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Reshaping Cognition in Building Dynamic Capability: Automobile Emission Control Technology Development

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Keywords:

Dynamic capability, Cognitive frame, Knowledge boundaries

Introduction

The fundamental issue of an organization when faced with a rapidly changing environment is determining how to develop or change its resources. Exploring new technological domains beyond previous expertise is filled with uncertainty. Since most innovation happens at the boundaries between disciplines of knowledge (Leonard-Barton, 1992), how to reshape the capabilities of an organization in a new way is a key ingredient of competitive advantage. Previous research revealed that the mechanism by which an organization changes its resources is a dynamic capability, defined as the firm's ability to integrate, build and reconfigure internal and external competences to address changing environment (Teece, Pisano and Shuen, 1997).

Despite an increasing understanding on the importance of building capabilities across organizational units (Keil et al., 2008), relatively little is known about how a firm leverage its resources base to accommodate with dynamic changing environment (Dannels, 2010). Especially dynamic capability is deemed as an organizational phenomenon accountable for the creation of novel knowledge that significantly deviates from a firm's existing knowledge trajectories (Keil et al., 2008), yet less present in the dynamic capability debate explained how firms develop capabilities to deliver products and service (Pandza and Thorpe, 2009).

In the managerial cognition literature, recently researchers have become increasingly interested in the cognitive drivers of capability building process (Barr et al., 1992; Gravetti, 2005; Ocasio, 1997; Tripsas and Gravetti, 2000). There is considerable evidence to suggest that firm's cognitive frameworks affect their response to technological change and capability development.

In the setting of new technology emergence, external disruptions requires firm to

recognize capability needs that may originate in domains distant from their existing capability base, thus making it difficult for incumbents to develop a coherent understanding of how to respond to the disruption (Gilbert, 2006). Constrained within the learning boundaries, firms find it challenging to make sense of knowledge that deviated from its previous trajectories (Levinthal and March, 1993). In order to decide on an appropriate course of action, related research has showed that reconfiguration capability into a new direction requires shifts in managerial cognition and attention (Narayanan et al., 2009; Cho and Hambrick, 2006). This implies that cognition makes up the difference on capability building, therefore makes it important to investigate the intersection between cognition and capabilities (Eggers and Kaplan, 2013).

Using an in-depth case study on emission control technology development, this paper examines how a firm shift its prior cognitive fame to leverage its resource base. By looking at the process of how automakers developed its existing knowledge base into a new direction, this paper contributes to previous research by addressing the role of cognition on the formation of dynamic capability development. How firms deal with exploring new opportunities while engaging in routinized activities is vital for survival. The emergence of new technology required substantial different skills and competencies than those that incumbents typically had (Pandza and Thorpe, 2009). In order to overcome potential blind spots in their response to technological change, management need to reshape their cognition in guiding precise action.

The reminder of this paper is organized as follows. Section 2 reviews current literature on cognitive aspect on dynamic capability and shows analytical viewpoints I will take. Section 3 describes the empirical field and research method in this paper. In the following section, using unique data from automobile industry, I will describe

three-way catalytic converter technology development especially focusing on different cognitive frames between automaker and its suppliers. Finally in section 5 findings and discussions are drawn.

2. Cognition Aspect on Understanding Dynamic Capabilities

Scholars in the dynamic capabilities literature have argued that to adapt, organizations need the ability to acquire new capabilities, integrate capabilities in a new way, or reconfigure existing capabilities (Eisenhardt and Martin, 2000; Teece et al., 1997). From knowledge creation based view, how firms create and share knowledge in a multi-organizational setting are key sources of sustainable competitive advantages and superior profitability within an industry (Grant 1996; Kogut and Zander, 1992). Therefore, a dynamic capability in a particular firm depends on if the firm is capable of creating novel knowledge that is not determined by the experiential dynamics of existent knowledge trajectories (Pandza and Thorpe, 2009).

Exploring new knowledge domains is cognitively challenging and uncertain (Levinthal and March, 1981). Given organizational learning is based on local search process (Levinthal and March 1993; Levitt and March 1988; March and Simon 1958), familiarity with what have done in the past can make actors miss-recognize what is value in the present. Recent work shows that firm's prior knowledge is embedded within manager's mental model on how to recognize and identify the value of the new knowledge (Clark and Henderson, 1995). These issues highlight the challenges that managers in the face of making sense of how to recognize and assess knowledge when technological unfamiliar circumstances arise (Weick et al. 1999).

