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Improvisational Intensive Problem-Solving Capability: The Case of Hyundai Motor's New Car Projects

Chulsik Kim | Academy of Korean Studies*
Jun Ho Jeong | Kangwon National University**
Hyung Je Jo | University of Ulsan

This paper attempts to explore how Korean companies have been able to build organizational capabilities over the course of rapid growth, using Hyundai Motor's new car projects as a case study. Hyundai has compensated for a lack of capability in the product design phase by improving the pilot production stage. Key to this is an intensive problem-solving capability that revolves around a pilot center established in 2003. Through the centralized pilot center, Hyundai has strengthened its ability to solve problems based on vertical information processing in the pre-production phase. With pressure to solve problems within a set period of time, engineers participate in problem-solving. Intuitive judgment is more important than routine skill when it comes to troubleshooting. This process of developing new cars, which includes elements of improvisation, illustrates that Hyundai's organizational capability has been shaped in a non-cumulative fashion rather than a step-by-step method of routine cumulative evolution.

Keywords: *Hyundai Motor Company, improvisation, intensive problem-solving capability, pilot center, new car projects*

*The first author
**Corresponding author

Introduction

Korea is regarded as a country that has succeeded in catching up with the industrial and economic capabilities of advanced capitalist countries in a relatively short period of time through rapid industrialization and economic development since the 1960s. Existing studies on Korea's late industrialization and rapid economic catch-up suggest that Korea makes good use of "windows of opportunity" opened by the emergence of new technologies or changes in market demand, and so on, or that institutional apparatuses based on industrial policies and *chaebol* organizations have contributed to Korea successfully catching up in the open, modular industries and the investment-driven processing and assembling-type industries (Hattori 2005; Lee 2014). However, even if windows of opportunity are open and institutional factors are appropriate, these do not necessarily make a rapid catch-up possible. It is necessary for main actors in charge of industrialization to build internal capabilities by taking advantage of such windows of opportunity and institutional factors. However, research on how the major companies that led Korea's industrialization were able to accumulate innovation capabilities internally in the process of catching up with advanced players, i.e., the internal mechanism of capability accumulation, has not been widely conducted.

International comparative studies related to organizational structure and practices have mainly conducted comparative work on the organizational characteristics of companies in major capitalist countries such as the United States, United Kingdom, Germany, and Japan. In particular, as Japanese companies emerged as significant players in the global market after the 1970s, studies to identify the unique characteristics of production and employment practices of Japanese companies that differentiate them from Western companies have emerged (Dore 1973; Aoki 1988). Lifetime employment, seniority-based wage system, intra-enterprise career system, enterprise training, enterprise unions, skill-based broad tasks and multi-skilled operation, corporate welfare, and networks of non-market, non-hierarchical, business-to-business relationships, referred to as *keiretsu*, they drew attention as a unique characteristic of Japanese companies that distinguishes them from Germany.

This prompts questions about whether Korea's course shares similarities with that of Japan. As work on the nature of Japanese companies as major organizations in East Asia has been undertaken, Korean companies belonging to the same East Asia have implicitly been regarded as similar to Japanese companies and as an epigone of Japanese companies. This point requires scrutiny. Do the *chaebol* organizations in the processing and assembling industries like automobiles, which have led Korea's industrialization and economic catch-up, take a similar form to those in Japan?

The purpose of this study is to identify the intra-organizational aspects of Korea's rapid economic catching-up, i.e., the characteristics of the formation of organizational capabilities unique to Korean companies. This study attempts to find out in what historical and industrial conditions and contexts Korean companies have developed their organizational capabilities and problem-solving methods in the process of rapid growth, and what their characteristics are. In order to analyze the characteristics of Korean companies' organizational capabilities in more detail, this study analyzes the case of Hyundai Motor Company (hereafter, Hyundai), a typical conglomerate affiliate that led Korea's industrialization. Since the core properties of a company's organizational capability formation may be best identified in the new product development process, this article attempts to explore the nature of organizational capacity at Hyundai with a focus on new car projects.

The process of developing a new car generally consists of three stages: product design, pilot car production, and mass production. In this study, we argue that the core of Hyundai's organizational capabilities lies in the intensive problem-solving capability in the pilot car production stage, which comes after design and before mass production.

The formation of organizational capabilities is generally believed to be cumulative in nature (Womack, Jones, and Roos 1990; Zollo and Winter 2002; Helfat and Peteraf 2003; Whitney et al. 2007). However, the building-up of organizational capabilities does not necessarily proceed in a cumulative and sequential manner. It may be possible to build organizational capabilities by repeating non-routinized and improvised work processes. This study suggests that Hyundai has built up organizational capabilities in a non-cumulative and disconnected manner rather than a cumulative and phased manner.

Bringing the Catch-up of Korean Firms into the Research Context

Levi and Kuo (1991) compared the electronics industries of Korea and Taiwan, and argued that, unlike Taiwan's "bootstrapping" strategy, it was the "assembly" strategy, with production carried out even in the face of unit costs exceeding market prices, that was key to Korea's growth. The assembly strategy builds organizational capabilities by accumulating technological experience within the company through economies of scale and hands-on learning. Because this strategy requires huge initial capital investment, large business-oriented industrial structures, and passing through a technology learning process that spans simple to complex technologies, it is important to update to the latest manufacturing engineering and process technologies. Therefore, it is necessary to improve the competency of the engineers responsible for these functions.

Hattori (2005) compares the industrialization of Korea and Japan and also insists that Korea has developed through "assembly-type" industrialization. In the 1960s, when Korea began to ramp up its industrialization, it was relatively easy to introduce cutting-edge technologies in the aftermath of the Microelectronics Revolution. Korea thus developed a production system that reduced the time and cost of technological learning as well as the need for accumulating skills. Since the 1990s, a trilateral combination of changes in geopolitical conditions including the Northeast Asian division of labor and the development of skill-saving technology paradigms, gradually followed by numerically controlled machinery (semi-automation), robots (automation), and IT-based modularization, and finally, effective government policy, has allowed Korea to become one of the few developing countries in history to succeed in industrialization.

Fujimoto (2006) explains that differences in technological capabilities and firm growth pathways depend on the nature of product architecture, pointing out that Korean companies have a competitive advantage in capital-intensive open modular products such as semiconductors, general-purpose steel, and petrochemical products. He adds that the reason large Korean companies remain competitive in these areas is due to enormous capital mobilization, quick decision-making, and high level of concentration at Korean *chaebol*.

Kim (1997), on the other hand, describes Korea's technological development in three stages: replicative imitation, creative imitation, and innovation. Specifically, the building of technological capabilities in latecomer countries, including Korea, can be understood as a process of evolving from the import of technology, to gradual improvement, then innovation-based competition, which entails a sequential chain of execution, absorption, and improvement. He perceives technological learning by latecomers as requiring a lot of effort and “capacity building” as part of a staged and sequential process rather than a spontaneous process that can be learned by importing and using foreign technology.

