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DYNAMICS OF INNOVATION IN THE ELECTRONIC WATCH INDUSTRY: A COMPARATIVE BUSINESS HISTORY OF LONGINES (SWITZERLAND) AND SEIKO (JAPAN), 1960-1980

Pierre-Yves Donzé
Graduate School of Economics
Osaka University
donze@econ.osaka-u.ac.jp

This article discusses the dynamics of innovation through a comparative business history of a Swiss watch company and a Japanese watch company. The design and production of quartz watches were major technological elements that enabled Japanese watch companies to strengthen their positions on the world market and challenge the traditional dominance of Swiss enterprises. A comparative analysis of the research and development activities at Longines (Switzerland) and Seiko (Japan), both of which promoted electronic watches in their respective countries, makes it possible to emphasize organizational differences and thereby shed light on the origins behind the competitiveness of Japanese watchmakers in the 1980s. This contribution argues that the dynamics of innovation resulted both from institutional differences between Switzerland and Japan, from the perspective of the Varieties of Capitalism and National Innovation Systems approaches, and from industry-specific and firm-specific institutional factors.

Introduction

The electronics industry is usually seen as a sector where innovation is the driving force of competitiveness. Moreover, since the last third of the twentieth century, innovation in the industry has led to a shift of power from Western countries to the Asian sphere. Many scholars in social sciences have thus focused on the process of innovation in the electronics

industry, paying special attention to explaining the rise of Japanese companies since the 1970s and the subsequent developments in Taiwan and South Korea since the 1990s. Literature on the dynamics of innovation in the electronics industry can be divided into two main approaches.

First, some works emphasize the differences between various innovation strategies of companies. In his seminal book *Inventing the Electronic Century*, Alfred D. Chandler Jr. (2005) argued that the ability of large enterprises to build and manage "learning bases" gave them a competitive advantage in world markets. This perspective has been echoed by several scholars in management and business history (Frieder Meyer-Krahmer and Guido Reger 1999; Robin Teigland, Carl Fey and Julian Birkinshaw 2000). For example, some researchers examining Japan have shed light on the weak and limited influence of the state and the key roles that private firms played in the context of a competitive market (Scott Callon 1995). This approach is also overwhelmingly dominant in the Japanese literature (Moriyaki Tsuchiya 1986).

Second, other works focus on national specificities to explain differences in innovation dynamics, inspired by research on National Innovation Systems (hereafter NIS; Bengt-Åke Lundvall 1992; Richard Nelson 1993). Most of the relevant literature in Western languages has emphasized the cooperation between the state and big business in explaining how the Japanese manufacturing industry shifted from the stage of playing "catch-up" with Western technology to driving its own innovation (Daniel Okimoto 1989; Tessa Morris-Suzuki 1994; Laura D'Andrea Tyson 1992). However, international academic works on the Japanese electronics industry within this tradition focus largely on a macroeconomic perspective, with most authors measuring corporate innovativeness based on research and development (R&D) expenses (Okimoto and Gary Saxonhouse 1987). A similar perspective is dominant in studies of the development of the electronics industry in Taiwan and South Korea. Scholars stress the various characteristics of their respective NIS (interfirm cooperation, the roles of conglomerates, joint research with universities, outsourcing for foreign companies, etc.) to explain the development of competitive electronics industries in these countries (Michael Hobday, Howard Rush and John Bessant 2004; Linsu Kim 1997; Bengt-Åke Lundvall, Patarapong Intarakumnerd and Jan Vang 2006). In

comparison with Japan's successes in the electronics industry during the 1970s and the 1980s, scholars also generally consider the European path a failure—a result that mainly ties back to protectionism and national policies aiming at nurturing *national champions* rather than firms that could compete in world markets (Geoffrey Owen 1999, 253-294).

Consequently, the question of whether the dynamics of innovation in the electronics industry were driven by the strategies and capabilities of large and multinational enterprises or by the nature of NIS is still open. The objective of this article is not to give a definite answer to this issue but rather to contribute to the debate on the dynamics of innovation in the electronics industry through the approach of comparative business history. The methodology I employ comprises the analysis of several firms with shared characteristics (e.g. same industry, same ownership structure, same organization) in different countries in order to shed light on the specificities of the firms and the relationships between their individual characteristics and their competitiveness. That type of approach was widely developed by Chandler (1962, 1990) in his works on large enterprises. Recently, comparative business history has emerged as a possible approach to combining the historical empirical tradition with theoretical discourse from the disciplines of management and the social sciences (Terry Gourvish 1995).

The idea is to conduct a comparative study on the organization of R&D and production on shop floors to explain the differences in technological development and competitiveness as William Lazonick (1990) did for the textile industry, for example. Hence, the action of individuals in organizations is a third level of analysis. It is approached through various preserved narratives, such as corporate archives, interviews and published testimonies. Although one could maintain that the action of engineers in various companies results mostly from individual psychological factors, I argue rather that individual action in organizations is related to a broader social context (the company and the nation). Consequently, analysing the roles of engineers within enterprises, as well as the interactions of their activities with various departments (R&D, production, marketing, and management), is surely a viable way of shedding light on the ways that engineering made it possible for Japanese companies to establish themselves as innovative and competitive

organizations, while it was not in Europe.

