenses (nine patents, 10.6 per cent).

R&D activities thus enabled Canon to internalize design of all parts for 35 mm cameras – at least from 1948 for shutters.\textsuperscript{81} The point should also be made that not all R&D activities were conducted in-house. Canon also benefited from joint R&D efforts, car-

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2}
\caption{Number of patents registered by Canon in Japan, 1948 to 1960}
\end{figure}

\textit{Source: Tokkyo bunrui betsu somokuroku, Tokyo 1958 (category 103 C); Industrial Property Digital Library, http://www.ipdl.inpit.go.jp [last access February 2012].}

\textsuperscript{80} Kiyanon shi (cf. n. 10), 32.
\textsuperscript{81} The Camera Industry in Japan, around 1948, in: National Diet Library, Tokyo, GHQ-SCAP papers, ESS (F) 06278.
ried out by universities, private firms and the State. This was essentially the case with the Machine Experiment Station (MES), a research centre under MITI, founded in 1937 and active in several sectors (automobiles, machine tools, watches, sewing machines, etc.). In the field of optical instruments, until the mid-50s, MES endeavoured to improve the quality of lenses, shutters and other key camera components. What is more, the various Japanese camera manufacturers collaborated through industry associations, which carried out joint R&D activities after the war to maintain their technological level. Finally, Canon outsourced some specific parts to subcontractors. Yet their number was very low, notably in comparison to other manufacturing industries such as automobiles, so they should be considered as exceptions. The two main subcontractors were the company Eikosha, a former clock and watch company, which produced rangefinders and other parts from 1949 onwards and set up a joint venture with Canon, Chichibu Eikosha Co. (1954), and Taiyo Optical Industry, which supplied Canon with various kinds of lenses from 1963 onwards.

In any event, nearly all parts needed for 35mm cameras were produced in-house starting in the 1950s, making it necessary for Canon to invest heavily in equipment, especially machine tools. Equipment spending amounted on average to 8.3 percent of gross sales in 1952 to 1970, peaking at 15.8 per cent in 1961 to 1964, precisely when Canon established itself as one of the main camera manufacturers in Japan (see figure 1). The firm possessed 198 machines tools in 1950 and 698 in 1960.

The supply channels for these machines were various but were characterized by a desire to acquire high-precision machines. First, Canon purchased foreign-made machine tools for the production of mechanical parts. In the 50s, Canon procured various American and especially Swiss automatic lathes, including special models used by watchmakers (Bechler, Hauser, Studer, Reischauer). Second, lenses were essentially produced using German machines, supplied in particular by the company Carl Zeiss. Third, Canon also purchased machine tools from Japanese machine makers, such as Hitachi Seiki, a firm specialized in the production of transfer machines for the automobile industry (1956), or the automatic lathe maker Seiko Seiki (1964).

However, implementation of the mass production system did not rely solely on the internalization of know-how related to the manufacture of parts and the use of high-precision machine tools. Rather, it was first and foremost a question of workflow organization. The production system was rationalized at Canon by a new generation of engineers trained in war material companies and at Nikon. In 1948, Canon organized many internal sessions for engineers to discuss ways and means of modernizing the production system. Accordingly, it was decided to introduce blueprints with tolerance norms, gauges, instruments for controlling work accuracy, standardization of parts, etc., whereas assembly work had previously been carried out piece by piece by trained work-

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82 Kikai shikenjo nijunengo nenshi, Tokyo 1963.
83 Sawai, Kagaku kogyo ni okeru kyodo kenkyu no tenkai (cf. n. 5).
84 Kiyanon shi (cf. n. 10), 72.
85 Ibid., 73.
86 Ibid., 368.
87 Kaisha nenkan, Tokyo 1950-1960. After 1969, this source no longer mentions the number of machines.
88 Kiyanon shi (cf. n. 10), 33ff.
89 Kiyanon shi (cf. n. 10), 43.
90 Ibid., 68.
91 Ibid., 68, and Seiko tokei no sengoshi, Tokyo 1996, 184.
ers, due to the lack of interchangeability between parts. Thus, in 1949, the division in charge of machine maintenance was specifically refocused on the production and maintenance of control and measuring instruments.92

