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Innovation and recurring shifts in industrial leadership: Three phases of change and persistence in the camera industry☆

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ABSTRACT

This study examines factors underlying three phases of change or persistence in industrial leadership in the sector of interchangeable-lens cameras over the past century. During this period there were two major phases of leadership change, both associated with the emergence of innovations involving major discontinuities in the industry's core technologies. First, Japan won market leadership from Germany in the mid-1960s after commercializing the single-lens reflex (SLR) camera that replaced the previously dominant German rangefinder camera. Second, in the late-2000s, Japanese latecomer firms and a Korean firm developed Mirrorless cameras, which allowed them to capture the majority of market share from the incumbent Japanese leaders. We also examine the long period (about 60 years) between these two phases of change, during which leading Japanese firms were able to sustain their market leadership despite the digital revolution from the 1980s to 1990s. This paper explores the factors influencing these contrasting experiences of change and persistence in industry leadership. The analysis integrates several aspects of sectoral innovation systems – i.e., windows of opportunity associated with technology, demand, and institution – as well as the strategies of incumbents and latecomer firms. The conclusions highlight the complex and diverse combinations and importance of the factors that help explain the patterns of shifts in leadership.

1. Introduction

Latecomer firms may have considerable difficulty catching up with industry leaders. Consumers frequently choose leading firms with better products, superior resources, and proven capabilities. Incumbent leaders strengthen their dominant position by leveraging their market power and building barriers to entry. Valuable assets resulting from market dominance, such as secure branding, good reputation, network effects, access to high-level information, and slack resources further reinforce their superior position. In this sense, many researchers and practitioners have emphasized the importance of market leadership and incumbent advantage.

Interestingly, however, latecomers occasionally surpass incumbents and become new industry leaders. Furthermore, this catch-up tends to occur repeatedly in many industries; new leaders subsequently lose the dominant market position to other rising firms. Although leading firms must have learned from their own experiences when catching up, they lose their technological edge and market competitiveness to challengers, just as former incumbents did before them. Despite the elaborate strategies and actions of new market leaders to satisfy consumers, they often seem powerless to prevent this pattern from being repeated.

We investigate recurrent shifts in industrial leadership and the mechanisms behind them in the context of the interchangeable-lens camera industry. In doing so, we look at multiple levels in two important dimensions of the industry. First, we identify recurrent shifts in leadership at the firm level – that is, shifts between (a group of) individual firms, sometimes occurring within economies – and also at the national level. Second, we note that catching up is not limited to explanatory factors relevant at the firm level. Leadership shifts that happen at the national level imply that analyses at the firm level cannot be exhaustive, and that broader perspectives and multiple levels of analysis are necessary. We therefore examine a wide range of explanatory factors that contribute to leadership shift or catch-up and their interactions on different levels..

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In this study, we analyze successive shifts in industrial leadership between countries as well as firms. We examine the influence of technological advances, market demand, government policies, international conditions, and the interaction between strategies in latecomer firms and the responses of leaders. Our cases include firms in the camera industry, which has been the focus of several studies. For example, Wu et al. (2014) examined technological changes in several camera manufacturing companies from the perspective of firm heterogeneity and complementary assets. Their focus, however, was on the relationship between complementary assets and trajectory choices *within* a firm rather than inter-firm competition. The growth of Canon and Nikon has been examined, with a focus on Japan's support for the optical industry before and during World War II, by Alexander (2002) and Donze (2014), respectively. However, the *dynamics* of innovation and industrial leadership, especially between countries, have been overlooked. To the best of our knowledge, no study has investigated successive changes in industrial leadership in the camera industry within a comprehensive analytical framework. In particular, the recent proliferation of Mirrorless cameras pioneered by Japanese and Korean latecomers requires elucidation.

Our focus is on the interchangeable-lens camera industry, which provides us with invaluable opportunities to examine the mechanisms behind its recurrent leadership shifts. Three major phases can be identified in its 100-year history. The first notable historical event was the development of the 35-mm rangefinder camera developed by German firms in the early twentieth century. This was followed by three different technologies or product designs. The first was the single lens reflex (SLR) camera introduced by Japanese firms in the mid-1950s, which captured the major market share by the mid-1960s. In turn, this was followed by the development of the digital SLR (DSLR) camera in the 1980s–1990s by the (then) leading Japanese firms, which continued to dominate the camera market. Finally, the Mirrorless camera was developed by other latecomer Japanese and Korean firms in the late 2000s, achieving a large market share by the mid-2010s despite significant barriers to entry in this industry. These varied episodes in the interchangeable-lens camera market provide ample opportunities to study changes in industrial leadership that occur repeatedly not only between firms, but also between countries.

In terms of research methodology, we rely mainly on secondary sources of information when scrutinizing the three phases of leadership in the interchangeable-lens camera market. We look at global or national market shares either at the individual firm level or at the level of technological standards. Other, less explicit dimensions, such as superiority of new technologies, their rapid diffusion/adoption, and industry experts' opinion, are considered as well.

Our baseline research question is as follows: what are the factors that make changes in industrial leadership possible (or impossible)? Subsequent questions that naturally arise include: why did the catch-up in this industry occur successively? Finally, what are the commonalities and peculiarities across multiple catch-up cases?

This paper is organized as follows. In Section 2, we provide the theoretical framework for our analyses on multiple leadership shifts across firms and nations. We also outline important concepts related to technological change and catch-up. In Section 3, we describe the specific product that claims our attention: the interchangeable-lens camera. In Sections 4–6, we analyze the three phases of industry leadership in chronological order. In each section, we begin with a brief narration of the catch-up story and then discuss three windows of opportunity and strategic actions of both latecomer and leader firms. Section 7 then summarizes our main findings and concludes the study.

2. Theoretical framework

In scrutinizing successive changes in industrial leadership that happened at the firm or country levels, we comprehensively identify explanatory factors at various levels. Several fine theories and frameworks have been developed, such as product cycle theory (Posner, 1961; Vernon, 1966), sectoral systems of innovation (Malerba, 2002), patterns of technological catch-up (Lee and Lim, 2001), and national innovation systems (Freeman, 1987; Lundvall, 1992; Nelson, 1993). However, given that our study entails both temporal variation (successive leadership shifts) and level-of-analysis variation (firm, industry, national, and international factors), no single theory may be adequate to explain the phenomena of interest.

Recognizing a need for a more integrative approach, Lee and Malerba (2017) devised a new theoretical framework that captures the various features of dynamic shifts in industrial leadership. Their framework consists of two main components: windows of opportunity and strategies of firms. First, they further developed the concept of windows of opportunity, building on Perez and Soete (1988), as follows. As an industry evolves, one or more of the fundamental components of the sectoral system may change. This change paves the way for latecomers to catch up. Three windows of opportunity are proposed in that study: (1) changes in knowledge/technology, (2) changes in demand, and (3) changes in institutions and public policy. The second component that completes the framework is firm capabilities and strategies. In dynamic industrial environments, firms are actors that compete in the market. In this study, we distinguish the strategies of incumbent leaders from those of challengers, and discuss strategic interactions between them. Windows of opportunity and firm strategies are intimately connected to each other and to the cycle of leadership shift (or catch-up) in industries.

To facilitate analysis of these two important components of Lee and Malerba (2017), we highlight several important concepts about technological change. First, to assess the effects of new technologies, we make use of Tushman and Anderson's (1986) insightful work; they classified technological discontinuity in terms of a firm's existing competence. A *competence-enhancing discontinuity* represents "an order-of-magnitude improvement over prior products [that] build[s] on existing know-how", whereas a *competence-destroying discontinuity* is a "mastery of the new technology which fundamentally alters the set of relevant competences within a product class" (Tushman and Anderson, 1986: p. 442). Incumbent firms in an industry are in a superior position to exploit competence-enhancing discontinuities, whereas a competence-destroying discontinuity, which disrupts the established industry structure, favors new entrants or latecomers.