This article thus aims to open the black box of innovation in the electronics industry, using the specific case of the watchmaking industry for explanatory purposes. The "quartz revolution," as David Landes termed it, generally refers to an innovation that precipitated "a radical transformation of the technology of time measurement and resulted in the creation of what still looked like a watch but was in reality a new product" (Landes 1983, 367). Landes (1983) then presents the development of prototypes in various countries, showing how Japan was the only one to launch successfully into industrialization; unlike Switzerland, which had dominated world markets until then. In Switzerland, "the only thing lacking was entrepreneurship: the manufacturers of watches were not interested" (Landes 1983, 373). The opposition between the eagerness of Japanese engineers on the one hand and the disinterest of Swiss watchmakers on the other appears in nearly all academic publications concerning electronic watchmaking—so much so that it has become a common narrative about R&D in the electronic watch industry (Junjiro Shintaku 1994; Tsuyoshi Numagami 1996; Carlene Stephens and Maggie Dennis 2000; K. Sakakibara 2005). However, the academic community needs to look past such a ready-made explanation and carry out a comparative analysis grounded in business and industry history.

Several approaches in economic policy and management studies offer tools for comparing Japanese and European companies during the second part of the twentieth century. The Varieties of Capitalism (VOC) theory could undoubtedly provide an analytical framework conducive to comparison. Based on the analysis of the relations between firms and their environment (e.g. labor market, financial system, and competitors), this theory argues that capitalism can take various organizational forms, between some economies based on free competition and others based on coordination. The classification of the models varies however between authors. Peter Hall and David Soskice (2001), who first provided the VOC theory, consider both Japan and Switzerland to be coordinated market economies. However, a subtler perspective illuminates the different brands of capitalism that govern the economies in the two countries. For example, Bruno Amable (2003) distinguishes between Asian capitalism (Japan) and the Continental European Model (Switzerland)—a distinction that reflects

a difference in innovation. In Japan, as Amable (2003) argues, R&D occurs at private companies with limited ties to universities, exhibits high levels of competition among large companies, and underscores the Japanese corporate world's ability to imitate and adapt goods to the market's needs (incremental innovation) quickly. Coordination is possible in some specific cases, however, such as in the automobile and electronics industries. In Switzerland, on the other hand, large public research projects and private projects coexist in specialized, higher-quality arrangements, and the adaptation to the market's needs is generally slower. These two models correspond quite well to the common conceptions of electronic watchmaking.

Research on NIS basically conforms to the VOC theory (Lundvall 1992; Nelson 1993). Generally, scholars in the field assume that the business and social systems in each country impact the nature of relations among governmental (civil and military) bodies, universities, and companies and consequently affect the ways in which different organizations conduct R&D. Consequently, the innovation system in each country presents distinctive features. In Japan, recent work by Minoru Sawai (2012) has emphasized that firms cooperate with each other and with the government during the phase of emergence (infant industry) and then build in-house R&D facilities to engage with the competition. In Switzerland, the majority of the few works that have examined the innovation system are by scholars in management studies. These researchers usually stress the benefits that the Swiss economy and firms reap from the high levels of university research and cooperation with private companies and venture capital (e.g. Christian Marxt and Claudia Brunner 2013).

This article goes beyond these general models, which focus mostly on macroeconomic levels, and examines industries and firms in order to offer an interpretation of how Japanese and Swiss enterprises went about developing and producing electronic watches. Both nations dominated the global watch industry and engaged actively in R&D related to electronics during the second part of the twentieth century. They had very different organizations, however. In 1970, there were more than 1,600 watch companies employing nearly 90,000 people in Switzerland (55 workers per firm, on average), while the Japanese watch industry at the time

consisted of five companies with a total workforce of 35,000 people (7,000 employees per firm).[1] The Swiss watch industry was organized as an industrial district and the Japanese as a competitive oligopoly. This difference in industrial organization impacted the way companies implemented their innovation strategies and carried out R&D, which makes it necessary to analyze the management of companies within their industrial contexts.

In tackling these issues, I apply an international comparative business history approach to examine Hattori and Co. in Japan and Compagnie des Montres Longines in Switzerland. Both companies were the first to develop quartz watches in their respective home countries. They also occupy important positions in their respective national industries: Hattori as the largest and most competitive firm and Longines as a part of one of the largest conglomerates, merged in 1983 by the Swatch Group—the world's largest watch company to date. However, looking beyond these common features, one must emphasize that the companies' relative size and weight in the overall industry were very different. In 1970, Hattori produced 14 million watches, which amounted to 58 percent of Japan's national production, while Longines manufactured only 450,000 watches that year—less than 1 percent of the total Swiss production volume.[2] As I will discuss below, this difference in size helped shape the strategies the two adopted regarding R&D in quartz watches.

Hence, the main research questions I address in this article are: How did Hattori and Longines carry out R&D in electronic watchmaking? What is the relation between the firm's strategy and the specificities of the industry? What factors explain the differences between Hattori and Longines: firm strategy, industrial organization, or national innovation system? The next section offers the perspective of industrial history and shows how a different industrial organization directly affected how companies organized their R&D operations. The following two sections

[1] *Recensement 2007*, La Chaux-de-Fonds, Convention patronale, 2007, 13; *La Suisse horlogère*, October 14, 1970, 40, 1542.

[2] For Hattori: Seiko Museum, Seiko and national production statistics. For Longines: Archives of the Compagnie des Montres Longines (AL), production statistics and *Statistique du commerce de la Suisse avec l'étranger*, Berne: Administration fédérale des douanes, 1970.

then follow a comparative business history approach in analyzing the cases of Longines and Hattori.