Lee (2013) argues for the Schumpeterian catch-up growth theory by criticizing Kim (1997)’s staged technological capability theory which implicitly assumes that technological catch-up is a cumulative and linear process. Lee and Lim (2001) suggest that technological catch-up by latecomers can be categorized into “path-following,” “stage-skipping,” and “path-creating” catching-up. Successful catch-up requires “stage-skipping” or “path-creating,” which is achieved by capitalizing on ”windows of opportunity” such as the emergence of new technologies like digital technology, economic fluctuations, changes in market demand, government interventions, or regulatory changes (Lee 2014). However, he does not elucidate the detailed, micro mechanisms of capacity-building or how capacity-building can be exploited by utilizing these windows of opportunity.

Previous studies explaining Korea’s late industrialization and rapid technological catch-up conjectured that Korea successfully caught up with open modular and investment-driven assembly industries by capitalizing on windows of opportunity or through institutional apparatuses such as industrial policies and *chaebol*. However, the internal mechanisms for accumulating innovation capabilities within companies have not yet been fully explored.

As large Korean companies tend to make large investments, it is important to upgrade manufacturing engineering and process technologies, as pointed out in the discussion of Levy and Kuo (1991).[1] However, there have been no empirical studies on the role of engineers in charge of manufacturing engineering and process technologies, which are believed to be core competencies that contributed to the rapid growth of Korean companies. Furthermore, previous studies have focused less on the role of

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[1] Manufacturing engineering technology refers to the way in which product information is replicated on a large scale through the production process (Fujimoto 2001). In other words, the technology that sets the conditions necessary to mass-produce new cars. On the other hand, process technology refers to technology that manages the automobile production process and enables gradual innovation within the framework of manufacturing engineering technology.

manufacturing engineering and process technologies in automotive manufacturing compared with that of product design technology and/or shop floor skills (Kim and Fujimoto 1991). In order to overcome these limitations, this study aims to clarify the role of manufacturing engineering and process technologies in the growth of Korean companies by examining Hyundai as a case study.

Analytical Frame and Methodology

The Building of Organizational Capabilities through Improvisation

Organizational capability is defined as "a firm's capacity to deploy its resources, tangible or intangible, to perform a task or activity to improve performance" (Inan and Bititci, 2015: 312). Organizational capability may be defined as technical resources, human resources, and an organization's ability to integrate and effectively utilize them (Helfat and Peterat 2003). It is the collective organization of skills and human capacities, or skills (Salah 2017). The organizational capabilities of a specific company show specific characteristics depending on how the actors within the organization demonstrate their skills in organizational relationships (Jo and Jeong 2022: 205).

Gong, Baker, and Miner (2006) assume two different pathways of connection between organizational capabilities and routines (see Table 1). The first path is one by which routines are transformed into new capabilities. In this context, routines exist first, and then come together to build organizational capabilities. In the second path, capabilities come before routines, and it is improvisation, rather than routine, that forms the main foundation of capabilities. Organizations create new capabilities by improvising solutions to problems. They then maintain these capabilities by repeating these improvisational activities. It is much later on in the process that routines supplant these improvisational activities and backfill capabilities.

Improvisation generally refers to the temporal convergence of planning and execution (Miner, Bassoff, and Moorman 2001) through agility, defined as quickness, lightness, and nimbleness (Highsmith 2004). Solutions are pursued using available resources, rather than optimal resources, within time pressures (Ciborra 1999). Moreover, organizational improvisation as a capability goes beyond ad hoc activity which does not reflect patterned

Table 1
Migration Paths between Routines and Capabilities

Type	Step 1	Step 2	Step 3
Migration Path 1	Creation of routines by planning, practice, or replication	Assemble, replicate, or expand routines into capability in a specific domain	Deployment or non-deployment of the capability
Migration Path 2	Creation of emergent capability by improvising a solution to a problem or opportunity	Sustain and recognize capability through repeated improvisation	Backfill the capability with supporting routines that supplant the improvisation

Source: adapted and revised Gong et al. (2006: 45).

behavior (Helfat and Winter 2011). Winter (2003) clearly distinguishes improvisation as a capability from ad hoc problem-solving, arguing that the latter is neither routine nor highly patterned while the former rests on a basis of patterned performance.

The integration of freedom (flexibility) and control (efficiency) has been considered a major challenge for product innovation in today's automotive firms (Clark and Fujimoto 1991). The improvisational model advocates a pragmatic way of addressing this puzzling necessity through the use of minimal structures as a control device. Minimal structures consist of a simple and well-defined set of rules and replace serial and sequential processes with the freedom to build a distinctive process within a set of accepted organizational rules (Kamoche and Cunha 2001). Under the improvisation model, although minimal, organizational hierarchy may provide direction and help coordination (Kamoche and Cunha 2001). Emergence is expected to entail because the new product concept is achieved gradually, while action develops. This gradual convergence provides firms with the potential for collective learning based on real-time information (Sobek, Ward, and Liker 1999). However, this model also poses some risks, such as high levels of stress and ambiguity along with the possibility of strategic drift due to unclear organizational goals (Miner et al. 2001).

Based on the literature on improvisation, we define improvisation as the organizational capability to act spontaneously in an attempt to respond to problems in an innovative way with a combination of organizational autonomy (freedom) with goal clarity (control) while facing a turbulent environment. Thus, the concept of improvisation contains four dimensions; first, improvisation is associated with minimal structuring of macro routines, meaning goal clarity is combined with autonomy. Second, improvisation involves the recombination of existing available resources, such as organizational experience and expertise, indicating an ability to engage in unexpected reconfigurations and execute actions using an existing palette of resources within time constraints. Third, is related rapid response, referring to an ability to respond to changes in the environment in a timely manner. Finally, improvisation entails innovative solutions, meaning that new ideas or processes created to solve problems in specific situations are relevant.

The formation of organizational capabilities in Hyundai was not based on the accumulation of routines in an orderly and sequential manner, but rather came about through the repetition of improvisational activities. Attempts were made to imitate and improve foreign imported technologies through improvisational activities, and in the process, Hyundai acquired novel problem-solving capabilities. We will explain the process of organizational capability building in Hyundai's new car development with the analytical frame of improvisation (see Figure 1), concentrating on the pilot production stage of the process of developing new cars.