Second, Lee and Lim (2001) developed a similar concept from the perspective of firm strategies. Building on Perez and Soete's (1988) "leapfrogging" concept, they drew a contrast between path-creating catch-up (in which a new technological trajectory is pioneered) and path-following catch-up (in which latecomers pursue the same technological path as the existing leaders). Path-skipping catch-up, in which the existing technological trajectory is followed but several steps are skipped, lies in between.

Along with challenging firms' capabilities and strategies, incumbents' responses also play an important role in the catch-up process. Incumbent leaders generally have superior resources and capabilities compared to latecomers and thus are inclined to build on their current technological assets or trajectories. This path dependency makes industrial leaders inattentive to changing demands or disruptive technologies. This is often called the "incumbent trap" (Chandy and Tellis, 2000) or "success trap" (Levinthal and March, 1993). We discuss how the competitive assets or strategies

that made catch-up possible in the past may become a *liability of success* at a later stage.

The ultimate goal of this study is to identify important explanatory factors, their interactions, and their changing roles over time. To this end, we verify the following propositions: (1) shifts in industrial leadership happen repeatedly in an industry (baseline); (2) the aforementioned three windows of opportunity and strategies of firms interact and together determine the success of a catch-up (framework); (3) certain factors are commonly observed as necessary conditions, such as competence-destroying discontinuity along with latecomers' path-creating strategies (commonalities); (4) the relative importance of each factor differs across catch-up cases, and there is no one-size-fits-all explanation for the catch-up cycle (peculiarities); and (5) shifts in industrial leadership can be grasped fully when we look at changes in windows of opportunity and firm responses comprehensively and weigh their relative importance (general implications).

3. The interchangeable-lens camera market

The camera industry is large and heterogeneous. It supplies a wide range of products for use in numerous applications (e.g., military, medical, scientific, and satellite) in widely differing settings and at different levels of technical skill (amateur, professional). Several criteria can be used to classify different types of cameras. These include differences in the product's applications and users, the particular characteristics of the equipment itself such as sensor size, the number of picture elements (pixels), lens interchangeability, body size, price, consumer substitutability, supplier substitutability, and so on. The approach to classification taken in this research differs from that in several other studies of the industry. For example, Tripsas and Gavetti (2000) focused narrowly on only the development of digital imaging cameras in a single U.S. company, Polaroid, while Miranda and Lima (2013) took a very broad approach by examining the camera industry as a whole. The studies ofWindrum (2005) and Windrum and Birchenhall (1998) fell between these extremes, using a classification of photographic products based on the type of consumer: amateur vs. professional. However, this definition is not suitable for the purposes of our research on the catch-up cycle. The distinction between amateur and professional is rather indefinite, and patterns of camera consumption for both groups have tended to converge over time as technology improves (producer side) and becomes more widespread and affordable (consumer side). A clearer and more consistent classification is required for our purposes. Therefore, we identify sensor size and lens interchangeability as the two most important characteristics that distinguish various camera products. We describe these characteristics as follows.

First, since a camera is an optical device that takes photographs by recording light, the size of the image sensor, which receives and processes light, largely determines the image quality. As seen in Table 1, sensors in digital cameras vary in size from 1/2.3" to Medium Format. Film cameras usually require 35-mm film, which corresponds to a Full Frame digital image sensor (36×24 mm).

Second, lens interchangeability determines the flexibility of user experience with camera products. An interchangeable-lens camera system consists of camera bodies and lenses that are compatible. For the consumer, interchangeable-lens cameras provide a superior user experience and better image quality that fits a specific purpose. Due to the interchangeability of lenses, the camera system becomes highly flexible in terms of choice of focal lengths, number of aperture blades, and maximum aperture size (lens speed). On the technology side, the interchangeable-lens camera system requires much more sophisticated technology. In addition, major players in the camera market do not share their lenses with other camera manufacturers, and thus all lenses are generally incompatible with cameras made by different makers. The interchangeable-lens camera and its lenses comprised 76.9% of the total sales revenue in the world camera market in 2015 (CIPA, 2016).

In our research on the camera industry, therefore, we investigate the intersection of these two important features: sensor size and lens interchangeability. Specifically, we focus on interchangeable-lens cameras with middle-range sensors ranging from (Micro) Four Thirds to Full Frame, following the views of camera experts and producers. We hereafter call this submarket the interchangeable-lens camera market. This enables us to define the relevant market of analysis consistently for all three phases of industrial leadership over the course of a century, which is discussed in the following three sections of the paper.

4. The leadership shift from Germany to Japan (mid-1960s)

4.1. Catch-up story

In the early 20th century, the 35-mm film rangefinder camera was an astounding invention. Oskar Barnack, a German optical engineer working for Ernst Leitz GmbH, invented 35-mm film, which produces high-quality photographs, by cutting movie film. Adopting its employee's innovation, Ernst Leitz GmbH first introduced a 35-mm film rangefinder camera, the Leica I, in 1925 (Forbes, 1988; Gustavson, 2009). The 35-mm film made it possible to design a much lighter, smaller, and more portable camera.

The rangefinder camera was a great success. After the release of the Leica I in 1925, the German rangefinder camera set the global standard for portable camera products; it quickly replaced the bulky and inconvenient box camera (Forbes, 1988). Later, in 1932, the second entrant Zeiss-Ikon of Germany released the Contax I. While various rangefinder cameras from different makers (including Japanese late entrants) were later released, Germany maintained its market leadership for several decades.

In the early days of their involvement in the camera business, Japan produced rangefinder cameras which resembled those of their German counterparts. Japanese latecomer firms, however, could not compete with German leaders in the rangefinder camera market. They also wanted to solve the problems inherent in the design of rangefinder cameras. As such, Japanese latecomers determined to develop a different technology, the SLR camera, in the late 1950s.

Products made by these Japanese challengers soon outperformed those made by the incumbent German firms. The SLR camera design ensured perfect compatibility between various lenses and camera bodies. Furthermore, SLR cameras were simpler to use and cheaper than rangefinder cameras (Forbes, 1988). For these reasons, although larger and weightier than the rangefinder camera, the Japanese SLR camera rapidly replaced the German-dominated rangefinder camera and became the market standard. Japan leapfrogged over Germany in terms of camera production and export in the early 1960s (Windrum, 2005; Donze, 2014).

4.2. Windows of opportunity: technology and demand

While Germany dominated the rangefinder camera market in the early 20th century, an opportunity to catch up – involving both technology and demand conditions – presented itself. Although rangefinder cameras replaced box cameras with their innovative product design and portability, two critical drawbacks were inherent in their design: parallax and limited lens interchangeability. The rangefinder camera embodies two lenses, as shown in Fig. 1. The one in the front is the main lens for receiving light and recording it

Table 1
Comparison of Image Sensors by Type.

Sensor Type	1/2.3"	1"	(Micro) Four Thirds	APS-C	35-mm (Full Frame)	Medium Format
Surface Area	28.5 mm^2	116.2 mm^2	224.9 mm^2	330–370 mm^2	864 mm^2	1,977 mm^2
Crop Factor	5.6	2.7	2	1.5–1.6	1	0.6–0.8
Most Adopted	Compact Camera		DSLR Camera, Mirrorless Camera			DSLR Camera

Crop factor: the ratio of a 35-mm frame's diagonal to the diagonal of other types of image sensors.