Swiss and Japanese Watch Industries in World Markets, 1945-1985

Competition between Swiss and Japanese watchmakers did not start with the development of the quartz watch. Rather, it fits in line with the broader historical context of the emergence and growth of the Japanese watch industry beginning in the late nineteenth century (Pierre-Yves Donzé 2014). After several decades of slowly acquiring know-how and technology pertaining to the design and mass-production of high-quality mechanical watches, the firms Hattori and Co. (brand: Seiko) and Citizen Watch Co. succeeded in establishing themselves as competitors with Swiss companies in world markets during the 1960s.

Comparative analysis of the production value of the Swiss and Japanese watch industries between 1960 and 1990 captures the growing intensity of the competition between the two countries (see Figure 1). During the 1960s, before quartz watches were on the market, Japan exhibited substantial production growth that gradually brought the country up to a level comparable with Switzerland: the value of Japanese watch production was only 24 percent of the Swiss production value in 1960, but rose to 47.3 percent in 1969. Consequently, quartz was not the technology that gave Japanese watch companies their competitive edge; it strengthened and accelerated their competitiveness, but the new technology did not create it (Donzé 2012a). The particularly strong growth in Japan at the end of the 1970s eventually allowed the country to overtake Switzerland between 1981 and 1985. Then, the launch of the famous Swatch (1983), the Plaza Accord (agreement between France, Japan, the UK, the US and West Germany to depreciate the US dollar) and the resulting stronger yen (1985), as well as the reorganization of the Swiss watch industry at the end of the 1980s enabled Swiss companies to recover their competitiveness in world markets (Donzé 2012b).

The so-called “quartz revolution” thus occurred in a specific historical context—one characterized by the gradual establishment of the Japanese watch industry in world markets—through the implementation of a system for mass-producing high-quality mechanical watches. Electronic technologies were radical innovations with the power to disrupt bases of

competition. The high precision of quartz watches made high-quality mechanic watches obsolete. In watchmaking nations, companies acquired knowledge of these new technologies through various means. The organization of R&D and the commercialization of the new electronic watches took place under specific conditions, which happened to have been the most effective in Japan. Although political economy theories stressing the differences between countries (e.g. VOC or NIS) could be useful in discussing these various paths, I prefer to employ the industry history approach—a method that focuses on industry-specific characteristics rather than political and economic environments, or on firm-specific resources (Bram Bouwens, Donzé and Takafumi Kurosawa 2018). As this approach argues that each industry is distinguished by a particular organizational structure (e.g. size and international extension of companies) and by products with specific features (e.g. design, technology, and social use), it can be used to focus on the actions of engineers on the basis of industry-specific factors. Industry history consequently offers an original contribution to the discussion about the dynamics of innovation.

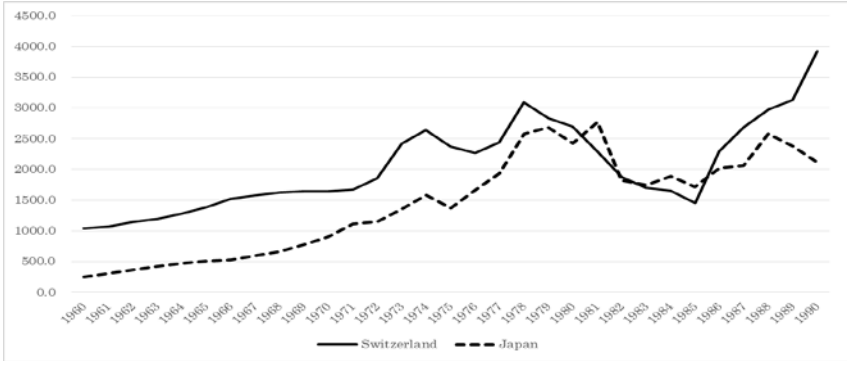

Figure 1

Value of watch production in Switzerland and Japan, 1960-1990 (unit: million USD 1982-1984)

Source and Notes: *Statistique annuelle du commerce extérieur de la Suisse*, Berne, Administration fédérale des douanes, 1960-1990; *Kikai tokei nenpo*, Tokyo: MITI, 1960-1990. Value of watch production for Switzerland is an estimate based on the value of exports plus 5% for the Swiss domestic market; author's calculation using Williamson, 2019.

Box 1: Electronics Technology in Watchmaking

Electronics had a deep impact on watch technology because they made the products more precise and cheaper to manufacture. They led to a twofold change in the architecture of a watch. First, electronics enabled a watch to reach an unprecedented level of precision. The use of an electronic oscillator synchronized by a quartz crystal, a material that vibrates regularly when in contact with electric current, makes it possible to measure time precisely. Watch companies throughout the world carried out R&D during the 1960s to master these technologies that would give them new competitive advantages. Quartz watches became the new technology standard during the mid-1970s, when it became possible to mass-produce them.

Second, electronics unlocked a new technology for displaying time: the liquid-crystal display (LCD). Development took place mostly outside the watch industry, with chemical and electronics firms leading the way, and the technology eventually found applications in quartz watches during the 1970s. Although traditional watch companies, including Longines and Seiko, launched LCD products, they continued focusing on traditional displays (dial and hands). The companies that used LCD technology successfully were newcomers like Casio in Japan.