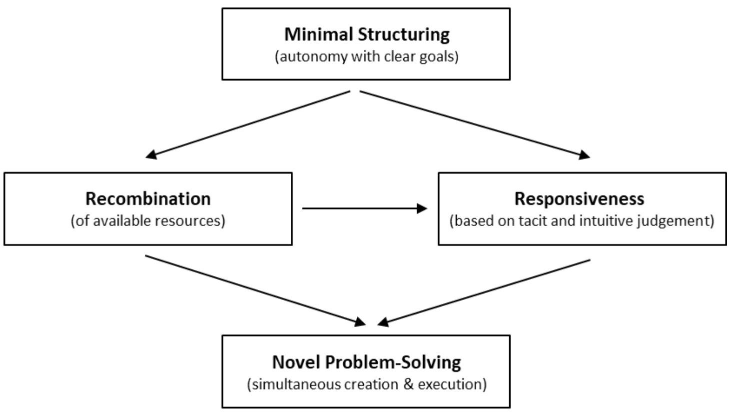

FIG. 1.—DIMENSIONS OF ORGANIZATIONAL IMPROVISATION

Research Methods

This study uses the case study method. Because the case study method deals with operational relationships that require tracking over time rather than the occurrence or frequency of a phenomenon, it is one of the suitable methods to useful for solving problems of a more explanatory nature, such as "how" or "why" (Yin, 2009). In particular, case studies target real-world events and are the preferred strategy when events-related behaviors may not be controlled.

TABLE 2
IN-DEPTH INTERVIEWEES AND INTERVIEW DATES

No.	Affiliation	Post	Interview Date
1	Pilot Center	Deputy Section Chief	May 19, 2017 Three times between May 21-27, 2021
2	Manufacturing Engineering Technology Center	Executive Director	July 19, 2017 February 10, 2020 December 4, 2020 May 13, 2021
3	Manufacturing Engineering Technology Center	Department Head	Six times from May 16 to August 8, 2017
4	Ulsan Plant	Director	March 30, 2017
5	Ulsan Plant	Department Head 1	Six times from April 4 to August 8, 2017
6	Ulsan Plant	Department Head 2	April 4 and June 21, 2017
7	Ulsan Plant	Deputy Department Head	July 25, 2017
8	Ulsan Plant	Section Chief 1	Three times from March 30 to August 8, 2017
9	Ulsan Plant	Section Chief 2	August 8, 2017
10	Ulsan Plant	Deputy Section Chief	Three times from March 30 to August 8, 2017 June 30, 2020 November 16, 2020
11	Product Quality HQ	Department Head	April 4 and May 25, 2017
12	Product Quality HQ	Deputy Department Head	June 23, 2017

Among the case study methods, this article presents a single case study that seeks a comprehensive explanation of a single case rather than a comparative study of multiple cases. Yin (2009) cites a case in which a specific case is representative of the majority of cases or has very typical characteristics as one of the conditions under which a single case study can be justified. Hyundai Motor is a representative company that has led Korea's rapid industrialization and economic development. The case of Hyundai Motor's capability-building typically shows the nature of the Korean *chaebol* that have grown on the basis of a skill-saving model centered on the assembly and processing manufacturing industry (Jeong and Lee 2007).

For this work, we interviewed managers at the pilot center, manufacturing engineering technology center, quality headquarters, and the Ulsan plant, one of Hyundai's key plants related to new car projects. These interviews were conducted between March 2017 and May 2021 and some of the interview results have been used directly or indirectly in this paper. In addition to conducting numerous, in-depth interviews face-to-face with interviewees, we also cross-checked issues between each of the interviewers to improve the objectivity and accuracy of these interviews (see Table 2).

Development of New Cars and Intensive Problem-solving Capabilities

Hyundai's New Car Development Stages

The new car development period goes through the following sequential stages: product design, the making and testing of a prototype car, and pilot production. After designing the various functions and parts of the product, a prototype car is manufactured and tested based on its design. Finally, a pilot car is produced and any problems that may occur in mass production are resolved in advance. According to a recent study comparing Toyota and Hyundai's new car development processes (Jo and Oh 2020), as of 2018, Toyota's new car development period is 17 months when developing a new platform and 10.5 months when using an existing platform. The figures for Hyundai are 19 months and 16 months, respectively. The difference in the development period can be explained by several factors, but it is clear that product design capability is one of them.

The difference in design capabilities between Toyota and Hyundai can be observed in Figure 2, which compares the frequency of design changes at

Hyundai with that of Toyota when developing new cars for major models. According to this, at Toyota most of the problems that may occur in a new car are solved through frequent design changes during the product design stage and the frequency of changes significantly decreases in the pilot production stage. Whereas at Hyundai, the number of design changes sharply increases during the production stage of the prototype car. The lack of capability for solving problems in the product design stage causes more problems later on in the pilot production stage.

Hyundai remedies its insufficient capability in the product design stage through improvements during the pilot production stage. The core of Hyundai's organizational competence and competitiveness lies in its intensive problem-solving capacity, centered around the pilot center.

At Hyundai, intensive problem-solving capabilities shine in the face of unexpected problems. The following quote demonstrates this:

> In the past, the A model was launched by competitor B. To respond to this, we developed the C model, and when we first developed the concept, we focused on dealing with frontal collisions. However, there is actually no such thing as a 100% frontal collision. When tested with a prototype car, most drivers unconsciously turn the steering wheel at the last second and collide at an angle of about 40%. (...) So, just before handing the design over to the pilot, I changed the structure of one drawing (which could meet the side collision criteria). The infrastructure of the model was changed after the launch date and schedule were fixed and the development of the new car was almost completed. (...) I asked if I should do it step by step, but I couldn't delay it any longer because the A model was already being released by company B. (...) To keep up with this sudden change, (...) I had to get it done in just a few days by staying up all night. (Interview with a Hyundai manager in 2017)

The above interview excerpt highlights the key features of improvisation at Hyundai. In the midst of the development of a new car, an important and unexpected problem arose in product design (unexpected problem). In a short period of time where the development schedule could not be delayed (time pressure), all available resources were rapidly mobilized to solve the problem (mobilize available resources rather than optimal resources, reach convergence between planning and execution).

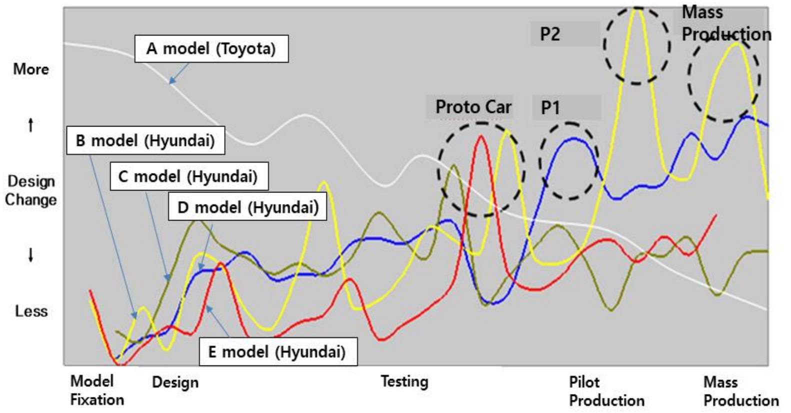

FIG. 2.—FREQUENCIES OF PRODUCT DESIGN CHANGES IN THE DEVELOPMENT STAGE OF NEW CARS: A COMPARISON OF HYUNDAI AND KIA'S MAIN MODELS WITH TOYOTA'S

Source: Hyundai's internal document.