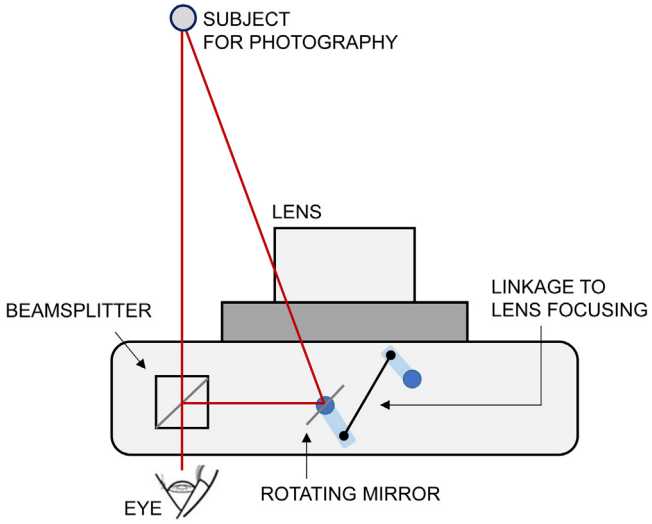

Fig. 1. Structure of the Rangefinder Camera.
Source: Camerapedia

to the film. Another lens is built into the viewfinder, which enables the photographer to frame the photo and adjust the focus.

Having two lenses in one camera causes a parallax problem, a displacement in the position of the subject viewed along two different lines of sight. The resulting image differs from what the photographer sees through the viewfinder. Moreover, the degree of difference is not consistent over distance; the closer the subject is, the larger the difference becomes. Therefore, the viewfinder does not support multiple lenses of different focal lengths.

In the early days of photography, on the demand side, the advantages (notably portability) of the rangefinder camera outweighed its demerits. As time went on, however, these two drawbacks became increasingly critical problems for photographers (Windrum, 2005). They wanted parallax-free cameras with full flexibility in terms of compatible lenses. On the technology side, however, this demand change could hardly be satisfied within the then-current design of rangefinder cameras. The situation was clearly an opportunity for the latecomer firm because the incumbent leaders could not adequately cope with new demand using their existing product designs and technological expertise. Japanese SLR cameras with their two new distinctive components – the mirror box and the penta-prism – resolved the drawbacks of rangefinder cameras. As Panel (A) of Fig. 2 illustrates, the SLR camera uses a *single* lens and reflex mechanisms to eliminate parallax or framing errors. This brought a competence-destroying discontinuity into the interchangeable-lens camera market.

4.3. Windows of opportunity: policy and institutions

Along with the demand and technology windows of opportunity, important industrial changes were induced by international affairs and government policies. World War II, in particular, provided an opportunity for market entry and growth for Japanese firms, whereas it worked against the leading German firms.

We first discuss the influence of World War II. During wartime, to cope with the surging demand for optical military equipment, Germany sent optical engineers to Japan. This allowed Japan to absorb advanced knowledge in the fields of optics and imaging. For instance, Nikon acquired most of its early technologies for optical products with the help of German firms before the war, and this technological aid was further accelerated during World War II when Nikon began producing optical instruments for military use (Business Week, 1965; Alexander, 2002).

The surge in demand due to the war can also be thought of in relation to international politics/institutions. Most manufacturers, including Canon and Nikon, engaged in producing optical components for munitions during the war (Donze, 2014). Accordingly, after the war, the Japanese optical industry was well equipped to fill postwar demand for optical products. In contrast, Germany's production facility was extensively damaged during the war. To make matters worse, postwar labor costs surged in Germany and made it almost impossible to withstand Japanese competition.

Furthermore, during the Korean War, opportunities arose to disseminate the brand and technology of Japanese cameras. American photographers experienced the excellence of the Nikon camera when they came to Korea and Japan as war correspondents. In this way, Nikon could promote their products in North America during the Korean War, and subsequently, its worldwide reputation for excellent camera products began to grow (Business Week, 1965).

Second, Japan implemented strong policies for promoting the camera and optics industries. Prior to the 1960s, Japan had actively promoted its camera and optics industries. With the aim of achieving self-sufficiency in important technologies, an optical research laboratory that had already been established in 1906 to promote the industry was used for producing optical weapons for the Japanese Army (Alexander, 2002). This was the origin of the current giants in the camera industry, Canon and Nikon. In addition, Japan strongly protected its camera industry by imposing a duty on imported optical products. The import duty for camera products was 50% from 1911 until World War II; it was even temporarily increased to 100% in 1924–1925. Camera imports were restricted by quotas and authorizations, including a ban on importing luxury cameras until 1960, by which time the Japanese had caught up with their German competitors in the camera industry (Donze, 2014).

Japanese promotional policies in the camera industry were not limited to a self-supply regime and high import duties. Many engineers were hired by the arsenals of the Army and Navy, providing private firms with a "human resource reservoir" in which engineers could be educated and trained (Donze, 2014). In addition, government-led projects and human resource development were later transferred to private companies. For instance, after the Great Kanto Earthquake of 1923, "many talented military engineers and research projects were assigned to Nippon Kogaku [Nikon]. . . expanding both the number of technicians or staff and the breadth of the company's research capabilities" (Alexander, 2002: p. 21). The Japanese government (and Navy Ministry) also swiftly intervened to help rebuild Nikon's production facilities after the earthquake. Japan strategically promoted the camera industry because this high value-added industry contributed to foreign exchange earnings and had great potential to be transformed into a civilian industry.

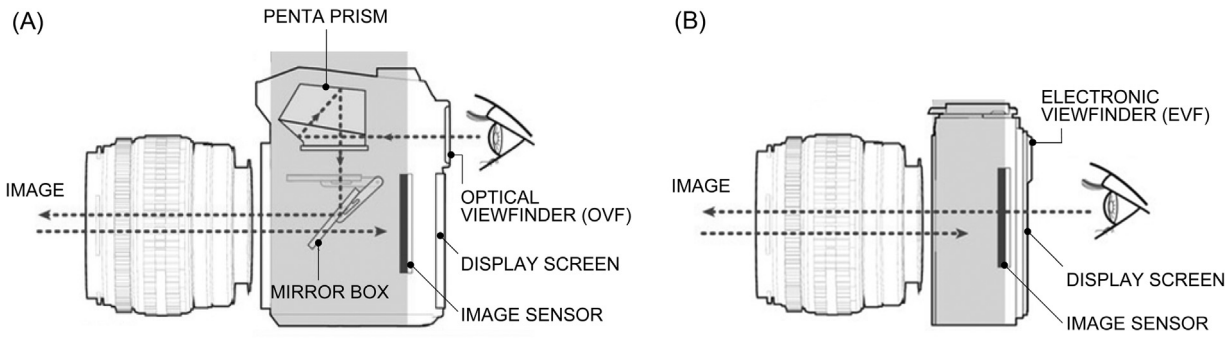

Fig. 2. DSLR Camera and Mirrorless Camera.

Source: Wakabayashi (2012).

Joint R&D activities among private firms, universities, and national institutes became popular after the war, during which time the Japanese further improved upon their camera and optic technologies. Japanese governments and industrial associations were deeply involved in promoting product quality and exporting in the camera/optics industry (or armaments industry), and most Japanese manufacturers of cameras and optical products benefited from their policies (Donze, 2014).

In connection with the demand window of opportunity, even after World War II, American occupation authorities and the new Japanese government demanded a large number of cameras. For example, Nikon's camera research and relevant technological achievements developed primarily as a result of direct demand and pressure from the Japanese government and military (Alexander, 2002: p. 26). A large-scale Japanese mass-production system (with low wages) also became possible because of the government's efforts. In contrast, Germany pursued a policy of "Klasse statt Masse" (quality beats quantity), resisting the shift to mass production (Windrum et al., 2014).

4.4. Latecomer capabilities and strategies

Latecomers, or followers, generally make good use of information leaked from their forerunners (Berndt et al., 2003; Ethiraj and Zhu, 2008; Hoppe and Lehmann-Grube, 2001). In the first case, Germany willingly transferred knowledge of camera technology and relocated many technicians to Japan. As a natural consequence, they initially imitated German camera designs and pursued a "Japanese Leica" via reverse engineering (Donze, 2014).