Yet the main decision pertaining to the organization of production was to concentrate production in June 1951 at a single industrial site, at Shimomaruko, while it was dispatched to three different places.93 The new workflow organization was set up within this new plant, with chain lines in production and assembly. During the implementation phase, Canon benefited from advice provided by external consultants, especially engineers from the Japan Management Association (Nihon Noritsu Kyokai), who supervised workshop layout.94 Some renowned independent consultants also worked for Canon in the late 40s. The first was the American William Gorham, who worked in particular for Nissan Motor and the machine tool manufacturer Hitachi Seiki in the 30s. His key principle was the introduction of methods making it possible to achieve good interchangeability between parts (tolerance norms, gauges, measuring instruments).95 The second was an engineer and former Army officer who became a technology advisor to various public banks after the war, Nagayama Mitsuo.96 He put the experience he acquired as head of the artillery workshop of the Tokyo First Army Arsenal, where he was in charge of the development of machine tools, to good use at various private companies dealing with mechanics.97 Finally, Canon’s management encouraged its own engineers to acquire the necessary knowledge and competences in terms of workflow organization. In 1955, Yamagata Ryoichiro, Head of the Manufacturing Division, was sent for one year to Germany and Switzerland to study the assembly methods used in fine mechanics companies.98 In addition, in 1959, Canon opened an in-house training centre for technicians (Gino kenshujo), to train its technical staff in the correct use of high-precision automatic lathes, gauges, and machine tools.99 Subsequently, in 1961, Canon introduced quality control measures and organized an IBM section in charge of production control.100

This close attention to quality and parts interchangeability made it possible to gradually introduce chain work in the assembly of various cameras during the years 1957 to 1960.101 The experienced workers and craftsmen were replaced by a young and cheap female workforce (see figure 3). While the share of female employees only amounted to an average of 17.5 per cent in the 50s, it peaked at 57.2 per cent in 1962 and stabilized around 46.8 percent on average in 1965 to 1970. The sudden and massive arrival of

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92 Kiyanon shi (cf. n. 10), 43.
93 Ibid., 44.
94 JMA: Nihon noritsu kyokai konsarutingu gijitsu 40 nen, Tokyo 1982, 484.
96 Kiyanon shi (cf. n. 10), 44; minutes of the 24rd session of the National Diet, Finance Committee, No. 17, 13 March 1954, http://kokkai.ndl.go.jp [last access 10 February 2012].
97 See for example his scientific paper Kosoku seiimitsu senban no shisaku oyobi kenkyu ni tsuite, in: Nihon kikai gakkaishi 45 (1942), 225-231.
98 Kiyanon shi (cf. n. 10), 68.
99 Masao Kogure, Kamera sangyo ni okeru jinzai no ikusei to jinji kanri, in: Yabe/Kogure, Nihon kamera sangyo no henbo to dainamizumu (cf. n. 3), 221.
100 Kiyanon shi (cf. n. 10), 106.
101 Ibid., 68.
women was also accompanied by a general sharp increase in the workforce. The total number of employees shot up from 1,009 persons in 1955 to more than 5,000 in 1946, not however without some difficulties. Indeed, Canon’s production engineers faced some resistance from trained workers, especially in the lens workshop, manned by the «aristocracy» of craftsmen in camera manufacturing, where several labour disputes broke out between 1955 and 1963.102

Finally, the point should be made that these huge investments in industrial equipments were greatly facilitated by Canon’s integration into the Fuyo keiretsu (group of firms), which provided capital to support this expansion. A quick look at the changes in Canon’s balance sheet during the 60s clearly reflects the importance of this move. Measured in constant 1960 yen, the firms’ total assets grew from 3,960 mn yen in 1960 to 17,860 mn yen in 1970, while shareholders’ equity fell from 62.2 per cent of assets to 37.5 per cent during the same period.103 At the time, Canon’s development relied on outside capital and the financial institutions which belonged to the same keiretsu provided most of the loans. In 1970, the three biggest creditors were two banks of Fuyo Group (Fuji Bank and Yasuda Trust Bank), together with the Industrial Bank of Japan (independent).

