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Introduction to innovation in the East Asian automotive industry: Exploring the interplay between product architectures, firm strategies, and national innovation systems

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ABSTRACT

East Asia is the origin and target market for an increasing number of technological innovations. We use the East Asian automotive industry as a focal point to discuss central questions of innovation research such as modularity, product architecture, and the dynamics of state sponsorship in national innovation systems. Two developments in the East Asian automotive industry are of particular interest to the broader innovation community: 1) East Asian firms and consumers are forerunners in the current transition to energy-efficient innovations and the future of automobiles. These technological developments will lead to a 'hybridization' of product architectures that need to be reflected in firm's competitive strategies. 2) Particularly in China, the role of the state for national innovation systems is pronounced in the automotive sector. The way national and regional frameworks interact with broader technology trends shapes business innovation, and this understanding can inform firms in other sectors as well. Before highlighting the contributions of each paper of the special issue, we provide contextual background regarding the unique trajectories of the Japanese, Chinese, and Korean automotive industry, and summarize the current state of research. We conclude with an outlook on future research topics.

1. Introduction

East Asia has emerged as the new center stage of automotive production and innovation: China alone accounted for three quarters of the automotive market growth in 2016 (IHS, 2017). Japanese carmakers with their large number of patents are leading Thompson's yearly list of global innovators' (Sedgwick, 2015). Key positions in emerging technologies such as automotive battery systems are dominated by Japanese, Korean and Chinese carmakers and their suppliers (Roland, 2017). Thus, there are strong indications that the geographic focus of innovation and competition is in the process of shifting. It is the aim of the special issue to shed more light on recent developments in the East-Asian automotive industry which are of high academic and managerial interest due to two main reasons:

First, the East-Asian automotive market can offer important insights in the current transition to energy-efficient innovations and the future of automobiles and its independence on fossil fuels. In late 2014, Toyota and Hyundai were competing to launch the first mass-produced fuel-cell vehicles, featuring what many experts assume to become a leading technology for future mobility (Nikkei, 2014). Korean and Japanese makers of lithium-ion batteries dominate the world market (Lowe et al., 2010), as do Chinese suppliers of magnets and rare earths. China is expected to become a major lead market for new drivetrain technologies. Chinese carmakers launch an increasing variety of new hybrid and electric models each year and use new modularized drivetrain technologies to 'leapfrog' past Western and Japanese incumbents. Second, East Asia is increasingly seen as a testing ground for "frugal innovations" – i.e., the development of lean, low-spec products for emerging markets (Economist, 2012, 2010). Carmakers from Korea, India or China might have an advantage vis-à-vis their Western competitors to bring 'good enough' products quickly to their domestic and neighboring markets (Leibowitz and Roth, 2012). For example, Chinese firms like Longxin have used part development practices of "localized modularization" - broadly specified, supplier driven part development to overtake competitors (Brown and Hagel, 2005).

The special issues also offers some broader lessons. The automotive industry is exemplary of two phenomena that have shaped technology and innovation in recent years: First, the development of electric propulsion technology in China shows an extreme case of a push towards modularization of automotive product architecture. In this sense, the East Asian automotive industry showcases the competition between modular and integral product architectures. This is part of a broader discussion on the interplay between product architectures and firm strategies that is highly relevant for innovation in other sectors (Fujimoto, 2008). Second, the current dynamics in the East Asian automotive industry illustrate the interplay between innovation and national institutional frameworks. National and regional frameworks interact with broader industry and technology trends to shape business innovation. This holds particularly true in the automotive industry, where both alternative propulsion technologies and autonomous driving are tightly linked to new infrastructure and regulatory frameworks, but also in the larger industry landscape, where the state/

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business interplay of investments in IT infrastructure and regulation will shape trends like connected manufacturing (“industry 4.0”).

Before we elaborate on these themes and the individual contributions of the papers in this special issue, the next section establishes the context of “East Asia”. The national innovation system of the three dominant regional players in the automotive industry, Japan, China and Korea, have followed distinct trajectories. These distinctions matter, since they shape the competitive positions of national players when they align their firm strategies to institutional frameworks and dominant product architectures. After a brief introduction of the concept of product architecture, which we will use to guide the comparison, the next section provides an outline of each trajectory and briefly sketches the current state of innovation research on the automotive industry in East Asia.

2. Historical development of the East Asian automotive industry and current challenges

The emergence of the East Asian automotive industry needs to be understood in light of a country's dominant model of industrial innovation and production. Two basic types of product-process architecture can be distinguished (Fujimoto, 2008), (1) “Integral architecture” with complex interdependence between product functions and product structures (such as automobiles, etc.), and (2) “Modular architecture” in which the relationship between a product's functional and structural elements have a simple and clear one-to-one correspondence (such as personal computers, etc.) (Ulrich, 1995). While the automotive sector is often cited as a typical example of integral architecture, new developments such as electric propulsion systems and the stronger integration of the IT and automotive sectors have led to a hybridization of product architectures. The dynamics of the evolution of the product architectures in the automotive sector and how these are shaped by carmaker strategies, national innovation systems, and consumer markets is a leading theme of this special issue.