After a certain point, however, incumbent leaders become reluctant to transfer knowledge and technology to other firms, which may become a potential threat (Kogut and Zander, 1996; Song et al., 2003). In addition, the reputation, brand power, and technology of German rangefinder cameras were almost unsurpassable. Confronting this competitive environment, Japan conducted market surveys and stayed sensitive to changes in consumer demand for new technologies (Business Week, 1965: p. 50). Japanese latecomers then recognized that the SLR camera held great potential to remedy the parallax and lens-incompatibility problems of rangefinder cameras, thereby satisfying changing consumer demands.

In the late 1950s, Japanese latecomers boldly pioneered a new technology, the SLR mechanism, which resolved parallax (or framing) errors. Their pioneering efforts to initiate a new technological trajectory (i.e., path creation) brought a competence-destroying discontinuity to the market, rendering the German incumbent's rangefinder camera obsolete (Windrum, 2005). Interestingly and importantly, the SLR camera was not a Japanese invention; a German firm, Zeiss Ikon, designed the first SLR camera, the Contax S, in 1949. However, the early SLR design had several problems. One of the most prominent was that an additional manual motion was required before shooting. The photographer must manually open the aperture fully in order to see an object through the single lens (viewfinder) and focus; the aperture then needs to be adjusted to the desired setting. By the time Nikon's SLR camera came onto the market in 1958, Japanese firms had already made this motion automatic and solved other problems, such as the 180° flipped image, further improving the SLR design (Business Week, 1965: p. 50). As a result, Japanese SLR cameras provided photographers with much more functionality and flexibility. One single camera was now usable with any kind of lens.

Two noteworthy strategies made the Japanese latecomers' catch-up possible: mass production and cooperation. First, while German incumbents pursued a wide range of camera products for diversified purposes for economies of scope, Japanese firms adopted a mass production system for general-purpose cameras for economies of scale (Windrum et al. 2014; Donze, 2014). By compartmentalization and rationalization of their manufacturing process, Japanese firms succeeded in achieving both high quality and low price. Second, being latecomers in the camera market, Japanese firms cooperated closely. Although Canon developed camera bodies, it lacked technologies and production lines for producing rangefinders and lenses. Nikon remedied this situation by providing Canon with these components, as they had superior facilities and technology for optical products, having supplied them to the Imperial Japanese Navy (Donze, 2014). The cooperation between these two specialized firms facilitated technological advances and economies of scale in the catch-up process. This pattern is also observed in the third case described in section 6.

4.5. Industry leaders' response

While Japanese followers searched for alternative technologies, German leaders continued to focus on the rangefinder camera. However, photographers increasingly demanded the freedom to utilize various lenses with full functionality. Due to the significant improvements provided by the SLR camera in terms of the two critical problems of the rangefinder camera, German manufacturers were in danger in the early 1960s. Nonetheless, Germany remained highly confident and looked down on Japanese firms (Donze, 2014). Leica, for example, cared (too much) about quality, as evidenced by the statement from Günther Leitz, a Leica president, that "Leica will produce nothing that it can't make to the highest standards of perfection, regardless of market demand" (Business Week, 1965: p. 50).

The successful history of German companies also lowered their incentive to move on to new technologies, which in the end made their established resources and capabilities partially obsolete. Their overconfidence and strategic inertia turned out to be critical to the leadership shift. Günther Leitz believed that "there will always be

a group of people large enough to provide a market for our kind of product" (Business Week, 1965: p. 56). Leica continued to manufacture rangefinder cameras despite the fact that "the ultimate answer to the problem of flexibility. . . was obviously the single lens reflex" (Business Week, 1965: p. 50). Japanese challengers with their SLR cameras offered more of what consumers wanted: a single camera for all purposes. Bruno Frey, who became the president of Leica in 1987, later acknowledged that "Leica hasn't had a strategy attuned to the market. . . Leica just gave up the market to the Japanese" (Forbes, 1988: p. 100). It was their inability to move away from their rangefinder camera design (i.e. the "success trap") that made the German forerunners fall behind.

It is noteworthy that Leica did endeavor to solve the problems of the rangefinder camera. After a long delay, Leica finally developed an "SLR-like" camera, an interchangeable-lens camera *within* the boundary of a rangefinder camera. The product was compatible with several lenses. Leica's M-3 (released in 1965), for instance, had a viewfinder that would support up to four different lenses. However, this short-sighted path-dependent advance was never enough to cope with the innovation in user experience and functionality brought about by the Japanese challengers. Its limited compatibility was still a great disadvantage of the German rangefinder, compared to the flexibility of Japanese SLR cameras.

5. Sustained Japanese leadership (late 1960s to late 2000s)

5.1. Leadership persistence story

In this second phase, incumbent firms' leadership persisted despite the transition to digital technology in the interchangeable-lens camera industry. This was a non-trivial technological discontinuity, although different from the two successful cases of catch-up described in this study. The incumbent Japanese leaders in the market persisted despite the efforts of latecomers who sought to challenge them. This contrasting case provides us with a valuable opportunity to deepen our understanding of shifts in industrial leadership.

The leaders in the SLR camera market, Canon and Nikon, developed the digital SLR (DSLR) cameras. Although they were not the very first manufacturers to introduce the DSLR camera in the market, they rapidly adopted and promoted this product when the digital revolution hit the market, thereby preserving their superiority in terms of resources and capabilities. Canon, together with Kodak, released a transitional DSLR camera (an SLR camera with a digital back), known as the EOS DCS3, in July 1995. Canon later introduced its first home-grown DSLR camera, the EOS D30, in May 2000. Nikon released its first DSLR camera, the Nikon D1, in June 1999.

The latecomers' technology shared the same trajectory as that of the incumbent firms. In fact, the first DSLR camera was developed by a latecomer in the SLR camera market. Eastman Kodak, an American camera manufacturer, was the first to develop a prototype digital camera in 1975 (Reuters, 2011). However, the company failed to commercialize and capitalize on its DSLR cameras in a timely manner, fearing that doing so would threaten Kodak's strong film business. Other latecomers introduced their DSLR cameras in the decade from 1990 to 2000. Some manufacturers that had not produced SLR cameras entered the DSLR market around this time as well, including Sony, Panasonic, Pentax and Samsung.

The digital technology revolution and relevant windows of opportunity, however, did not change the leadership in this industry. In the era of digitization, Japanese leaders succeeded in further strengthening their leadership position in the interchangeable-lens camera market. Reuters reported that Canon and Nikon together occupied nearly 100% of the global interchangeable-lens camera market in 2003, at a time when the market was still young (Reuters, 2004). Fig. 3 shows that these firms continued to occupy about 80% of both the Japanese and global interchangeable-lens camera markets in 2008; indeed, their dominance had persisted for several decades from the 1960s to the mid-2000s despite the introduction of digital technology.

5.2. Windows of opportunity: technology

The "digital revolution", or the large-scale change from analog to digital technology, gradually occurred from the 1960s to the 2000s. The camera industry was no exception; the digital SLR (DSLR) camera, in which photographic film is replaced with a digital imaging sensor, was developed as a result of the digital revolution. The DSLR camera had evident advantages over the SLR camera. The SLR camera uses film, which is non-reusable, inconvenient, and costly. For photographic films, for example, its speed (i.e., the sensitivity of the film to light) and color impressions (such as Provia and Astra) are pre-determined. In contrast, digital photography using an image sensor allows photographers to change such photographic settings just before or even after shooting. They can also re-use the memory card and review an image immediately through a digital display, not requiring film exchange and development.

The technological change from SLR to DSLR cameras differed fundamentally from the changes involved in our two cases of successful catch-up in several respects. First, similar to the development of television technology, where 60% of the digital television production process was the same as that of analog television (Lee et al., 2005), the DSLR design was developed based largely on existing technology, the SLR design. As they shared the same technological path, the DSLR camera could be described as a predictable extension of the SLR camera. One major difference was that film-related parts were substituted by the image sensor. For incumbent SLR camera makers, however, this substitution was not costly or difficult to adopt technically. Therefore, incumbent leaders still had significant advantages in dealing with new demand and made good use of technological and institutional windows of opportunity.