Source: Stephens and Dennis 2000.

The atomized structure of the Swiss watch industry, where hundreds of small- and medium- sized enterprises coexisted, had a significant impact on R&D (Hélène Pasquier 2008). Organizations in the market adopted three policies in developing quartz watches (Frederick Knickerbocker 1974; Stephens and Dennis 2000). First, the Centre électronique horloger (CEH; Electronic watch center), a joint research center, was founded as a joint-stock company in 1962. It was created at the urging of the Federation of the Swiss Watch Industry (FH) and counted private enterprises like Omega and Rolex among its shareholders (Thomas Perret, Laurent Tissot, André Beyner, Pierre Debély, and François Jeanneret 2000). CEH's research led to the presentation of the prototype of the world's first quartz watch in 1967. The industrial production of this movement consumed large amounts of time, however; it took until 1972 for three firms (CEH, Ebauches SA, and Omega) to launch a joint first

series of 6,000 pieces.[3] Second, some Swiss watch enterprises engaged in their own in-house development of quartz watches. Consequently, the largest manufacturers—sometimes CEH shareholders—marketed electronic watches in the early 1970s (particularly Longines, Omega, and Girard Perregaux). These firms also controlled liquid-crystal display (LCD)-related technologies but did not adopt real strategies for digital watch production. Third, cooperation among Swiss and foreign (mostly European) companies helped facilitate the acquisition of electronic technology. Worth noting here is the 1966 founding of Faselec, a joint venture uniting two watch companies (FH Electronic Holding and Enaches SA), three Swiss electro-technical companies (Brown Boveri, Landis and Gyr, and Autophon) and the Dutch multinational Philips (Gérard Bauer 2002, 360-363). The objective of Faselec was to carry out R&D in the field of semiconductors and integrated circuits in order to make the Swiss watch industry less dependent on US electronic firms. As a result, Ebauches SA and Faselec presented their first digital watch prototype in 1973. The Swiss watch industry thus controlled quartz-related technology as early as the end of the 1960s but faced difficulties in entering the industrial production phase. Quartz watches amounted to just 2 percent of the overall volume of Swiss watch exports in 1975 and 20.7 percent in 1980.[4]

While the United States stood at the vanguard of the electronics industry, no US firm succeeded in leveraging quartz watches into an established position in the global arena. Most of the enterprises that developed the new technologies necessary for quartz watches were indeed American; the most famous example was Intersil Co., which Jean Hoerni—a Swiss engineer who had lived in the United States since the 1950s—founded in California in 1967 (Bob Johnstone 1999). The firm specialized in the production of CMOS chips (integrated circuits used for a high variety of applications, including quartz watches) for the watch industry. However, US watch companies failed to apply their electronics technologies toward carving out more competitive positions in world

[3] The movement of a watch is the system (made of several components) that measures time.

[4] *Statistique du commerce de la Suisse avec l'étranger*, Berne, Département fédéral des Douanes, 1975-1980.

markets; their different technical choices ended up delaying or even preventing the adoption of quartz. For example, Bulova showed its innovative streak by launching a tuning-fork watch in 1960, but this technical choice postponed the adoption of quartz and contributed to the decline of the firm, which a Hong Kong investor eventually took over in 1976.[5] Moreover, some 30 US companies from the watch (e.g. General Watch, Gruen Industries, Waltham, Elgin, Timex, and Benrus) and electronics (e.g. Microma Inc., General Electric, Intersil, Fairchild Camera and Instrument Co, and Texas Instruments Inc.) industries launched quartz digital watches during the 1970s. However, none of them was able to survive on world markets: the lack of a clear marketing strategy and sufficiently developed sales channels was what precluded success (Osamu Shimizu 1991, 72).

The Japanese market developed quartz watches in a context different from the situations in both Switzerland and the United States: companies had started to see quartz technology as a major challenge for marketing issues and global competitiveness as early as the end of the 1950s. R&D and production efforts for this new technology took two main forms. First, the two largest watch groups (Hattori and Citizen) essentially developed the technology in-house through cooperative arrangements with some US firms. The other pattern, which many other smaller companies followed, involved acquiring quartz-related technology through connections with Japanese electronics firms. For example, Orient Watch founded a joint R&D center with Sharp to develop digital watches, while Casio cooperated with Sanyo Electric.[6] Unlike the conditions that arose in the United States, the growth of digital watches in Japan did not lead to a profusion of newcomers; existing watch companies, such as Hattori and Co (1973), Ricoh (1973), Citizen (1974), and Orient (1974), were quick to take up the new technologies. The only successful newcomer was Casio (Donzé 2016, 139).

The industrial organizations in the largest watchmaking nations thus provide many of the reasons behind the different technological paths that

[5] *International Directory of Company Histories*, Farmington Hills: St. James Press, vol. 13, 1996, 120-123.

[6] *Tokei sentan gijustu kaihatsu doko chosa*, Tokyo, MITI, 1978, 30.

the countries followed. However, a proper understanding of this phenomenon requires an investigation that goes beyond the level of industry and enters into the strata of firms and workshops—a context where one can see exactly how the various actors in the industry acquired the new electronics technology and set up organizations to produce quartz watches. The following two sections focus on the cases of Compagnie des Montres Longines and Hattori and Co., two major companies involved in the development of quartz watches in Switzerland and Japan, respectively. Both embody various dynamics of innovation for a similar product.