Gavetti (2005) argues that transforming existent knowledge into a completely new

domain of application cannot be interpreted as simple knowledge exploitation. Especially in the setting of technological discontinuities, knowledge pertaining is often fundamentally different from existing knowledge and does not fit into existing cognitive frames (Kaplan and Tripsas, 2008). The causal understanding of the fit between existent knowledge in the firm and the competitive environment is destroyed, therefore blinding incumbents to the potential gains from competing in new area. Under this situation, managerial cognition is a prerequisite to an affective organizational response to capability development.

A large portion of literature has focused primarily on the cognitive puzzles lead to rigidity in response to environmental or technological change. Firms are characterized as highly inert systems incapable of fundamental change (Hannan and Freeman 1977). Others have argued that firms can adopt, but are constrained by existing organizational routines (Nelson and Winter 1982). When looking at new technologies based on unfamiliar knowledge, firms don't stray too far from what is familiar. Established firms have been shown to search more closely to their existing areas of technological expertise (Podolny and Stuart 1995). Firms will attempt to approach new technological knowledge in terms of their existing frames, imposing assumption, knowledge, and expectations about familiar knowledge on the unfamiliar settings (Orlikowski and Gash, 1994). Therefore, an organization that has developed strong historical resources or technologies may come to view the world from the frames created by that technology (Thompson, 1967). Within the previous learning boundaries, firms are constrained by established cognitive frames and dominant logic on previous resources (Prahalad and Bettis, 1986).

Cognitive frames are self-reinforcing, to the point of rejecting knowledge that does

not fit their system of meaning (Orlikowski and Gash, 1994). Rigid cognitive frame limits the gathering, interpretation, and use of information because the organization comes to rely on its past successes (March & Simon, 1958). Organization with a rigid resources or cognitive frame come to see the world in light of current strength, thereby overlooks the gaps between their current strengths and those required in a changed environment (Levitt & March, 1988; Leonard-Barton, 1992)

Given cognitive barriers are powerful inhibitors in the process of capability development, how an organization shift its cognitive frame is indispensable in building dynamic capability (Eggers and Kaplan, 2013) .Scholars have noted that the decision on dynamic capability relies on the perception and attention of firm's management in regard to its external environment and internal situation (Cho and Hambrick, 2006). Cognitive constrains on knowledge learning in a new direction emphasizes the decision to develop a capability is associated with a change in the member's cognitive orientation (Narayanan et al., 2009). This emerging research stream implies that cognitive shift enables managers to recognize and develop capability in leading to a change in the firm's resource base (Laamanen and Wallin, 2008). Although the role of cognition has been emphasized in the prior research, there is much less evidence on the linkage between cognition and capability development. More detailed elaboration and mechanism on micro-level process of how to create and sustain dynamic capability is still subject to future research (Buenstorf and Murmann, 2005). In this paper, I examine the process of how cognitive representation influence firms action to leverage its resources base into a new direction.

3. The Empirical Field

3.1. Research Method

The empirical field is the development of the three way catalytic converter system (TWC) in the 1970s. The TWC system significantly reduces the emissions of three types of pollutants: hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x). It was commercialized in the 1970s to meet the requirements of the Clean Air Act (CAA), and after forty years, this technology still remains the dominant emission control technology for gasoline engines in the world auto industry.

The case of TWC is a salient example to examine how firms renew its resource base in the face of technological changes which is distant from its existing knowledge base. TWC is a complicated technology that combines electronic fuel injection devices, oxygen sensors and a catalytic device, which requires a wide range of understanding on a very complex set of knowledge modules in engineering, electronics, and chemistry. In the 1970s, the traditional car industry was based on mechanical engineering with few related electronics and materials concepts. Introduction of this new technology required the traditional auto makers to integrate and reconfigure internal and external knowledge into a new direction. Thus, TWC development is an ideal research setting for understanding of dynamic capability development in which novel knowledge is required.

The research concern in this study is with the mechanisms through which a shift on cognition contributes to capability development. To capture the richness and complexity of learning and cognitive process is virtually impossible by means of a cross-sectional study (Yin, 1994), thus inductive case method is much better suited to analyzing complex longitudinal phenomena (Keil et al., 2010).