Second, barriers to entry arising from cross-brand lens incompatibility were preserved even after the change to digital technologies. The cross-brand incompatibility of lenses served as a particularly strong entry barrier to latecomers, because existing consumers were forced to continue to buy the same brand in order to retain the value of their previous investments in photographic equipment. In addition, as the consumer base increased, suppliers of complementary goods – including third-party lens producers – had greater incentives to develop additional lenses and accessories compatible with the expanding brand. The result was a large direct network effect. Furthermore, the after-sales service network in the camera industry generated strong indirect network effects. These direct and indirect network effects made Canon and Nikon oligopolistic leaders in this industry for decades. In this sense, the technological change from SLR to DSLR cameras was a competence-enhancing discontinuity that allowed leading firms to exploit existing competence, thereby consolidating their leadership positions.

Interestingly enough, previous studies have consistently taken the view that digitization was a competence-destroying discontinuity in the camera industry (e.g., Tripsas and Gavetti, 2000; Benner and Tripsas, 2012; Miranda and Lima, 2013). This discrepancy in perspective results from differences in the way researchers define the market of interest. Tripsas and Gavetti (2000) exclusively focused on the compact camera, where the transition to digital technologies may understandably be considered a competence-destroying discontinuity. Miranda and Lima (2013) viewed the camera industry as a whole, making no distinction between built-in lens and interchangeable-lens cameras. However, in the

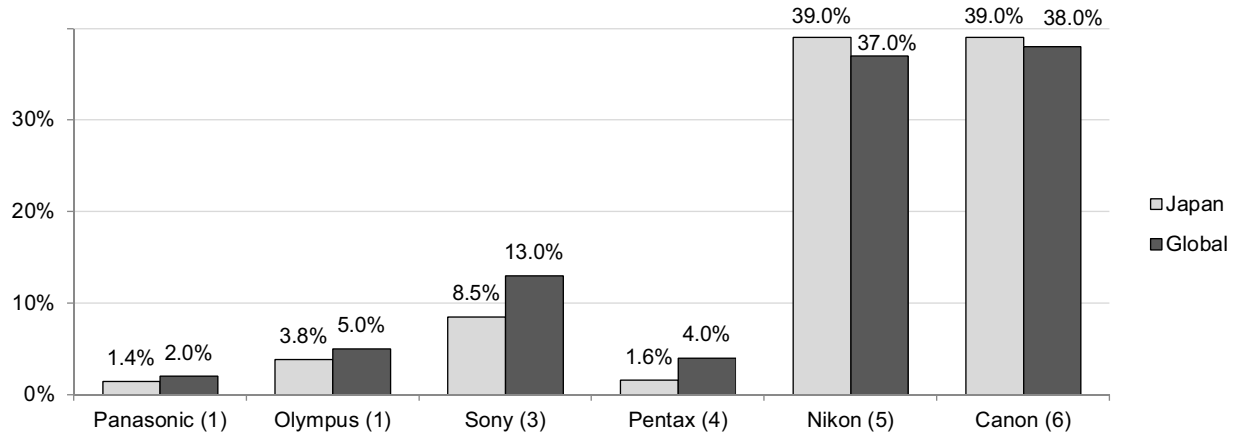

Fig. 3. 2008 Interchangeable-lens Camera Market Share in Japan.
Note: The order of the entry to the Mirrorless camera market is presented in parentheses following the company name. Samsung is omitted in the figure because it did not sell cameras in the Japanese market.
Source: BCN Japan and Slashgear.com (Japan), photoscala (Global).

interchangeable-lens camera market, the "digital revolution" was more like a mere component substitution from film to digital image sensors.

5.3. Windows of opportunity: demand and policy

A demand-side window of opportunity arose when the National Aeronautics and Space Administration (NASA) in the U.S. desired to photograph and send digital images in outer space back to Earth in the early 1970s. NASA thus supported the development of digital cameras. Photographers in the news industry also wanted digital cameras for tele-photography (i.e., immediate transmission of images over telephone wires).

On the institutional and policy side, the trend toward digitization and relevant policy-related support began in the 1980s (Lee et al., 2005). Adoption of digital imaging technology was largely determined by changes in the information technology infrastructure as a whole (Teisberg and Leonard, 1996), not at the discretion of individual firms. Many companies found it relatively easy to obtain funding and relevant knowledge from adjacent technological areas, taking advantage of network externalities. Industrial environments and government policies have also supported R&D efforts in digital technologies since the 1980s (Lee et al., 2005). This support has often come from government or multinational consortia.

An important feature of these demand and policy windows was that they did not asymmetrically favor latecomer firms or new entrants to the industry. In fact, as incumbent firms have superior resources and technologies, institutions and policies tended to support the incumbent leaders. Governments usually supported industry leaders in order to secure a dominant position in the international competition for digital technologies. For example, the aforementioned NASA projects favored leaders in the camera market; NASA co-developed an early digital camera, the NASA F4 (1987–1991), with Nikon. From the perspective of latecomers' catch-up, policy and institutional windows of opportunity played a minimal role.

5.4. Capabilities and strategies of latecomers and leaders

The technological discontinuity from SLR to DSLR cameras maintained the competences of incumbent leaders. Unlike the German rangefinder camera manufacturers responding to the emergence of SLR cameras, therefore, Canon and Nikon made a smooth transition to DSLR cameras. They continued along the competence-enhancing technological trajectory, leveraging their superior resources and capabilities.

From the perspective of latecomers, on the other hand, the adoption of digital technology was a path-following strategy. Both latecomer SLR manufacturers and new entrants developed DSLR cameras very similar to those of incumbent leaders. As a consequence, the gaps in resources and capabilities between leaders and latecomer firms were well preserved, and there was little opportunity for latecomer firms to squeeze into the interchangeable-lens camera market.

This second case differs from the other two successful catch-up cases in the following ways. Digitization was not an endogenous change that latecomers implemented based on their own initiative. It was rather an exogenous pressure – a widely accepted global trend – imposed on all firms in the market. Facing this emerging and predictable transition, both incumbent leaders and latecomers shifted their attention to the change in paradigm from analog to digital technology. As a consequence, an important strategic pattern observable in the other two successful cases of catch-up – that is, incumbent leaders exploiting their existing competences while latecomer challengers pioneer a new technological or strategic path – was not present in this second case.

6. The Leadership shift to latecomer Japanese and Korean firms (mid-2010s)

6.1. Catch-up story

Since taking over industrial leadership in the 1950s, Canon and Nikon had developed formidable technological capabilities, an excellent market reputation, and a secure customer base for about 60 years. In the late 2000s, a threat to the long-standing dominance of these Japanese firms eventually began to emerge. Second-tier Japanese firms and a Korean camera manufacturer turned their attention to a new technology and product, the Mirrorless camera.[1] In the Mirrorless camera, the mirror box and penta-prism, which solved the problems of the rangefinder camera, were completely removed; instead, an electronic display and electronic viewfinder were developed. This path of technological development was adopted by firms that had hitherto been minor

[1] In June 2015, the Consumer Electronics Association (CEA) officially recognized "Mirrorless" as the industry standard name for this camera system.