Compagnie des Montres Longines (Switzerland)

Compagnie des Montres Longines was the first major Swiss watch company to market a quartz watch (Patrick Linder 2008; Donzé 2012c). A family firm with origins dating back to the 1830s, the company established itself as a leader in the mechanized production of watches at the end of the nineteenth century. While the managers of the company began deliberately limiting its development in the 1940s to help maintain family control, pressure from competitors—in Switzerland and abroad—led them to open Longines' capital to Ebauches SA (1971), the subsidiary of the trust Allgemeine Uhrenindustrie AG (ASUAG), Switzerland's largest watch group, which included the Federal State and large banks among its shareholders (Christophe Koller 2003). Despite the presence of a fast-growing world market, Longines was thus on the defensive when it engaged in R&D concerning electronic watches. Its objective was to master a technology that would change the nature of competition based on precision while continuing the manufacture of mechanical watches. As it was still a family firm in the 1960s, Longines' management had neither the necessary capital nor the will to make a massive investment to transform product development and production technology (machine tools, automation, and workshops). This stance shaped the way the company pursued its research.

In her study on R&D in the Swiss watch industry, Pasquier emphasized that Longines isolated its R&D unit for mechanical watches from production and other divisions during the 1950s (Pasquier 2008, 101-110). In 1955, the company set up a research section for electric watches and hired a new engineer to supervise the new organization. However,

Longines did not integrate the section within the department of mechanical production, which organized production in workshops. The electric watch section thus depended directly on the technical steering committee (*direction technique*) of the company, as the acquisition of knowledge in this field was considered as technology intelligence. The management was skeptical about its potential use to mass produce a new kind of watch. This autonomy continued to grow into the following decade, when the R&D unit was cut loose from the company's chief technical officer and put under the direct control of the executive management committee (*direction générale*, above the technical steering committee) in 1964.

This organizational divide between R&D and production largely explains the difficulties that Longines encountered in industrializing its prototypes. When they decided to launch the development of a quartz watch, Longines' managers faced an organizational challenge: their engineers lacked the knowledge necessary for this new technology. The small R&D unit set up to develop an electric watch continued its cooperation with an independent engineering company, Bernard Golay SA (Pasquier 2008, 375-380). In 1965, this cooperation led to the presentation of an initial quartz pocket watch prototype. Two years later, the two partners signed an agreement to define roles and responsibilities (Pasquier 2008, 376). The agreement assigned R&D activities to Longines (mechanical parts) and Golay (electronic parts) and quartz resonators to Oscilloquartz, a department of Ebauches SA—the holding company that held a quasi-monopoly on the production of movements in the Swiss watch industry. Under the agreement, both companies also had joint ownership of patents, with Longines paying royalties to Golay for the sales of quartz watches. The companies worked to miniaturize their prototype and to create a quartz wristwatch called the "Ultra-Quartz."

Longines unveiled the new prototype to journalists in August 1969, but the shift toward industrialization and commercialization led to many practical problems. In December 1972, Claude Ray, an employee of Longines' R&D unit, exposed the causes in a long report.[7] Originally charged with supervising the production of mechanical modules for the Ultra-Quartz in March 1970, Ray soon noticed that the conditions for

[7] AL, F2251, report by Ray, December 10, 1972.

industrialization were absent and that the product was still in the development phase. The lack of coordination with the engineers from the firm's technical steering committee, which supervised the organization of workshops and production, led to the conceptualization of a prototype that the company would not be able to industrialize immediately. In technical terms, the company had to rebuild the caliber, recalculate the frequency of the quartz, and develop a new electronic chip. Ray's objective was then to "make Ultra-Quartz suitable for serial production", and he planned to have the additional development works complete in the spring of 1971. In February 1971, his team gave the sales department 50 of the first watch movements for exhibition at the Basel Fair, the watch industry's largest trade show. However, these initial models were still beset by quality issues—and Longines and Golay blamed each other for the shortcomings.

Despite these problems and the lack of laboratory tests, the firms attempted a serial production run of 200 pieces in August 1971. The first sales of Ultra-Quartz flopped, however, with buyers returning many of their purchases to Longines due to technical defects. André Beyner, technical director of Ebauches SA and member of the board of directors at Longines since 1971, declared in April 1972 that "the Ultra-Quartz watch works with satisfaction" and that Longines "has a valuable caliber on the market,"[8] but nothing could make the watch a commercial success. The product was technically outdated: contemporary rivals produced other kinds of movements at lower prices. In December 1972, Ray—appointed deputy director in the meanwhile—thus humbly admitted that he had been misled "by the complexity of a product that happened to be at the end of the limits of feasibility and that we now have to call a first-generation product."[9]

The isolation of the R&D unit and the absence of a clear strategy on the part of the company's technical steering committee also correlate with the arrival of Ebauches SA as the main shareholder during the years 1970 and 1971. This change of ownership led to uncertainty that made quick decisions risky; Longines' technical steering committee wanted to stay prudent and avoid making mistakes so that it could maintain its position

[8] AL, B32.5, minutes of the board of directors, April 25, 1972.
[9] AL, F2251, report by Ray, December 10, 1972.

in the case of a restructuring. Although Longines was taken over by Ebauches SA, a company that had produced its own movements for quartz watches since 1972, it still continued cooperating with Bernard Golay for several years. The company also decided not to make an aggressive attempt at the development of a digital quartz watch. After designing a futurist prototype with Ebauches SA and the US company Texas Instruments, Longines presented its new creation in 1972, but never took the development initiative any further (Jacqueline Henry-Bédat 1992, 162). When Golay eventually went bankrupt in 1975, Longines had no choice but to start using Ebauches SA's quartz movements.[10] That year, watch movements from other companies accounted for 39 percent of all Longines watches (see Table 1).