Hyundai's Formation of Intensive Problem-solving Capabilities

It was in the 1970s, when the first original model Pony was developed, that the Hyundai Group's intensive problem-solving capability became apparent. The Hyundai Group dispatched employees of its affiliates to Hyundai Motor and concentrated its management resources to support the development of the Pony, Hyundai Motor's first car model development project. Experienced engineers who were successful at Hyundai Engineering and Construction Co. Ltd., and Hyundai Shipbuilding Co. Ltd., were sent to Hyundai Motor and played a vital role in the success of the Pony project (Kim 1998). After the success of this project, Hyundai Motor built up its internal capabilities in a way that aimed to develop and produce new models for each vehicle class that would be replaced at regular intervals, and solve problems that arose throughout the projects. During this process, Hyundai showed a tendency to pursue problem-solving by pushing forward resources from the group.

In 1978, during the construction of the first plant with a production capacity of 100,000 units, Hyundai's intensive problem-solving capability faced difficult challenges. Mitsubishi, one of Hyundai's cooperative partners, demanded that production be discontinued for two months, but Hyundai's director of manufacturing engineering technology successfully shortened the production deadline after a pause of 15 days (Interview with a Hyundai manger 2017). Additionally, its intensive problem-solving capability was developed in a leapfrog manner through the experience of constructing and upgrading the 300,000-car production plant that manufactured the Excel model for export to America by 1985 (Hyundai Motor Company 1987).

Hyundai engineers' commitment to accumulating intensive problem-solving capabilities and the pressure from above that demanded they do so, have been important contributions. In the early days of Hyundai there were not enough experienced engineers, but instead of providing systematic training, the engineers were often left to complete the tasks at hand using their accumulated capabilities through trial and error with no constraints. Once the project goals were established, engineers with the ability to solve problems and achieve those goals were trained (Jo 2016).

> At the time, I thought it was natural to get a job at an auto company when I graduated from the mechanical engineering department or related departments of engineering. I've come all the way here because I've been working on product development and production since I joined the company. Once the project goals were set, we had to achieve them on time by any means. I can't tell you what I've been through, but I feel well rewarded. (Interview with a Hyundai manager in 2017)

A certain degree of compulsiveness from above and the relatively voluntary commitments of engineers were supported by the internal promotion system for Hyundai engineers. Hyundai's wages and in-house benefits were among the best in the Korean manufacturing industry, so engineers sought to build capabilities through commitment under an internal promotion system rather than consider moving to other companies. In addition, since there were no engineering associations to represent their interests and they had the opportunity to be promoted to managers, rather than maintaining their identities as engineers, they actively participated in the company's work.

Capabilities acquired through intensive problem-solving have become established organizational routines. Since the early 1990s, Hyundai's capabilities accumulated over the years have gradually been crafted into "work standards," or formalized documents describing organizational routines, work processes, and rules (Jo 2016). But work standards as codified knowledge are loosely coupled with "work practices" as tacit knowledge. Hyundai's work practices are flexible in that they are generally subject to the work standards, but the person in charge can exercise discretion when applying them. Accordingly, the intuitive judgment of the person in charge and non-standardized capacities gain importance. This shows the process of dynamic formation and development of organizational capabilities, in which the experience of improvisational intensive problem-solving is established as a routine afterward, and new improvisational intensive problem-solving that does not depend entirely on the routine is carried out.

The financial crisis at the end of 1997 triggered a rapid restructuring of the Korean automobile industry. The Korean auto industry underwent a major shift due to the bankruptcy of Kia Motors and Daewoo Motors, the overseas sales of Samsung Motors, Hyundai Motor's layoffs and restructuring, and GM's acquisition of Daewoo Motors. Amid such a drastic restructuring, Hyundai's top management was replaced in 1998, bringing about a dramatic change in the company's management. Furthermore, as part of the internal conflict over the succession of existing Hyundai Group's overall management rights, Hyundai Motor was separated from the Hyundai Group and started anew as Hyundai Motor Group.

Taking advantage of the big change in the governance structure, Hyundai set an ambitious goal to become the world's fifth-largest automaker by 2010. To achieve this, the newly replaced CEO pushed forward aggressive management strategies and vigorously promoted them by providing minimal guidelines for the development of quality cars.

First, in order to improve Hyundai's image as a producer of cheap cars, the CEO presented a guideline called "Making an inexpensive car with quality." He pushed this through rigorously, advocating for quality management. At the time, he asked the quality control manager to select the 10 most frequently complained about items in the US, and then report progress on resolving those problems every week. In addition, he demanded that the resolution period be much shorter than the department's estimate. In order to improve quality, the company hired a large number of researchers twice a year for several years in the 2000s, securing nearly 10,000 researchers total (Interview with a former Hyundai quality management executive 2019). Under the CEO's minimal guidelines and high pressure, engineers began to commit themselves to improving quality, and Hyundai's intensive ability to solve problems marked a new leap forward.

Meanwhile, Hyundai Motor acquired Kia Motors, which had gone bankrupt during the restructuring of the Korean auto industry. As a result, the domestic automobile market changed from an oligopolistic structure centered on Hyundai, Kia, and Daewoo to a monopolistic market in which the Hyundai Motor Group accounted for approximately 70 to 80 percent of the domestic market. The monopolization of the domestic market became an important factor in Hyundai's aggressive management strategy of confidence in the 2000s. In addition, the monopoly in the domestic market made it virtually impossible for engineers to move to other carmakers, thus acting as a background factor that led to engineers committing themselves fully to Hyundai.

Enhancing Intensive Problem-solving Capabilities through the Construction of the Pilot Center

Hyundai's intensive problem-solving capability grew even further after the establishment of the pilot center. In 2003, Hyundai built a pilot center on the site of the Namyang Research & Development Center, one of Hyundai's key R&D centers located separately from the main plant. Hyundai invested KRW 300 billion to build this large pilot center that manages pilot car production for the entire group collectively.

The decision to establish a Hyundai pilot center was made in 2003 after the automaker's top management toured the Mercedes-Benz pilot car production line. Rather than being based on a well-established plan, this is another example of improvisation, where problems are solved in a short period of time in a vertical manner.

After the construction of the pilot center, the new car development process was transformed through intensive problem-solving in the pilot stage before mass production. Since the design drawings and the real product can be seen at the same time during pilot car production, it is easy to identify and solve any anticipated problems. In other words, the pilot center is a key link between the R&D headquarters and the production plants.

Hyundai's large pilot center is the place where manufacturing engineering and process technologies come together. It is also a major point where improvisation activities are used to solve problems occurring in product design while under time pressure, before the product enters mass production.

Changes in New Car Development Processes after the Opening of the Pilot Center

A New Car Development Process based on Concurrent Engineering

Functional departments such as the R&D center, the manufacturing engineering technology center, and the plants are all involved in new car projects, but they each have different interests. For example, while the R&D center aims to minimize the cost of the product and achieve superior design and performance, the plant seeks to operate its equipment smoothly and maximize the convenience of workers. The manufacturing engineering technology center tries to achieve high quality, low cost, and figure out logistics at the same time while mediating the different needs of the R&D center and the plant.