2.1. The Japanese innovation trajectory

Japan is the prime example of the East Asian economic catch-up. The post-war automotive industry in Japan was characterized by a number of product and process innovations, most prominently the Toyota Production System, which led to Japan's rise in industrial competitiveness (Clark and Fujimoto, 1991; Song and Dyer, 1995; Womack et al., 1990). Japanese companies enjoyed high levels of productivity, especially for coordination-intensive products with an integral product architecture – such as automotive.

Several factors were driving innovations in Japan. The high-growth era of Japan in the 1950s and 1960s were characterized by resource scarcity, particularly concerning labour (Fujimoto, 1999). The chronic labour shortage motivated firms to select long-term employment systems and build long term-relations with subcontractors, leading to the accumulation of coordinative capabilities within and between manufacturing firms and suppliers. This “economy of scarcity” may be the source of Japan's industrial competitiveness and innovativeness, particularly for products with integral product architectures (Fujimoto, 1999).

In the 1990s two major events challenged this competitive advantage: One was the entry of Chinese low-cost competitors into the global market. The other was the rise of the internet and other digital communication technologies in the mid-1990s which caused the rapid substitution of analog (relatively coordination-intensive) devices by digital (relatively coordination-efficient) ones. These changes made the competitive gaps in market performance between coordination-intensive goods (e.g. cars, machine tools) and coordination-efficient ones (e.g. bicycles, PCs) increasingly evident. For example, as TV sets became digital, Japan's major TV manufacturers such as Panasonic, SONY, and Sharp suffered substantial deficits (Economist, 2014).

For researchers on the Japanese automotive industry, the organization of automotive product development has traditionally attracted considerable interest (e.g. Cristiano et al., 2000; Ueki et al., 2010), including the integration of suppliers into the innovation process (e.g. Dyer and Nobeoka, 2000; Dyer and Hatch, 2006; Kotabe et al., 2003; Takeishi, 2001). Another theme is the overseas transfer of process innovations. A high number of studies looked especially at the challenge to innovate by adapting existing business models to foreign environments (e.g. Morimoto, 2006; Saka-Helmhout, 2010). Relatively few studies investigate how Japanese carmakers and their suppliers respond to ever increasing competitive pressures. Can they move towards more market-oriented relationships and still retain the system logic that made them innovative (see also Aoki and Wilhelm, 2017; Aoki and Lennerfors, 2013)?

2.2. The Chinese innovation trajectory

In the late 20th century, China adopted a Soviet-style national innovation system under the Communist Party regime in which industrial R&D activities were highly concentrated at the nation state level. As a matter of fact, manufacturing firms in China often did not have their own R&D function. The design of Chinese products tended to lag behind that of advanced countries. Thus, when China opened up its economy in the 1970s, many of the manufacturing firms, those in Southern coastal provinces in particular, had to license foreign technologies or copy foreign products (Fujimoto, 2008). In order to rapidly catch-up, many of the Chinese firms, state-owned or private, bought licensed or copied parts as generic modules and started new manufacturing businesses by mixing and matching generic components. A “quasi-open architecture” thus characterized Chinese products such as motorcycles, trucks, air conditioners, TVs, and other digital consumer goods. About one hundred assembly makers for each product segment received copied parts from hundreds of local suppliers, leading to extreme price competition fueled by the use of temporary workers from low-wage regions of inland China. By the end of the 20th century, China became a major exporter of labour-intensive modular architecture goods.

Innovation studies have mainly focused on Chinese carmakers' and suppliers' competency building strategies for catching-up and leapfrogging (Zhao et al., 2005; Guo et al., 2014). Since the mid-1980s, some Chinese automobile firms have accumulated substantial internal resources through international joint ventures (IJV) or domestic mergers (Nam, 2015). Some studies demonstrate the positive effects of IJV with foreign carmakers (Gallagher, 2006; Rui and Yip, 2008; Zhao et al., 2005) and collaboration with foreign parts suppliers (Sadoi, 2008) on knowledge transfer to Chinese automobile producers.

However, the intended knowledge transfer through these IJVs did not lead to the desired success and Chinese carmakers are still struggling to enter the highly competitive mature markets (Nam, 2015). Even in the Chinese domestic market, Western incumbents continue to be dominant players, and Chinese carmakers reach market shares below 20% (Colum, 2015; Economist, 2013). Major reasons for the technology transfer problem seem to be the reluctance of foreign multinationals to transfer core technology to Chinese partners (Rui and Yip, 2008) but also the local firms' low ability to absorb new knowledge (Hatani, 2009).

Rules and incentives set by government policy are frequently cited as supporting factors for facilitating knowledge transfer from foreign MNCs to Chinese local firms. At the same time, strong differences in implementation success point at the importance of individual firm strategies (Nam, 2015). In sum, the literature on knowledge transfer to Chinese automotive firms shows that although FDI, IJV and M&A are central strategies for the Chinese automobile industry to upgrade their technological base, much depends on the details of implementation. Effective knowledge transfer thus remains a challenging issue for the Chinese automotive industry.

The technological shift towards electric vehicles might, however,