Table 1

Supply of movements for Longines watches, 1975-1980

		1975	1976	1977	1978	1979	1980
Volume (pieces, 000s)		348	490	497	493	476	455
In-house production (%)	Mechanical	61	73	73	69	56	36
	Quartz	-	-	-	-	19	52
Produced by external suppliers, mechanical and quartz (%)		39	27	27	31	25	12

Source: Archives of Compagnie des Montres Longines, B31.6, Evolution des mouvements manufacture, May 18, 1981.
Note: This document does not distinguish between mechanical and quartz movements produced by external suppliers.

For several years, Ebauches supplied the quartz movements that Longines needed. In 1977, however, the growing success of electronic watches in world markets led Longines' directors to revise the company's strategy. The board of directors declared in May that it had decided to shift

[10] AL, B32.5, minutes of the board of directors, April 8, 1975.

from "elegant manual watches [hand-winding] to elegant automatic and quartz watches."[11] At that time, Longines was still essentially a producer of mechanical watches; quartz watches made up only eight percent of the company's total sales volume in 1977 (Henry-Bédat 1992, 166). In 1977 and 1978, Longines converted its workshops into serial production sites for electronic watches. While Longines did continue to purchase electronic movements from Ebauches, it also developed its own movements in-house and created several models between 1978 and 1984 (Linder 2007, 613). The objective was to regain its independence from external suppliers. The mutation was rapid: in 1979, in-house quartz movements represented less than one-fifth of the company's complete watch production (17.6 percent)—a percentage that grew to more than half of all complete watches (57.3 percent) by the following year and continued to grow rapidly during the early 1980s. It reached 70.1 percent in 1981 and more than 90 percent in 1984. However, the foundation of the Société suisse de microélectronique et d'horlogerie (the Swatch Group since 1998) through the merger of ASUAG—including its subsidiary Longines—and Société suisse pour l'industrie horlogère (SSIH, Omega group) in 1983 gave way to a large industrial reorganization. It led to the suppression of Longines' technical steering committee (1984) and the end of R&D and production (1988), since when Longines has focused on marketing and sales.

Hattori and Co. (Japan)

Like Longines in Switzerland, Hattori and Co. was the first company in Japan to market a quartz watch—but that is where the similarities between the companies end in terms of their quartz operations. Unlike its Swiss rival, Hattori, a company that originated in Tokyo in 1881 and created the "Seiko" brand, established itself in world markets not only as the world's first company to commercialize a quartz watch but also through successful mass-production of the new product (Seiko 1996; Donzé 2014). This success came about as the result of an early integration of electronic watch R&D into the production system as well as a clear technical choice by the directors of the company.

The decision to develop and produce electronic watches was made by

[11] AL, B32.5, minutes of the board of directors, May 11, 1977.

Hattori's management at the end of the 1950s. This objective aligned with the strategy to mass-produce high-quality mechanical watches, an approach that the company adopted during the interwar years and pursued after World War Two. Hattori used its mechanical watches to establish itself as a major competitor against Swiss companies in world markets, particularly in the US, during the 1960s. Quartz was seen as a new technology that would sharpen that competitive edge and enable Seiko to become the global frontrunner in the watch industry (Donzé 2011). Suwa Seikosha (hereafter "Suwa"; now Seiko Epson), one of the two watch manufacturers in the Hattori group, organized a research team—"Project 59A"—in 1959 and charged the group with studying new watch types (electric, tuning-fork, and quartz). The team comprised company engineers, all of whom had a background in mechanics. Given this imbalance in expertise, Suwa decided in 1960 to hire three more electronics-oriented engineers (Seiko 1996, 150). That same year, the R&D team received a new goal from upper management: the development of a portable quartz clock for the 1964 Summer Olympics in Tokyo (Hattori and Co. had already obtained the timing). The clock was ready in February 1964. Afterward, Suwa's engineers worked to miniaturize the model into a large pocket watch (1966) and a wristwatch (1967).

These products were still only prototypes, however. As in Switzerland, the most important challenge for Hattori's engineers was to master the development of electronic parts essential to implement production. After several attempts at in-house development, Suwa outsourced the design of C-MOS chips to the US firm Intersil (Seiko 1996, 153-156). Once Intersil developed the chip, the two companies signed an agreement that made it possible for Hattori to use the technology in its Japanese plants and consequently directly control the entire production process (1969).[12] Hattori's internalization of knowledge and competencies related to the design and production of C-MOS chips for quartz watches went beyond its cooperation with Intersil. The Hattori group hired two consultants: Sugano Takuo, a professor at the University of Tokyo and a specialist in transistors; and Tarui Yasuo, head of the semiconductor division of the

[12] *Kigyo bestu gaishi donyu soran: jojo kigyo hen*, Tokyo: Keizai chosa kyokai, 1980, 16, 598.

laboratory of electro-technics of the Ministry of International Trade and Industry (MITI) (Seiko 1996, 159-160). These various forms of joint activity supported the implementation of quartz watch mass-production and model diversification. In addition, knowledge acquired via the design and manufacture of chips and integrated circuits led Suwa to open a "semi-conductor division" for the production of electronics parts for sectors outside the watchmaking realm. This was the origin of this firm's diversification into electronics. However, even though Hattori developed its own facilities to produce electronic components, it continued to get about half of its supplies from outside the group throughout the 1970s. Japanese general electronics companies like Hitachi, NEC, and Toshiba were among the largest providers to Hattori during the decade. For Hattori, working with these companies to co-develop new kinds of chips ensured access to the best electronic technology available at that time (Yongdo Kim 2006).