As can be seen in Figure 3, Hyundai's functional departments adopt a parallel and concurrent engineering approach where the time of development overlaps, balancing the conflicting interests of each party to successfully achieve the goals of the new car project. This is possible because the pilot center is located in Namyang, where the research center is also located, so communication regarding product design, preparation for manufacturing engineering technology, and pilot production can be conducted face-to-face. In this way, Hyundai has continued to reduce the time it takes to fix problems while developing new cars using concurrent engineering. Most of the conflict between the organizations involved in the development of new cars can be resolved between the involved parties, but when intervention is required, the conflict is reported to upper management and solved through the vertical hierarchy.

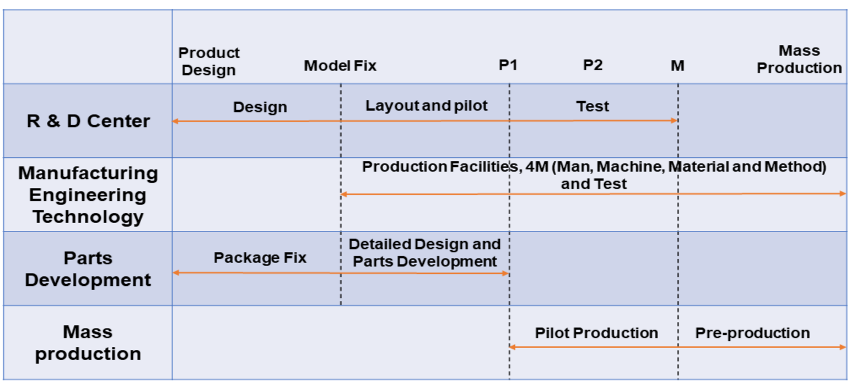

FIG. 3.—HYUNDAI'S NEW CAR DEVELOPMENT PROCESS

Source: adapted and compiled from multiple interviews.

Matrix Organization and the Vertical Decision-making Structure

At Hyundai's R&D center, each department is given a voice. Since the head of the functional department conducts performance assessments, engineers are forced to consider the interests of the department to which they belong. Accordingly, coordinating the interests of each functional department can be a very difficult task in the new car development process (Jo and Oh 2020).

Like other automakers, Hyundai operates a matrix organization to develop new cars. The core structure of the pilot center is the cross functional team (CFT) (see Figure 4). The CFT is responsible for integrating and coordinating the development of new products by enabling engineers from all departments involved in product development to identify and solve problems with the pilot car. The CFT staff are managed by both the pilot center and the advanced manufacturing engineering technology center. The former is mainly responsible for product design and quality work related to the R&D center, while the latter is mainly responsible for parts and mass production. The secretaries of both departments play a key role in coordinating and resolving the interests of different departments in matters

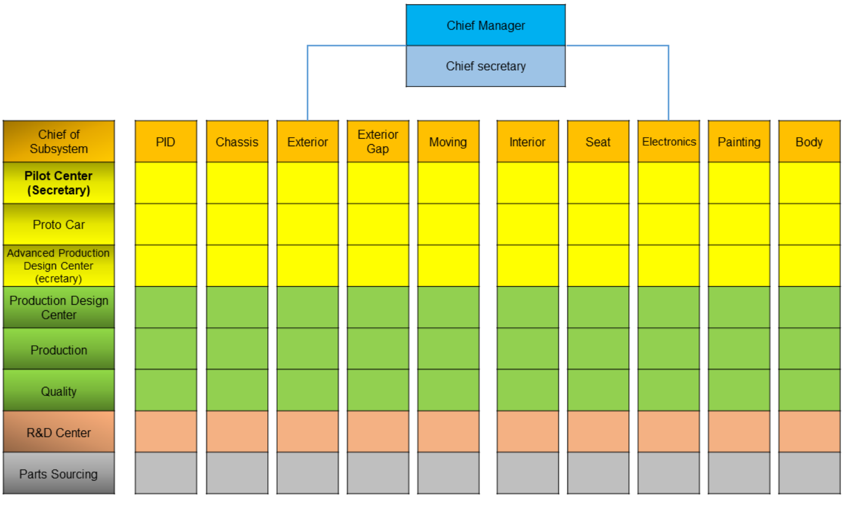

Fig. 4.—Organizational Structure of a Cross Functional Team (CFT) at the Hyundai Pilot Center

Note: PID = Pre-inspection Delivery
Source: adapted and compiled from multiple interviews.

arising from the pilot center. While project managers play a leading role in solving problems through their powerful authority and capabilities in Toyota Motor's new car development organization, the two secretaries of the CFT in Hyundai serve as coordinators, matching the interests between departments rather than guiding the solution of the problem.

The pilot center produces an average of 200 pilot cars at the P1 stage, and an average of 100 pilot cars at the P2 stage. Both P1 and P2 produce the pilot cars by assembling parts made from mass production molds, with each stage taking about a month. The CFT for each branded model is present throughout P1 and P2 and remains for two weeks after mass production begins, identifying an average of 1,000 to 1,500 problems for each car, thereby improving product quality over a short period of time. In other words, the team finds and resolves problems with internal and external parts and components, assembly, and driving performance by taking on the customer's perspective.

The goal of the CFT is to reconcile tensions and conflicts between relevant departments to solve problems in a desirable way. When a problem is identified, the CFT ask the relevant department to solve the problem: 1) changing the design structure; 2) improving facilities and parts; and 3) promoting standardization of assembly with the same structure. Let us give an example of how to solve a quality problem. If when the window wiper of a new product moves downward the joint is found to make noise, the CFT identifies the cause and then 1) modifies the design data identified as the cause; 2) corrects errors in manufacturing parts; 3) corrects and manages the error range of parts assembly.

Let us now explain the role of the CFT secretary in more detail. The interests of Hyundai Motor's functional departments participating in new car development often do not coincide with each other. When a noise problem, for example, occurs while producing a pilot car, it is necessary to find out the main cause through the CFT meeting. However, it would be difficult to investigate where it mainly arises from the research institute in charge of design, the parts suppliers, and the plant in charge of assembling the finished product and thus to reach an amicable agreement each other. In this case, the role of coordination and mediation by the CFT secretary becomes important. If it is difficult to resolve problems between the people in charge of each function, a decision would be made to the secretary and, in most cases, the result would be accepted. Since the secretary has accumulated experience in solving dozens of new car problems per year as a member of the pilot center, the secretary supervises the problem-solving process to meet the quality assurance standards that correspond to the work standards within a set period during the pilot production stage. However, when doing so is practically difficult, the secretary uses its discretion to solve problems on an improvisational basis.