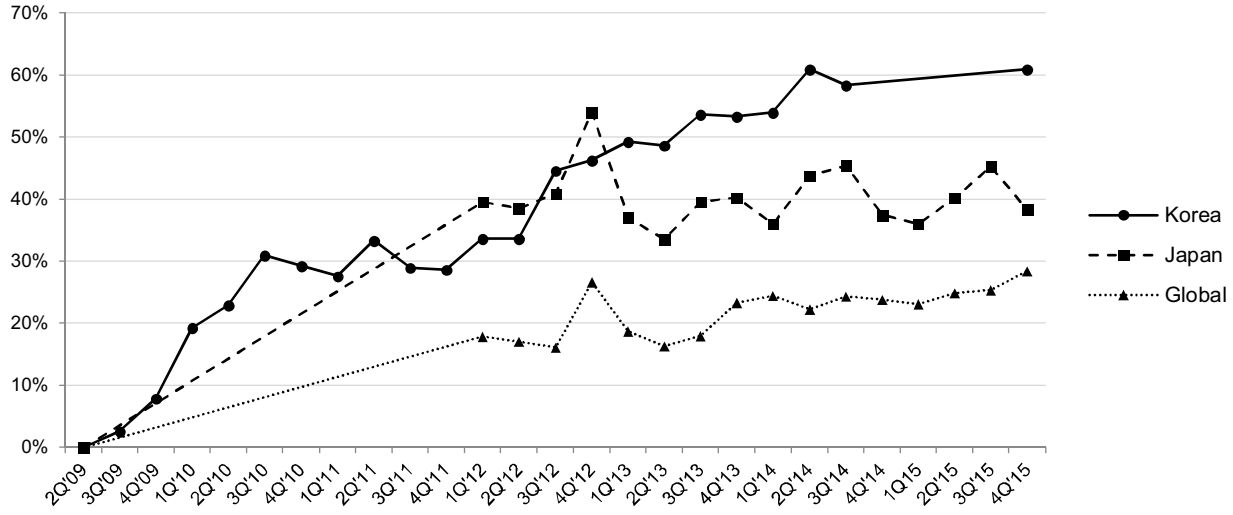

Fig. 4. Mirrorless Camera Share in Interchangeable-lens Camera Markets (by unit).
Note: The Mirrorless camera share in the global market is underestimated because CIPA statistics do not count Samsung's sales. The share in Japan and the global market was linearly projected between September 2009 and January 2012.
Source: CIPA (Camera & Imaging Products Association) for Japan and global shares; Gfk and Sony Korea for Korean shares.

players in the interchangeable-lens camera industry or absent from it altogether. Because they were both Japanese and Korean firms, this path of change involves not only (partial) leadership shifts *between* national industries, but also shifts between (a group of) individual firms *within* Japan. Although these changes and consequent market turnover are considered to be still in progress, the evidence for changes in industrial leadership and technological standards are sufficiently strong to be included here.

The Mirrorless camera was first introduced in mid-2008 by the second-tier Japanese firms, Olympus and Panasonic. Then, Samsung (January 2010), Sony (June 2010), and Fujifilm (January 2012) joined the Mirrorless camp. The Mirrorless camera, which is much smaller and lighter than the DSLR camera, initially appealed to light users, and then to professional users of the DSLR camera as well. The industry leaders, Canon and Nikon, looked down on this new, nascent technology and retained the mirror-based technology in all cameras. As a result, Canon and Nikon lost their edge, especially in the East Asian market, where consumers were among the earliest adopters of the new technology.

The Mirrorless camera rapidly came into wide use, and its market share was close to or even exceeded that of the DSLR camera in Japan and Korea, as shown in Fig. 4. Globally, the Mirrorless camera market has since grown rapidly worldwide, albeit at a slower pace than in the East Asian market. The share of the former leaders in the interchangeable-lens camera market had already declined to less than 50% in Japan and Korea by 2011. Although Canon and Nikon had expanded their share in the Japanese DSLR market to around 90% in 2013 (BCN Ranking, 2014), the whole DSLR camera segment had lost its competitive edge against the Mirrorless camera. Fig. 5 shows that challengers in Japan and Korea became the leaders in the rapidly expanding Mirrorless camera markets in Japan and Korea. Sony, in particular, became the top supplier of both the interchangeable-lens camera market as a whole and its Mirrorless camera submarket in Korea in 2015.

6.2. *Windows of opportunity: technology*

The DSLR camera, with its embedded mirror box and penta-prism, had inherent disadvantages; it had reached a technological limit in terms of miniaturization and lightening. Mirrorless camera technology addressed the two critical drawbacks of the DSLR camera, just as the SLR camera did for the rangefinder camera. The complicated inner structures of the DSLR camera are shown in Panel (A) of Fig. 2. When light enters the lens, the mirror box reflects it to the penta-prism. The penta-prism then reflects it back to the optical viewfinder and our eyes. If a photographer presses the shutter button, the mirror box goes up, allowing the light to reach the image sensor, which then records it. This great invention solved the parallax problem of the rangefinder camera. However, the penta-prism and mirror box made the camera heavy and bulky. To make the camera body smaller and lighter, makers of the Mirrorless camera removed the penta-prism, mirror box, and optical viewfinder.

At the time of development of the Mirrorless camera, latecomers confronted two important challenges: to replace the optical viewfinder, and to replace the phase detection auto-focus (PDAF) system. First, since the mirror box and penta-prism were eliminated in the Mirrorless camera system, the product had the same problem as the rangefinder camera: inferiority of the optical viewfinder. To cope with this problem, the very first Mirrorless camera model featured a large electronic display that only partially replaced the optical viewfinder. Although this was a reasonable strategy for early entry models aiming at beginner-level users, a viewfinder was necessary for stable shooting and for daytime shooting in strong sunlight. Moreover, most photographers who had been using DSLR cameras were well acquainted with the viewfinder and found the compact camera-like large screens inconvenient for shooting. Second, Mirrorless cameras lacked a PDAF module due to the elimination of the penta-prism and mirror box. Early Mirrorless cameras featured the contrast detection auto-focus (CDAF) system which had been used for compact cameras. This was initially inferior to the PDAF system in terms of focusing speed.

Around August 2008, when the very first Mirrorless cameras were introduced on the market, most of the above-mentioned technological issues had already been addressed due to significant technological advances in camera-related industries. First, taking advantage of rapid advancements in electronic display technology, Mirrorless camera manufacturers could use electronic viewfinders. Panel (B) of Fig. 2 depicts the mechanism of the Mirrorless camera. Light goes directly to the image sensor, and an electronic viewfinder with a small high-definition electronic display shows the image. Electronic viewfinders provided perfect support for all lenses on the market with 100% frame coverage, replacing the heavy and bulky mirror box and penta-prism. Moreover, while an optical viewfinder shows what we see through the glass, an electronic viewfinder

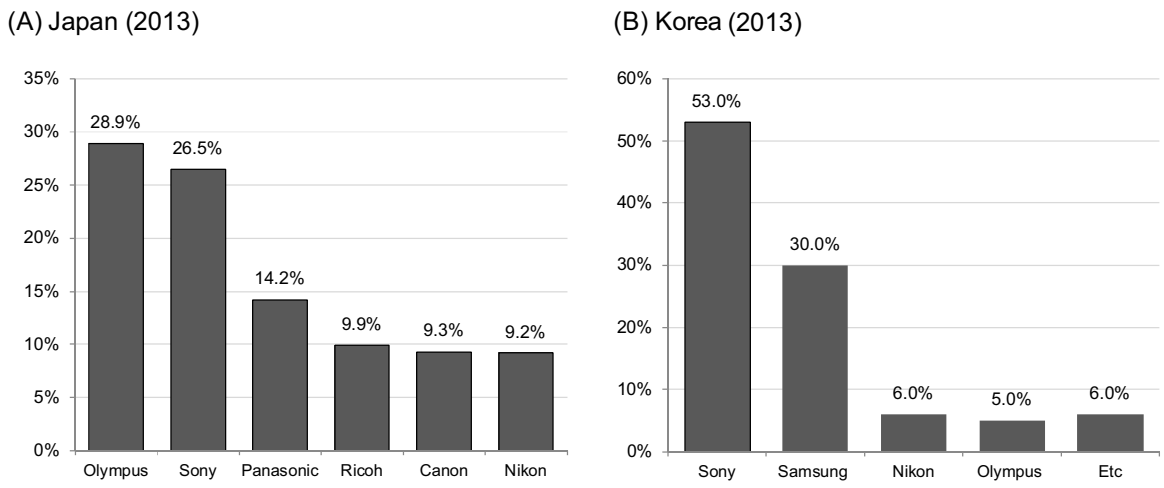

Fig. 5. Mirrorless Camera Market Share in Japan and Korea.