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102 Kiyanon shi (cf. n. 10), 69.
103 Kaisha nenkan, Tokyo 1961 and 1971. Inflation calculated on the basis of the price index published by Miwa e.a., Kingendai nihon keizaishi yoran (cf. n.44), 36.
Conclusion

The case of the camera manufacturing company Canon tackled in this paper shows a development process covering some 30 years, during which the enterprise moved from a start-up firm for designing and producing high-quality 35 mm cameras (copies of Leica models) in Japan to one of the world’s leading camera manufacturers, accounting for over one-quarter of Japan’s overall production in the 60s. The transformation of the small workshop of the mid-30s into a large industrial company helped make Japan the No. 1 nation in the camera industry and allowed it to overtake Germany, which had dominated the sector since the end of the 19th century.

This successful change relies essentially on the progressive internalization of competences related to product design, parts production and workflow organization. Up until the end of World War II, Canon indeed relied mainly on outside suppliers for key camera components such as lenses, shutters and rangefinders. At the time, it was primarily an assembler of high-quality cameras. After 1945, Canon benefited from the consequences of the technology policy adopted by Japanese authorities during the interwar period and the war, aimed at backing the expansion of the armaments industry. The Army and Navy arsenals, the Department for Arms Production of the University of Tokyo, as well as the company Nikon, which was specialized in optical instruments for the Navy, appear to have been the main training and formation venues for Canon’s engineers, who not only took over the design of cameras and the development of parts but also, in the 50s, implemented a new workflow organization characterized by the mass production of high-quality 35 mm cameras. When seen from this angle, Canon’s technological and industrial success was a legacy of the military’s technology policy. Canon’s post-war growth also relied on a product development strategy which led it to shift from rangefinder cameras to SLR cameras in the late 50s. The objective of this change was to extend its sales outside the market of professional photographers and to offer high-quality goods on mass markets, first in Japan, then in the United States and in Europe. The integration of process innovation and marketing strategy explains how Canon established itself as one of the world’s leading camera makers in the 60s.

Therefore, the fact that German camera manufacturers did not adopt a similar strategy after the war is rather surprising. Like Japan, Germany indeed had numerous engineers trained in the industrial production of arms. Unfortunately, the lack of academic works on the German camera companies has thus far precluded a comparative analysis on this question. Windrum, as well as Oberthür and Albach, explained this weakness primarily as a consequence of the self-confidence and the lack of awareness of German managers, but these assertions do not rely on the analysis of primary sources. More extensive business history studies on German camera companies are necessary to appreciate fully differences regarding the organization of production systems and management practices.

Beyond the case of Canon, this paper contributes to a better understanding of the technological base for the competitiveness of the Japanese manufacturing industry after World War II. The production system implemented by Canon, that is, the mass production of a low range of high-quality goods, can be observed in many companies and in various industries. This was for example the case with Matsushita Electric (today:
Panasonic) for the production of radios from the early 30s onwards,\textsuperscript{104} of all the TV makers since the late 50s,\textsuperscript{105} of Seiko for mechanical watches in the 50s to 60s,\textsuperscript{106} as well as Toyota when the so-called lean production system was first introduced.\textsuperscript{107} Thus, while Canon was a first mover in the camera industry, it is definitely not a special case: rather, it is representative of a production system which was widespread in the Japanese manufacturing industry prior to the electronics revolution.

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\textsuperscript{104} Atsushi Hiramoto, *Senzen nihon no erukutoronikusu: rajo sangyo no dainanmikusu*, Kyoto 2010.

\textsuperscript{105} Atsushi Hiramoto, *Terebi sangyo ni okeru kasen taisei no kensei*, in: The Keizai Gaku (Tohoku University), 36 (1995), 139-151.