For example, when a parts maker fails to develop a mass-production mold and a component quality problem occurs, the pilot production stage may be advanced to the next in consideration of the mass production schedule, even though the quality assurance standard has not been met. In this case, even if the problem is later revealed, the secretary will not be held responsible for personnel management. The secretary does not align with work standards rather, but resolves the matter on an improvisational basis. The exercise of the CFT secretary's discretion is based on the personal problem-solving experience he has accumulated. However, he has accumulated experience within the CFT organization, and it would be impossible to exercise personal discretion without an organizational culture that tolerates it. In this sense, it can be said that the improvisational capability of engineers is expressed at the collective level rather than the individual level.

Next, let us take an example of how to solve the assembly problem. When a vehicle's roof rack is mounted, since the structure of the work space of the assembly line is different for each plant, it is necessary to change the design to solve the problem. That is, when the working space is small, it would be necessary to reduce the number of parts and mount them at once, or when the working space is low, it would be necessary to shorten the length of the bolt or increase the hole to facilitate the mounting. The CFT secretary plays an important role in resolving this sort of assemblability problem, and when a tension or conflict cannot be resolved, the secretary exercises theirs discretion and plays the role of coordinator and mediator.

If, in the course of the pilot center's work, differences of opinion between functional departments are not resolved autonomously at the horizontal level, how are they reconciled? Most of the problems that occur in the pilot production stage are resolved at the manager level CFT meeting, but in about 5-10% of cases, the quality problems cannot be resolved due to the disapproval and non-cooperation of the functional organization. For example, in the case of a specific car product development, there were 1,450 quality problems, among which 70 unresolved problems were raised to the agenda of the general CFT meeting. This meeting is held once a week as a body that deals with issues that cannot be solved by the manager level CFT. At the general CFT meeting, the heads of each department attend and resolve the issues raised on the agenda through the meeting. The top-level meeting to solve problems related to the new cars is called the "Quality Conference." CEO-level executives attend this conference, convened during the new car development stage when quality issues are to finally be fixed, enabling the product development process to move on to its next stage. For example, the level of quality needed at the P1 stage is ensured before moving on to the P2 stage, with the conference acting as a kind of gatekeeper.

In short, Hyundai Motor has solved the problems of quality and assembly in the new car development process through intensive problem-solving in the pilot production stage. When it would be difficult to solve problems autonomously between managers of each function, the full-time CFT secretary at the pilot center with abundant problem-solving experiences makes a decision on an improvisation basis. If independent coordination among functional organizations fails to properly address a problem, it is resolved through the vertical hierarchy (Interview with a Hyundai manager 2020).

Hyundai has an organizational governance of segmented departments, meaning there is a lot of competition between them. Additionally, Hyundai's top management, from finance or planning as well as the owner, are relatively unfamiliar with the detailed technical and engineering process of product development, so each department's head has a certain degree of autonomy. In other words, they have operational autonomy at the department level without needing to always seek top management's approval, but not strategic autonomy, meaning the freedom to set one's own problem. This allows for trial and error at the department level (Sundstrom, De Meuse, and Futrell 1990).

Changes in the Relationship between Manufacturing Engineering Technology and Process Technology

Hyundai has compensated for its insufficient capability in product design through intensive problem-solving capability in the pilot production stage. For this reason, the role of manufacturing engineering technology is important in the development of new cars as an intermediate step to enable the mass production of designed products without any faults. Manufacturing engineering technology prepares the "4Ms" of machines, materials, methods, and manpower necessary for mass production.

Before the construction of the pilot center in 2003, Hyundai's process technology engineers actively participated in the new car development process, capitalizing on their accumulated skills in close cooperation with manufacturing engineering technologists. While the manufacturing engineering technologists prepared the 4Ms, the process technology engineers were responsible for raising and solving problems by referring to the conditions of the production plant when reviewing the new car drawings. The accumulated skills of process technology engineers, who maintain close communication with shop floor workers, were used beneficially. Since the main R&D center was in Ulsan, the location of Hyundai's mother plant at the time, the problems raised by process technology engineers could be easily solved by updating the product design through close communication with manufacturing engineering technologists.

Since the construction of the pilot center in 2003, the relationship between manufacturing engineering technologists and process technology engineers has shifted. One of the biggest changes is that manufacturing engineering technology center was divided into the advanced manufacturing engineering technology division, which plays a role in the early stage of new car development in Namyang, and the shop-floor manufacturing engineering technology division, which prepares for mass production in Ulsan. The former focuses on frontloading work which preemptively resolves problems in new car designs and seeks to improve the parts, while communicating with the R&D center located in Namyang. This division is responsible for carrying out 80-90% of the tasks related to the development of new cars, such as new manufacturing methods and facilities. Specifically, when reviewing the drawings, if any problems are discovered with the mold, press, body, painting, assembly, or power train from the setup of the prototype all the way through to pilot car production, such problems can be addressed and resolved in design through consultation with the R&D center. In addition, the advanced manufacturing engineering technology division calculates the optimal number of man-hours[2] and the criteria for determining how workers should be arranged on the shop floor through MODAPTS, a formalized technique used at Hyundai. The division also puts forward efficient manufacturing methods and improves workability by comparing domestic and overseas plants to the shop-floor manufacturing engineering technology division located at the Ulsan plant.

On the other hand, the shop-floor manufacturing engineering technology division, located in Ulsan, is mainly responsible for ordering and

[2] Man-hours is a measure of the number of hours that an average skilled worker takes to produce a car, which is the basis for deciding how many workers should be placed on the shop floor.

commissioning new car facilities and preparing for mass production at the plant. The division places more emphasis on the back-end process rather than reviewing the drawings. In other words, at the development stage of the process, transportation and automated equipment is arranged with consideration given to the layout of the mass production plant as well as ease of operation and the safety of workers. Moreover, this division plays an important role in the training of shop-floor workers. First, it is in charge of new car training where department and group heads, along with skilled workers, visit the pilot center located in Namyang and gain hands-on experience related to assembly methods for producing the pilot cars. Second, the division organizes a one-week new car training session for other shop-floor workers at the assembly technology center in Ulsan who cannot travel to Namyang. The work standards stipulate that 20% of all shop-floor workers must be trained at the pilot level.

In short, the advanced manufacturing engineering technology division concentrates on intensive problem-solving in the early stages of new car development, which mainly takes place in the pilot center, while the shop floor manufacturing engineering technology division is more focused on arranging the production facilities and manpower in Ulsan and other plants.

How, then, has the role of process technology changed? The process technology engineers play a more passive role as the intensity of problem-solving increases because there is little need for them in the front-end process. However, the role of process technology becomes more important in the back-end process of new car development. Process technology engineers collect and summarize the production experience and problems with past cars in each line to inform the production technology engineers of areas that need to be improved and confirm whether such improvements have been incorporated into the development of the new car. They also identify new problems found in the new car and ask for improvements.

Process technology engineers also play a leading role in determining the layout of the production line and the coordination of work orders related to new car development, taking over the assembly methods written by the production technology engineers, establishing principles of personnel management in accordance with the conditions of the shop floor, and finalizing the number of shop-floor workers and their workloads. While the manufacturing engineering technologists produce an assembly method report that calculates the man-hours of shop-floor workers based on the MODAPTS technique, the process technology engineers then rearrange an array of processes and create work standards that reflect the actual conditions of the shop floor. Shop-floor supervisors such as the head of the department and the group, play a supplementary role because of their lack of ability to write such documents.