Competition with Swiss watchmakers to be the first to market a quartz watch was very strong, and Longines announced in August 1969 that it planned to commercialize its prototype soon. On the orders of Hattori Shoji, the top executive at the Hattori group, Suwa's engineers succeeded in getting a quartz watch to market before the company's Swiss rival (John Goodall 2003, 57). The watch released by Suwa on Christmas Day, 1969 (the 35 SQ model) was an expensive luxury item (450,000 yen, or about 1,257 USD) (Seiko 1996, 153). After this commercial victory, Suwa's engineers worked to improve the product and launched a new version (the SG 38 model) with a better quality and lower price (135,000 yen, or about 389 USD) in 1971 (Seiko 1996, 154). At the same time, the Hattori group's second watch manufacturer, Daini Seikosha (hereafter "Daini"; now SII), marketed its own first quartz watch in 1970 (the 36 SQ model).

Suwa and Daini also engaged actively in the development of a digital watch. After having tried in vain to purchase digital watch technology from the US firm RCA, the Japanese engineers started in-house R&D under the supervision of Tohoku University professors Toyoshima and Mitsui (1968). This alliance gave birth to digital prototypes, which Daini and Suwa presented in 1972 and 1973, respectively. Digital technology made it possible to quickly add new functions, such as calendar (1976), alarm (1977), chronograph (1977), world time (1977), calculator (1977)

and date (1978) features (Seiko, 1996, 162). Finally, in 1983, Hattori launched the world's first TV-watch. The world of innovation possibilities that electronics opened up seemed endless.

The quartz revolution in the Hattori group was not only a matter of product innovation. The commercialization of the world's first quartz watch on Christmas Day, 1969, was largely a communication operation aimed at establishing the image of an innovative enterprise. The first models were expensive and produced in such small quantities that quartz watches did not even appear as a specific category in the Hattori group's official statistics until 1971, when they still amounted to only 3,000 pieces. The company's volume of quartz watches climbed to 64,000 pieces in 1972 and experienced a dramatic increase to 1.7 million pieces in 1975, 25.5 million in 1980, and more than 100 million since 1990 (see Table 2). While Longines produced less than 250,000 quartz watches in 1980, Hattori churned out more than 25 million that same year. This stark difference in scale made it possible for the Japanese company to decrease production costs and thrive in world markets.

Table 2

Watch production by the Hattori group, 1970-1990

	1970	1975	1980	1985	1990
Watches, total (million pieces)	14.0	16.9	35.9	68.8	125.4
Quartz watches (million pieces)	0	1.7	25.5	60.1	118.6
Quartz watches as percentage of total production	0	10.1	71.6	87.4	94.6

Source: Production statistics provided by the Seiko Museum.

The implementation of a mass-production system resulted from the use of automatization methods for assembly, which the Hattori group had been developing since the late 1960s. In 1968, Daini and Suwa received a three-year, 334-million-yen (about 930,000-USD) grant from the MITI to develop a system of automatized assembly chains capable of producing more than 100,000 watches a month (Seiko 1996, 167-168). This "system A," for which some fifty patents were registered in Japan, represented an investment of 2.5 billion yen (about 8.3 million USD in 1972) and won the

prestigious prize for industrial production from the Okochi Foundation in 1975. Suwa introduced automated assembly technology in its most important subsidiaries, which specialized in this activity, while the parent company focused on developing an automated assembly system for new kinds of watches. The high level of product innovation (functions, sizes, and types of movements) required a continuous adaptation of mass-production technology. In 1978, *Nikkei Business*, the most influential business magazine in Japan, profiled Suwa as "an R&D center equipped with a plant."[13] At that time the company employed some 2,500 people—65 percent of whom were involved in R&D. They developed new prototypes and then tested their production and assembly on an automated system in small series (4,000–5,000 pieces) before transferring their mass-production to subsidiaries.

The main consequence of the implementation of automated production and assembly was the ability to mass-produce watch movements—first mechanical, then quartz—for a very low unit cost. The drop in production costs, essential for the manufacture of electronic watches, gave the Hattori group a major competitive advantage over its Swiss rivals, which were slow to industrialize the production of quartz watches.

Conclusion

The above comparative analysis of the dynamics of innovation in the quartz watch at Compagnies des Montres Longines and Hattori and Co. (Seiko), the first companies to commercialize quartz watches in Switzerland and Japan, respectively, highlights rather distinct organizational models. Two key characteristics emerge from the analysis.