In order to examine the cognitive process on developing dynamic capabilities,

multiple resources and methods are required for data collection. The study began with interviews and archival data collection to establish a historical viewpoint on industry and an internal viewpoint on how actors reacted when they are faced with explorative activities which was unfamiliar with their prior knowledge boundaries.

Data were hand collected from a broad range of primary and secondary industry sources including company and industry association archives. The first step of my data gathering was to develop a comprehensive collection of publicly accessible sources of evidence. I collected extensive archival data on TWC development. Most of these data come from company reports and business press, and were collected in exhaustive searches of automobile technology reports and professional journals. I reviewed every article from 1968 to 1978 relevant to emission control issues published at the *Automotive Technology Journal*, a prestigious publication for automobile engineers in Japan. Journal data is helpful to clarify interview data based on personal views.

Interview data was mainly collected between Toyota and its electronic supplier Denso Corporation. The key engineers involved in the development were interviewed, including the former vice president of Toyota and former senior executives of Denso. In order to gain a wider appreciation of engineers' cognition on EFI development, I attended the conference of the Society of Automotive Engineers of Japan, which enabled further interviews with key engineers in the industry and collection of public and technical information.

Information from a specific interviewee was triangulated with information from other interviewees as well as contemporaneous secondary data. This triangulation lowers the risk of retrospectively imposing meaning on historical events based on our knowledge outcome (Aldrich, 2000).

3.2. The Emission Control and the Concept of TWC

The TWC system was first placed in the spotlight at the IIECP conference in 1971. The IIECP originated in 1967 by the Mobile Oil Company and the Ford Motor Company to conduct long-range research toward the development of emission-controls on gasoline-powered vehicles. Many Japanese automakers, such as Nissan and Mitsubishi Motors became original participants of the IIECP in 1968. Toyota became an affiliated member in the program in 1971.

In 1971 at the IIECP conference in Italy, Robert Bosch, the German automotive supplier, presented its current research on TWC system. According to Bosch's presentation, if the oxygen sensor, catalytic device, and EFI (electronic fuel injection) were in proper combination, the most stringent NO_x standards could be met without penalizing fuel economy and power output. At the time the automobiles were faced with the most stringent emission control of 1970 CAA. The act specified a 90% reduction in the level of HC and CO emissions from the 1970 levels by Model Year (MY) 1975, followed by a 90% reduction of NO_x from the 1971 level by MY 1976. It was a very stringent environmental regulation, requiring that HC, CO, and NO_x all would have to be reduced by 90% of the prior standard less than six years.

Given this backdrop, Bosch's presentation on TWC seemed worth pursuing, yet the use of catalytic converter and EFI for automobiles was still a remote commercial possibility in those years.

Auto makers had no explicit strategy to commercialize TWC. Nor was it clear how to meet the emission control standard with this technology. The major obstacle for automakers was the lack of internal knowledge for developing TWC. In the 1970s the

core knowledge base in automobile industry was mechanical engineering. There were few chemical engineers in the industry and no electronic experts. Motohiko Suzuki, the former vice president of Mitsubishi Motor Company, who participated in the IIECP conference recalled in my interview like this:

When I sat on the IIECP conference and listened to Bosch's presentation, I really could not believe what I heard. The prerequisite for TWC was precise control of the air-to-fuel ratio near the stoichiometric point of round 14.5, where a narrow-range window exists for simultaneous conversion of all three pollutions. I could not help but wonder, is it possible? At the time we were using carburetors and it was a well-known fact that the air-to-fuel ratio could not be controlled precisely, especially at the narrow range of the stoichiometric point. I was really shocked. After the presentation I sent a telegram to my colleagues in Nippon Denso immediately to inform them this crazy idea. (Interviewed by the author)

Nor was it clear for automakers on how to meet the emission control by such an unfamiliar technology. As Kiyoshi Matsumoto, who was in charge of emission control development at the time and later became vice president of Toyota, succinctly stated, "We didn't really know a thing about three-way catalytic converter."

4. Cognition shift on TWC development

4.1. From preliminary stage to an in-house Development

In the time that followed, auto makers decided to explore the feasibility of TWC. Prior to the 1970s, catalytic converters were used in non-automobile sectors such as chemical plants, where a certain temperature is a prerequisite. But this prerequisite condition is impossible in the auto industry, because engines operate in various conditions. The temperature is always changing and the road conditions are impossible to predict. The catalytic approach seemed ridiculous to the traditional mechanical

engineers.