Furthermore, the process technology engineers are responsible for identifying and improving on-site problems without being actively involved on the shop floor. In this sense, it can be said that process technology engineers have taken on a greater burden compared to before with regard to improving the shop floor.

Figure 5 shows the change that has occurred in the relationship between manufacturing engineering technology and process technology since the construction of the pilot center. As the proportion of pilot production has increased, new car projects have evolved into a vertical division of labor with manufacturing engineering technology centered on the front-end process and process technology on the back-end process. Manufacturing engineering technology has also been separated into the advanced and shop floor divisions; the role of the former has taken on greater importance, while that of the latter has been reorganized. The role of process technology engineers has also undergone a monumental change, with more importance being placed in the back-end process than the front-end process. The engineers are responsible for mass production preparation and improvements, with limited participation from shop-floor workers.

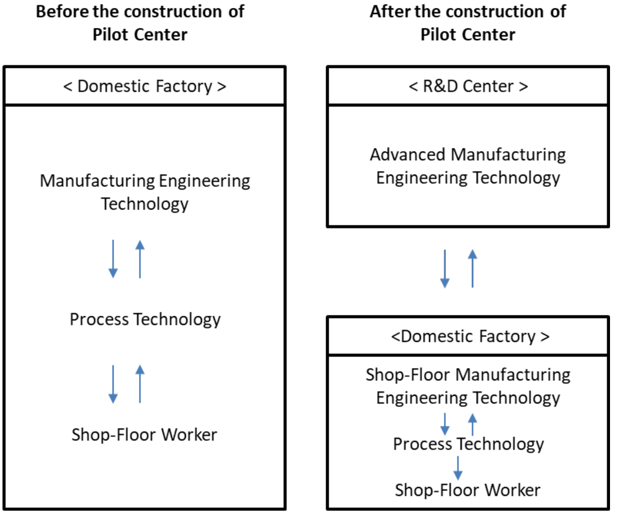

FIG. 5.—CHANGES IN THE RELATIONSHIP BETWEEN MANUFACTURING ENGINEERING TECHNOLOGY AND PROCESS TECHNOLOGY

Hyundai's Improvisational Product Development Model

During the restructuring of the Korean automobile industry in the late 1990s and early 2000s, Hyundai initiated aggressive global management by changing its top executive. The new CEO launched a quality management drive to improve Hyundai's image as a producer of cheap and low-quality cars. The CEO demanded that the company make an inexpensive yet quality car and pressed the company to periodically report results of quality improvement. The pressures presented by top management who were not familiar with the finer technical elements of product development have served as minimal structures for engineers. Since most upper management have their backgrounds in strategic and financial departments and thus do not tend to understand the complex product development process very well, engineers have enjoyed relatively highly autonomous atmosphere of trial and error in the process of product development. Operational—not strategic—autonomy, referring to the discretion to decide how to pursue an established goal, has been allowed and exploited.

Under the rather abstract guidelines that come from above, Hyundai has actively reconstructed existing elements that were established during its beginning to bolster problem-solving and innovation capabilities. Since its early days, Hyundai has intensively mobilized resources within the *chaebol* business group to boldly solve issues. The pilot center built in 2003 also illustrates a problem-solving method that uses existing capabilities. By reorganizing the capabilities of engineers scattered throughout individual plants and focusing them at the pilot center, the company tried to realize the economies of scale for this preemptive problem-solving function. On the other hand, the internal promotion system has acted as the basis for the voluntary commitment of engineers. Engineers at Hyundai have mobilized their unlimited dedication to solving problems while pursuing internal promotion rather than seeking new jobs in other companies due to Hyundai's de facto monopolistic position in the Korean auto industry.

Reconstructing existing elements according to minimal guidelines provided by the CEO, engineers have devoted themselves to solving problems arising in the course of the new car development process. In particular, if a problem arises in the pilot production process, the CFT leads the development of the new car by identifying and resolving the cause of the problem through frequent meetings. The CFT secretary acts as an essential coordinator to convene meetings and mediate problem-solving. The CFT's process of resolving problems is to solve them in a non-routine and improvisational manner based on experience rather than following existing prescribed work standards. Meanwhile, the division of labor among the engineers was reorganized. The proportion of manufacturing technology engineers in pilot production has increased, while the role of process technology engineers has been readjusted to the back-end processes.

The construction of a large-scale centralized pilot center served as a new opportunity for Hyundai to take a leap forward. Hyundai has implemented intensive problem-solving methods in the production stage of pilot cars. Hyundai's new problem-solving method has been established to integrate design and production under the leadership of engineers during the pilot production phase.

The above-mentioned new car development methods of Hyundai are similar to the second path of capacity-building suggested by Gong et al. (2006). In other words, capabilities are not built up in an orderly sequential manner through the formation and accumulation of routines as commonly assumed, but rather, they are formed according to the way in which improvisational activities are developed and repeated prior to the routine, becoming capabilities and propelling the company forward. As Clark and Fujimoto (1991) suggested, the integration of product design and production is a major challenge in product development in the automotive industry. Hyundai did not resolve the integration between product development and production through close interaction between skilled shop-floor workers and engineers like Toyota, but through the link between engineer-led product development and the pilot center's operation, in fact excluding shop-floor workers' participation, resulting in a successful catch-up in the middle to low segments of automobiles. Table 3 summarize the characteristics of Hyundai's improvisational product development model.

In what follows, we highlight Hyundai's improvisational product development model by comparing the characteristics of the new car development processes of Hyundai and Toyota, which are considered major carmakers in East Asia. Problem-solving in the pre-mass production phase is a general trend shared by major carmakers. This trend can be observed not only at Hyundai but at Toyota as well. However, Hyundai and Toyota are clearly distinct in their specific ways of developing new cars.

First of all, Toyota is distinguished from Hyundai, which values problem-solving in the pilot production stage, in that Toyota solves most of the problems in the product design stage before pilot production. This can be observed in Figure 2. At Toyota, most of the problems that may occur in the

Table 3
Dimensions of Hyundai's Improvisational Product Development Model

Minimal structuring	Recombination	Responsiveness	Novel solutions
- "Making an inexpensive car with quality" - Declarative Quality Management	- Mobilizing the experience and resources of diverse subsidiaries in the *chaebol* group to solve the problem - Concentrating problem-solving capabilities scattered throughout the company at the large-scale pilot center - Internal promotion system through commitment and compulsion	- Quickly responding to unexpected problems without following a rigid predefined script - Improvised response of the CFT as an essential coordinator - Differentiation of engineer groups in the process of product development	- Intensive problem-solving through centralized pilot center -Mainly engineer-led integration of product design and production

new car are solved through frequent design changes in the product design stage. On the other hand, at Hyundai the large pilot center complements the lack of problem-solving capabilities in the product design stage through intensive problem-solving.