First, both companies reacted in very different ways in response to new electronics technologies that neither of them could master in the early 1960s. In Switzerland, Longines outsourced the development and production of electronics components to a small specialized company, Bernard Golay SA. After Golay went bankrupt, Longines proceeded to procure supplies from its main shareholder, Ebauches SA. Not until 1977-1978 did Longines start producing quartz watches on a fully in-house

[13] *Nikkei Business*, June 19, 1978.

basis; for about ten years, then, the Swiss watchmaker did not internalize electronics technologies.

Hattori contrasted its Swiss counterpart by following a path of extremely rapid internalization. Like Longines, the Japanese watchmaker was unable to master electronics technology in the early 1960s and thus collaborated with an external partner, the US company Intersil, to develop a chip for a quartz movement for watches. However, Hattori managed to bring this technology back to its production centers in Japan soon after development was complete. Through the employment of electronics-oriented engineers and cooperative efforts with universities and public R&D centers, Hattori succeeded in improving its electronic modules and developing new models of quartz watches in-house.

Second, R&D centers occupied a very different position within the corporate contexts of Longines and Hattori. At Longines, R&D on electronic watches took place in a small, isolated unit that lay outside the company's production system. The unit's main responsibility was to develop prototypes of quartz watches with electronic modules acquired from other companies. Many practical difficulties thus appeared when the company decided to enter the production phase of quartz watches, as the company had failed to develop prototypes from the perspective of serial production and to organize workshops to support the mass-production of these goods.

Hattori presents a completely different kind of organization. R&D was totally integrated into the production system and devised since the beginning in view of future mass-production. The engineers who developed the new models of quartz watches at Hattori also worked on the implementation of "system A," which aimed to automate assembly lines.[14]

This twofold difference—divergent approaches to the internalization of electronics technology and the integration of R&D into the production system—represents a major difference in strategy, a result of differences in terms of size and capacity to invest in a new technology. At Hattori, the management of the group's long-term strategy was to mass-produce high-quality watches—whether they were mechanical or electronic. Longines' directors, meanwhile, were more commited to a wait-and-see policy. They

[14] *Gijutsu no genryu*, Tokyo, Daini Seikosha, 1991.

did not demonstrate a particular technical conservatism, as some scholars have argued (Landes, 1983), but tried at first to maintain the structure of their enterprise as an independent family firm. Consequently, Hattori and Longines had no major difference in the rhythm of their acquisition of electronics technology: they presented their first prototypes in 1967 and 1969, respectively, and reached a level where electronic goods accounted for more than 70 percent of their watch production in 1980 and 1981, respectively. However, their production volumes reveal different industrial worlds: in 1980, Hattori had a quartz watch production capacity that was one hundred times larger than that of Longines, a gap that only continued to widen until the end of the 1980s.

Consequently, the focus on firm-specific factors explains the competitiveness of Japanese companies by the adoption of a strategy and the implementation of an organization that allowed more effective mobilization of resources than their Swiss rivals. However, the approaches that emphasize rather country-specific factors (VOC and NIS) can also be used to clarify the competitive advantage of Hattori. Two major points can be underlined.

First, in Switzerland, market relations played a key role in organizing R&D and procuring supplies of electronic components. For about 10 years, Longines did not internalize these elements of know-how and relied on other private companies. The firm limited its in-house research to the basic understanding of electronics technology and the development of prototypes but outsourced applied research and the production of specific parts. There was no need to have direct control over the innovation itself. Despite joint research taking place in the Swiss watch industry during the 1960s, private companies nevertheless adopted their own R&D strategies instead of relying on this cooperative form of innovation. In this sense, Switzerland can be classified as a liberal market economy (Hall and Soskice 2001) or liberal market capitalism (Amable 2003).

Second, Hattori's strategy regarding electronic watches embodies a typical coordinated market economy (Hall and Soskice 2001) or Asian capitalism (Amable 2003). Since its inception, the company carried out research with applied goals (improving watch precision and achieving mass production) and implemented a strategy to control the innovation directly. However, the company cooperated actively with general

electronics companies like Hitachi, NEC, and Toshiba on the co-development of chips—a trend noticeable elsewhere in the Japanese manufacturing industry during the 1960s and 1970s (Kim 2006). Still, Hattori exercised full control over the design and production of electronic watches.

In this sense, this capitalism type has a major impact on the dynamics of innovation. Institutional differences between nations certainly have an effect on corporate strategy, but any attempt to understand the dynamics fully needs to balance the degree of that influence with the specificities of industries and firms (Bouwens, Donzé and Kurosawa 2018). For example, as the Swiss watch industry comprised hundreds of small and medium-sized enterprises at the time, companies used market mechanisms to access innovation given how demanding it would have been to invest in building new R&D facilities. Industry-specific factors (organizational structure) therefore had a deep impact on the way in which innovation was carried out. In other sectors of the Swiss economy, such as the large enterprise-dominated chemical or electric machinery industries, however, in-house R&D was the rule. Innovation is carried out directly by companies, often organized as multinational enterprises, which usually do not cooperate to jointly develop new technology.

As for the specificities of firms, although Longines and Hattori were both family businesses, their historical development, weights in their respective domestic industry, and their respective sizes also had an impact on the ways they carried out innovation. Consequently, this article has emphasized the need to adopt a multidimensional perspective in forming a comparative business history of the dynamics of innovation. Firm-specific and country-specific factors offer different approaches to consider innovation that are sometimes opposing. The focus on individuals in organizations (like engineers in watch companies) highlights the importance of considering the specificities of industries to explain properly what shaped their actions.

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