Source: BCN Ranking (Japan), GfK (Korea)

displays exactly what the *camera* sees through the digital image sensor. In other words, Mirrorless camera users can preview and inspect the exact image that will be taken even before shooting. Adjustments of exposure, color impressions, and ISO numbers are immediately reflected in the electronic viewfinder. This is a great advantage, especially for beginners.

Second, the challengers to industry incumbents invested heavily in R&D to improve the speed and accuracy of the CDAF system. Panasonic and Olympus succeeded in developing a fast, accurate CDAF system comparable to the PDAF one. Other firms such as Samsung, Sony, and Fujifilm even introduced a so-called "hybrid AF system" that combined the merits of PDAF and CDAF systems. In addition, Mirrorless camera manufacturers further adopted cutting-edge functionalities. Samsung and Sony, for example, developed a 180° "flip display", which helped significantly in the taking of self-portrait photographs. Samsung even loaded the Android mobile operating system, enabling retouching and photo uploading online via a camera device. Remote shooting, in which a smartphone screen is used as a viewfinder, has also been introduced. A technological comparison of a compact camera, a DSLR camera, and a Mirrorless camera is provided in Table 2.

6.3. Windows of opportunity: demand

Significant changes in the market environment occurred during the period of Canon and Nikon's domination. Consumer needs, in particular, changed for both professional and amateur photographers. Ever-changing demand may mean an opportunity to provide a detour from the current strategic/technological path.

The SLR camera was inherently heavy and bulky due to the mirror box and penta-prism. Although these are exactly the components that solved the problems of the rangefinder camera, as time went on, the market demanded smaller and lighter cameras without sacrificing photo quality and camera functionality. Being sensitive to changing consumer demands, Olympus and Panasonic conducted comprehensive market research. They found that potential consumers, especially women, strongly desired a smaller, lighter, and more stylish camera. However, many users of then-existing light cameras were unsatisfied with low-end compact cameras. As televisions, laptops, and mobile devices featured much higher-definition displays, moreover, consumers began to expect more advanced cameras also to take high-resolution photos. As a result, the camera market became specialized to larger-sensor cameras with interchangeable lenses for which smart devices or compact cameras cannot substitute.

However, the entry-level DSLR camera could hardly be an alternative. This professional-looking, heavy camera was burdensome for a casual user to carry everywhere. Furthermore, consumer surveys revealed that even professional photographers demanded lighter cameras either as substitutes for their main cameras, or for supplementary purposes.

It should also be emphasized that consumers in markets in Japan and Korea were *early adopters* of new technologies compared to consumers in any other markets; they were more willing to adopt and test the new type of camera. As their domestic markets were essentially "test bed" markets, latecomers in Japan and Korea took advantage of another demand-related window of opportunity.

6.4. Windows of opportunity: policy and institutions

In direct contrast to the first leadership shift, in which policy and institution played a crucial role, demand- and technology-side windows of opportunity were the critical driving forces in this third case (along with various firm strategies that will be discussed in Sections 6.5 and 6.6). Not much can be said about the policies and institutions in the third leadership shift, which makes this case much more interesting.

The third shift in leadership can be examined in two parts: (1) shifts within Japan, and (2) the emergence of Korea. For the leadership shifts within Japan, we can hardly attribute the Japanese latecomers' catch-up with Japanese leaders (Canon and Nikon) to Japan's government policy unless such policy exclusively affected either of the two parties. This is primarily because, in general, policies have an influence on all firms in an industry. As for the leapfrogging by Samsung of Korea, we previously mentioned that Samsung attempted to produce DSLR cameras in the mid-2000s, an effort which ended in failure. Accordingly, if we are to attribute the successful catch-up by Samsung in the late 2000s to policy and institutional windows of opportunity, we would need to identify a drastic change in government policy or institutional governance between Samsung's failure in the DSLR camera market and its success in the Mirrorless camera market. To the best of our knowledge, however, very few policy or institutional changes were implemented between the mid-2000s and early 2010s.

This discrepancy in government or macroeconomic roles between the two successful catch-up cases provides us with strong evidence that different windows of opportunity play different roles in catch-up cycles.

Table 2
Comparison of Cameras by Type.

	Compact Camera	DSLR Camera	Mirrorless Camera
Sensor Size	1/2.3"–1/1.7"	4/3"—Medium Format	4/3"–35 mm
AF system	CDAF	PDAF	CDAF or Hybrid (CDAF + PDAF)
View Finder	–	OVF	EVF or Hybrid (OVF + EVF)
Complementary Display AF Speed	–	Slower than viewfinder mode	Fast (same as viewfinder mode)
Flange Back	–	Long	Short
Weight	Approx. 150 g	More than 500 g	200–350 g
Color and Design	Varied	Relatively uniform	Varied

6.5. Latecomer capabilities and strategies

Firm strategies were arguably the most important success factors in this third phase of leadership. Latecomers wanted to change the rules of the game and therefore pioneered a new technological path, implementing a path-creating catch-up strategy. Shiro Kitajima, head of Panasonic's consumer marketing division in North America, commented that "Nikon and Canon have a long legacy for SLRs. We don't want to play on the same ground. We tried to play it on our ground" (Wakabayashi, 2012). Samsung executives also acknowledged that the company moved into the Mirrorless camera market because its DSLR camera could not compete with the products of Canon and Nikon (Demolder, 2011). The emergence and proliferation of Mirrorless cameras may have been the biggest shift in technology in the interchangeable-lens camera market in six decades (Yasu and Amano, 2011). This introduced a competence-destroying discontinuity in the market that favored latecomer firms. Fig. 5 shows that, in both the Japanese and Korean Mirrorless camera markets, challengers in the Mirrorless camp such as Olympus, Sony, and Samsung outperformed the former Japanese leaders, Canon and Nikon.

The first Mirrorless camera was released into the market in September 2008. The sensitivity to market changes and the strategic agility of the Olympus and Panasonic coalition allowed their development of the Mirrorless camera. As an important strategy for market entry, Olympus and Panasonic cooperated when developing and marketing the Mirrorless camera, just like Canon and Nikon did when they released SLR cameras. Olympus had an advantage in optics, whereas Panasonic had an advantage in electronics. Furthermore, to overcome the disadvantages of the lack of brand awareness and complementary assets (e.g., lenses), these two makers co-developed and shared the new Mirrorless camera mount standard, the Micro Four Thirds. Olympus and Panasonic adopted the same standard so that their camera bodies and lenses could interchange signals. This obviously was a great advantage for promoting the new system and expanding their lens bases, especially in the early stages of its introduction.

It is noteworthy that the Mirrorless camera penetrated the interchangeable-lens camera market from the bottom in terms of sensor sizes. In the early days, Mirrorless cameras were equipped with sensors of the same size as entry-level DSLR cameras. The first pioneers, Olympus and Panasonic, adopted the Micro Four Thirds sensor in 2008. Second entrants, Samsung and Sony, then developed their Mirrorless cameras with an Advanced Photo System type-C (APS-C) sensor, which is most common in DSLR cameras and larger than the (Micro) Four Thirds sensor, and which appeared in 2010. As the market for Mirrorless cameras began to grow rapidly, Sony further expanded to the Full Frame sensor Mirrorless camera in 2013. This market segment is especially important, as it appeals to photography experts who have the greatest influence on brand reputation. Consistent with Christensen's (1997) disruptive innovation model, Mirrorless camera manufacturers' entry into the market from the lowest-end segment made incumbent leaders in the traditional market facile and pushed them to develop higher-end products. As Mirrorless cameras expanded to higher-end products, the incumbent leaders lost their footing in the market.