Second, the two companies differ greatly in the way that organizational capabilities are formed. According to Whitney et al. (2007), Toyota is an example of standardizing production processes and design, where all essential procedures are recorded as standards in the production process. Engineers choose their data and design methods and perform routine tasks based on established standards. These standards are rigorously updated by the "Evaluation Group," which consists of several engineers. This process can be described as incremental and cumulative innovation based on standards.

However, Hyundai's organizational capability formation does not proceed in a cumulative and staged way through standards and routines. At the large pilot center there are important problems that are not predicted in product design. To intensively solve them, all available resources are employed. In the process, the intuitive judgment of the engineers and the improvisational capability play a significant role. The process of exerting intensive problem-solving capability at the pilot production stage is closer to the path of organizational capability building through organizational improvisation than to standards and routines.

Third, Hyundai and Toyota also differ in their decision-making structures. In new car development, the key is to improve the expertise of functional departments and to manage their different interests in an integrated manner. To this end, both Toyota and Hyundai have chosen to use a matrix organization for their new car development organization.

However, the decision-making structure of the matrix organization is different in both companies. In the case of Toyota, a matrix organization with agents from each functional department under the project manager (PM) or chief engineer (chief executive) lead the development of new cars. The PM has the responsibility and authority to set up product concepts, adopt major technologies, write main specifications, manage sales targets, manage costs and profits, and select key members. They strive to achieve the integration of new product development while also frequently carrying out direct talks with engineers from each functional department. At Toyota, the PM's in-house status is the same as the head of the functional department, and if necessary, they resolve confrontation and conflict through direct talks with the functional department head (Jo and Oh 2020).

Hyundai also runs a matrix organization called CFT to develop new cars. The CFT, however, is an organization of multiple engineers with multiple secretaries but no PM who holds the same powerful authority as at Toyota.[3] When differences between functional departments appear, Hyundai tries to solve the problem through a general CFT meeting, and if the problem is not resolved there, the CFT then reports the problem to the chief executive officer and the vertical information processing method of solving the problem resolve the issue.

Finally, Hyundai and Toyota also show different characteristics of relationship between their manufacturing engineering technology and process technology. At Toyota shop-floor workers actively participate in improvement activities. Process technology maintains a horizontal division with manufacturing engineering technology using the active participation of

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[3] This is partly because Hyundai does not have an executive with extensive experience to cover the entire process of new car development, but also reflects the characteristics of Hyundai's organizational culture, which gives a large voice to functional organizations (Jo and Oh 2020).

shop-floor workers in improvement activities (Adler, Goldoftas, and Levine 1999; Shibata 2009). On the other hand, Hyundai's intensive problem-solving increases the weight of manufacturing engineering technology in the front-end process. In this case, the participation of shop-floor workers in improvement activities is passive and process technology engineers are burdened with most of the workers' improvement activities.

Concluding Remarks

This study has tried to identify the characteristics of organizational capability formation unique to Korean companies through the case of Hyundai. Shedding light on the evolution of Hyundai's organizational capabilities provides a typical example of understanding the dynamics of Korea's technological catch-up at the micro level. The intensive problem-solving ability built around the large-scale pilot center in the new car development process cannot be explained by the view of capabilities as a "collection of routines" in which capabilities are built up through the repetition of existing practices.

Intensive problem-solving capabilities imply improvised work, as well as impromptu skills that are not routinized into standards. The centralized pilot center represents the culmination of Hyundai's problem-solving capability at the stage prior to mass production, where the labor is excluded from participation. Hyundai's intensive problem-solving capability is tacit knowledge that cannot be routinized, and is unleashed in an environment free from external constraints. The simultaneous development of strategic planning and execution is achieved through a new car development process based on the principle of concurrent engineering and under minimal guidelines from top management. Participation from engineers is a part of the problem-solving process, with time pressure to solve problems. Intuitive judgment is more important than routine in the problem-solving process. With these elements of organizational improvisation, Hyundai has not only caught up to more advanced carmakers but has now progressed to the stage of developing new, high-quality cars in its own right.

Are Hyundai's organizational capabilities through intensive problem-solving at the pilot center sustainable? Regarding this question, we would like to conclude this paper by raising four issues.

First, the intensive problem-solving capacity of Hyundai could lower the possibility of horizontal decentralization of power and autonomous problem-solving. If a problem occurs at a time when communication between departments is not going well, the problem may be concealed in the process of avoiding mutual responsibility rather than being resolved internally. This could pose a serious threat to product quality and safety.[4]

Second, Hyundai has been successful in shortening the development period for new cars and stabilizing mass production quality through intensive problem-solving at the pilot center. However, securing and updating product design technology remains a challenge for Hyundai. This requires a large accumulation of empirical data, but this is not a problem that can be solved in the short term.

Third, Hyundai's intensive problem-solving method has imposed heavy burdens on the process technology engineers responsible for both preparing for mass production and making improvements on the shop floor, without the participation of shop-floor workers. The excessive workload for process technology engineers could lower their morale as middle managers and have the unwanted side effect of them avoiding the shop floor.

Finally, intensive problem-solving through the pilot center implies that the mass production process has been simplified as much as possible to minimize variation. This creates a double exclusion for workers on the shop floor. Workers are excluded from decision-making as well as from the development of new skills.

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[4] Hyundai has undergone massive recalls in the United States and Korea several times since 2015 due to engine defects. During this process, accusations that Hyundai knew about and deliberately hid the defects have taken a toll on the company's perceived reliability. A whistle blower who worked at Hyundai's Quality Control Headquarters at the time reported that the team was "accustomed to illegal actions such as concealing safety-related manufacturing defects even after they had been confirmed" (*Kyunghyang Shinmun* September 23, 2016).

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Chulsik Kim is an assistant professor in the division of social science at the Academy of Korean Studies, Seongnam, South Korea. He has a Ph.D. in sociology from Seoul National University, Seoul, South Korea. His research interests are industry, organization, labor market and labor relations. Currently he is working on the relationship between technology and work in the digital age. [*Email:* cskim@aks.ac.kr]

Jun Ho Jeong is a professor in the real estate department at Kangwon National University, Chuncheon, South Korea. He has a D. Phil. in economic geography from the University of Oxford, Oxford, UK. His research interests include wealth and income inequalities, the housing market, industrial and innovation policies, and national and regional development theories. Currently he is working on changes in social opportunity and mobility at the national and regional level in relation to the worsening of personal income inequality. [*Email:* jhj33@kangwon.ac.kr]

Hyung je jo is a professor emeritus of social science at the University of Ulsan, Ulsan, South Korea. He has a Ph.D. in sociology from Seoul National University, Seoul, South Korea. His research interests are industry, region, production system, labor relations. Currently he is working on the employment change in the transition to eco-friendly automobile industry. [*Email:* hjjo@ulsan.ac.kr]