In the early stage of development, auto makers were struggling with the lack of knowledge and accompanied human resources. Toyota invited a chemical professor from Kyoto University to give a lecture to its engineers. The professor was available at the mechanical engineers' request once but never showed up again. "I think he (the professor) was desperate to see the catalytic converter failed the engine test and blow into the air like ashes. He must have felt that this was a really stupid idea," stated Kiyoshi Matsumoto, the former vice president of Toyota and the general director for emission control development in the 1970s.

Given the lack of in house chemical knowledge, Toyota made a contract with US catalytic suppliers. The first contract was made with UOP (Universal Oil Product). According to the contract, UOP prohibited Japanese makers from disassembling and analyzing the converters by themselves. Therefore all broken devices had to be returned to UOP and tested by the US side. Since catalytic converter broke frequently in the endurance test, this contract made the product lead time longer than expected. "We were so frustrated waiting for the analysis result from UOP. We would miss the lead time if we relied on this contract." (Former chief engineer).

Given technological uncertainty, unexpected problems could occur in the product line, which requires the iterative process of design and rectification. It became difficult to manage this process under the contract. As a result, Toyota established a "particular component lab" in house to develop catalytic converter. One of the engineers recalled, "We named the lab as 'particular component' because we had no clear direction on what to do and how long it would take to develop catalytic converter." Given no specific catalytic experts in house, Toyota convened engineers from metal and plastic materials

in house to work on the project.

Toyota bought a small activated carbons firm, named Daiichi-Tansoku. The company renamed Cataler Corporation later to be in charge of specialized automotive catalytic technology. Cataler established research lab particularly in conducting design on manufacturing and quality control. In order to raise the yields rate of catalytic converter, engineers from Toyota were working with catalytic engineers for months at the Cataler plant.

In the case of Nissan motor at the time, given the lack of chemical engineers, the company asked help from Nissan Chemical Corporation, an affiliated company of Nissan-Group. Catalytic experts were scouted to join Nissan motor. In the peak time, 200 engineers were involved in the development of catalytic converter at Nissan.

4.2. EFI Development by Suppliers

EFI is the key component for TWC. Theoretically, if the air-to-fuel ratio was precisely controlled near the stoichiometric point of 14.5, all three emissions would be controlled simultaneously. EFI used sensors and an on-board computer to monitor the engine's performance and to change parameters in real time to adjust to changing conditions. This allowed precise control of an automobile's air/ fuel mixture. The increased precision allowed automakers to use more advanced emissions control devices and it gave cars better fuel economy performance.

The need for precise control of the air-to- fuel ratio required the development of an electronic feedback system including EFI (electronic fuel injection) device and the oxygen sensor device. The oxygen sensor device, typically made by platinum-coated zirconium oxide, is placed before the catalyst in the exhaust manifold. It compares the

oxygen level in the air with that in the exhaust gas stream and sends a voltage signal to the electronic control unit, which then achieves the optimum air-to-fuel ratio by controlling either the carburetor or the fuel injection control device.

In the beginning, car makers worked to improve carburetor performance. In particular, they strove to improve emission and fuel economy performance by increasing the precision of control for the ratio of air and gasoline entering the engine. But by the end of the 1970s, carburetor performance seemed to have reached its limits in terms of consistent delivery of a stoichiometric mixture of air and fuel (Snow, 2010).

Although EFI could realize precise control of automobile's air/fuel mixture by applying sensors and an on-board computer to monitor the engine's performance in real time and various conditions, in the heyday of carburetors, few mechanical engineers understood electronic control. In fact, however, prior to 1971, auto-related supplier, Denso Corporation, began to show great interest in electronic fuel injection control technology.

Denso Corporation, began as the electrical and radiator department of Toyota in 1937. It was spun off as an independent but partly owned affiliate of Toyota in 1949. In the face of decreased business and lagged technology, Denso was eager to form technology alliances and partnerships with western makers. In 1953, a strategic alliance with Robert Bosch allowed Denso to access Bosch's fuel injection patents. Denso could thus rely on experienced partners who were committed to the new technology.

The concept of gasoline injection could be traced back to the 1930s, when the aircraft industry became involved in injection technology. In 1950, fuel injection was put into use in expensive cars. In 1951, an engineer at Bendix developed the first

electronic controlled injection device and enrolled the patent. Five years later Bosch began to develop the electronic controlled injection device for high-end and racing automobiles. However, after emission control standard was strengthened in the 1960s, automakers began to show interest in fuel injection in response to regulations and market demand for fuel-efficiency. In 1965, with the aims to accompany with 1968 emission control standards from California government, Volkswagen approached Bosch to develop an advanced injection device with air-fuel-ratio control. Bosch accelerated its electronic device development based on contract with Volkswagen.