Interestingly enough, Samsung, which previously had a hard time penetrating the DSLR camera market with its path-following strategy in the mid-2000s, performed much better in the Mirrorless camera market with a path-creating strategy. Being a second entrant into the market, Samsung was the first manufacturer to introduce a Mirrorless camera with the APS-C format sensor.[2]

6.6. Industry leaders' response

If the incumbent leaders had invested in the Mirrorless cameras early on, the latecomer firms would have had a much harder time catching up with the leaders. This happened when a competence-enhancing discontinuity from the SLR to DSLR camera took place in the 1980s and 1990s. In this third phase, however, the new technology was brought endogenously by latecomers, and its future was highly uncertain. Canon and Nikon did not consider the Mirrorless camera to be a serious threat. Rainer Fuehres, head of Canon Consumer Imaging Europe, said in 2011 that "Mirrorless cameras have been introduced by manufacturers that find it difficult to compete in the DSLR market" (Demolder, 2011). Although they recognized that consumers desired lighter cameras, Canon and Nikon chose to improve their products *within* the boundaries of the DSLR design. These former leaders built on their existing DSLR-related resources, capabilities, and product lines, which had brought them success in the past (similar to the way that Leica responded to the advent of the SLR camera). It is thus not surprising that the order of entry into the Mirrorless camera market was almost opposite to the market share rank in the DSLR camera market, as Fig. 3 illustrates.

Although the incumbents' *sustaining* innovation makes sense given that their DSLR camera business was still highly lucrative (Yasu and Amano, 2011), the power of competence-destroying discontinuity overwhelmed their *status quo* strategies. The result of sticking to a current technology/strategy that had become misaligned to the changing market environment was painful ("success trap"). Although Canon and Nikon belatedly and reluctantly entered the Mirrorless camera market in 2013, their main product line was still the DSLR camera, which was already losing ground to the Mirrorless camera.

7. Implications and conclusions

In this study, we identified three phases of change or persistence of industry leadership (or catch-up cycles) across nations/firms in the interchangeable-lens camera market. We examined successful catch-up stories along with an aborted catch-up case based on the framework of Lee and Malerba (2017), who identified windows of opportunity and firm capabilities/strategies as essential

[2] After launching NX models in 2015, Samsung did not release any other Mirrorless camera. We believe that this decision was based on Samsung's classification of the camera business as a non-core business in its corporate-wide restructuring.

Table 3
Explanatory Factors Affecting the Three Phases of Industrial Leadership.

	First Phase: Leadership shift (mid-1960s)	Second Phase: Sustained leadership (1980s)	Third Phase: Leadership shift (mid-2010s)
Windows of opportunity			
Technology	*** (SLR camera: competence-destroying)	** (DSLR camera: competence-enhancing)	*** (Mirrorless camera: competence-destroying)
Demand	*** (demanded lens interchangeability and parallax-free camera)	** (demanded tele-transmission, digital retouch, reusable memory)	*** (demanded smaller and lighter camera with high image quality)
Policy & Institution	*** (WWII and Japan's promotion of optics industry)	*** (worldwide support for digital technologies)	* (no policy specifically favoring latecomers)
Firm Capabilities & Strategies			
Latecomer challengers	*** (path creating strategies)	* (path following strategies)	*** (path creating strategies)
Incumbent leaders	*** (incumbent trap)	*** (rapidly adopted the new digital technology)	*** (incumbent trap)

Asterisks indicate the importance of each explanatory factor. ***: significant, **: facilitating, and *: minimal.

components of catch-up. Table 3 provides a summary of the three cases.

The common element in the successful catch-up cases examined in this study is that innovation and path-creation were initiated by latecomer firms. In the first case, although the SLR mechanism was not a Japanese invention, Japanese challengers actively adopted and improved this new technology (i.e. exogenous invention and endogenous adoption). In the third case, latecomers in Japan and Korea developed their own new technologies to compete with strong incumbent leaders (i.e. endogenous invention and endogenous adoption). These path-creating strategies introduced a competence-destroying discontinuity to the market. The importance of active initiatives on the part of latecomers is further supported when we consider the aborted catch-up case, in which widely accepted trends resulting from the worldwide digital revolution brought a competence-enhancing discontinuity that favored the incumbent leaders (exogenous invention and exogenous adoption). These three phases of the history of the interchangeable-lens camera market strongly highlight the importance of latecomers' technological initiatives and the dangers of incumbent leaders' short-sighted or delayed responses.

In addition, the rigid response of incumbent leaders expedited the leadership turnovers described herein. In the two successful catch-up cases, the industry leaders underestimated the latecomers' new, disruptive innovations, which later developed into the new standard. The ever-changing nature of consumer preference observed in these cases implies a major discrepancy between *changing* consumer demand and the *unidirectionally accumulating* technological competence of incumbents. Incumbents with a strong competitive edge will be in danger if challengers target the ever-increasing gap between industrial environments (demand, technology, and policy/institutional influence) and incumbent responses.

Another important commonality of the success stories share is that latecomers require adequate knowledge bases or capabilities in order to initiate path-creating strategies. In the first leadership shift, Japanese firms initially produced rangefinder cameras, imitating their German competitors. Similarly, in the third shift, all the firms in the Mirrorless camp had considerable experience with DSLR cameras and lenses. No single firm suddenly appeared in the market and succeeded in catch-up. Thus, we conclude that a certain depth of historically accumulated capabilities and knowledge is required for successful catch-up.

Similarly, coordination of efforts among latecomers was important in both successful catch-up cases. In the first case, Canon and Nikon cooperated to catch up with German leaders, complementing each other's weaknesses. When Olympus and Panasonic introduced the brand-new Mirrorless cameras in the third catch-up case, they worked together to develop a common mount standard. This cooperation allowed them to release as many lenses as possible into the market, thus aiding them in overcoming second-mover disadvantages.

We also note that neither latecomer initiative nor path creation alone may be sufficient to cause changes in industry leadership. Each of the successful leadership shifts entailed significant changes in multiple windows of opportunity (see Table 3). In the first case, technology transfer from Germany to Japan during World War II, along with Japan's protective trade policy and promotion of the camera industry, proved to be crucial to the change in industry leadership. Consumers' desire for a more flexible camera system without parallax also played an important role. In the third leadership shift, changes in demand for lighter, high-quality cameras and technological advances in the electronics field facilitated the latecomers' path-creating catch-up. Our contrasting case to the successful cases of catch-up also indicates that incumbents' negligence or lack of response is another necessary condition for successful catch-up. Thus, no single, individual factor (sufficient condition) can be exclusively identified as the cause of the successive leadership shifts in the three cases.

However, not all the factors involved in these cases are equally important. The key factors influencing successful catch-up differ and carry different weight in different cases. The impact of World War II and the policies of the Japanese government and military were instrumental in the first leadership shift. In contrast, policy and institutional windows had little influence in the third, Mirrorless camera case. On the other hand, in the second case of sustained leadership, incumbents' agile response to emerging digital technologies was a crucial factor, whereas demand and latecomers' capabilities were less influential.

Lastly, we find an interesting peculiarity of catch-up when carefully examining the third phase of the history of the interchangeable-lens camera. With the advent of Mirrorless cameras, business declined for traditional optical manufacturers, while for electronics companies, it increased. Samsung Electronics, Sony, and Panasonic had been engaged in various electronics businesses before developing Mirrorless cameras. Contemporary cameras feature Wi-Fi-based photo transmission, mobile application-based photo retouching, remote operation of cameras using smartphones, and unified user experience with smart televisions or tablets. Thus, capabilities other than optical technique have become increasingly important. This feature of the third shift may provide an important indication of what future changes may be in store for this industry; it is certainly worth further research.

Catch-up cases are rare and highly specific to firms, countries, and industries; a *cycle* of catch-up is even less common. A catch-up cycle is a complex combination of demand and technology conditions, a country's public policies/institutional influence, and relevant firms' strategic choices. Nonetheless, there are still some

markets that are interesting and merit investigation. Thus, we call for in-depth studies on successive changes in industrial leadership that occur concurrently or discordantly at the firm and country levels. We hope our study has contributed to this research stream.

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