Based on the technology partnership with Bosch, Denso started mechanical fuel injection development in the 1960s. Pump department was in charge of the research and was succeed in producing mechanical fuel injection device for Suzuki and Fuji Industry in 1966. In 1967, Denso sent two of its engineers from the pump department to Bosch to discuss patent licensing on fuel injection. Bosch demonstrated the ongoing prototype of fuel injection device. One of the members in the delegation recalled it in my interviews: “I was so impressed to see that the density of carbon dioxide was precisely controlled by such a simple device. Moreover, the controllability and the match ability were superior to traditional carburetors.” (former chief engineer).

After returning from Bosch, Denso decided to establish a project team devoted to EFI development. Most of project members came from pump injection unit. In the beginning the research was greatly due to Bosch’s patent, but Denso tried to develop electronic control technology based on an in-house manner.

4.3. Conflicts on Cognitive Frames: Mechanical knowledge vs. the Electronic Knowledge

In order to expand its EFI business, In 1968 Denso submitted an electronic fuel injection (EFI) proposal to Toyota. However, in the heyday of carburetor-control, only limited mechanical engineers were interested in electronic controlled devices. Most of Toyota engineers opposed the proposal by arguing that “why should we develop such a high cost and uncertain technology to replace carburetor”. Since the commercial success of EFI was still uncertain, most automakers were not inclined to invest to EFI, as they forecast their widespread use in the distant future.

Regarding to electronic engine control, cognition gap lied between mechanical engineers and electronic engineers. (Figure 1).

Insert Figure 1 Here

“The mechanical engineer’s mind is based on the five senses of human beings. They trusted the mechanical instrument because machine lets them see it, touch it and smell the oil. They did not trust the electronic devices from the beginning, because the electronics are invisible. Mechanical engineers were nervous about the induction of electronic devices. The old engineers, in particular, usually shouted at us like this: why don’t you use words we can understand,” (multi-interviews with electronic engineers by the author)

On the contrary, the electronic engineers had a different view of electronic technology.

“Basically we write and rewrite program to control engine precisely under various conditions. This is our job. Although we do not have knowledge on the mechanical side, we have reached to the sanctuary of the car industry: controlling engine by invisible devices.” (Former electronic engineers at Denso)

Hisashi Suda, the former managing director at Denso, recalled the following when he approached Toyota for engine testing.

“When I first went to Toyota for the meeting about the prototype, all the engineers listened to my demonstration without a response. The only one who showed great interest in our concept was a young manager in the engine department. He was trained in electronic field. He raised his hand and spoke out ‘I would like to do it in my department’. Thanks to his words, the engine test started.” (Interviewed by the author)

In order to convince Toyota of the advantages of using EFI instead of carburetors and to overcome the skepticism and resistance of engineers, Denso bought a Toyota car and installed the EFI devices. When Denso showed the car working with EFI, the difference between carburetor and electronic-controlled cars was quite clear. Especially in the reliability of the air-to-fuel ratio, the predominant performance of EFI was proved. Gradually mechanical engineers changed their minds.

4.4. Cognition shift in Building Capability

Toyota began to realize the importance of EFI and began to take the lead in the development. One of the reasons behind that was Japanese government enacted the emission control for NO_x standards in spite of opposition from the automakers, which forced the auto industry to reshape its resources to EFI development. More than that, mechanical engineers realized it is important to shift their capability base into a new domain. Engine control by electronic devices raised an identity question for automaker. By realizing that engine control by electronic devices would challenge their identity, automakers shift their cognition to compensate the gap on its knowledge base. Kiyoshi Matsumoto, the former vice president who was in charge of emission control technology development at Toyota, recalled like this:

“When we used the EFI device to control the engine, I was the general director of the

engine department. The electronic control program was produced and designed by Denso, so we just bought what Denso provided and there was no electronic control related department at Toyota. I thought this would be a big problem for Toyota, so I pushed engineers, especially the engineers in manager class, to learn electronic related knowledge. I remember I always threatened them like this: if we don't know the mechanism of electronic-controlled engine, Denso will replace us to produce Toyota's engine one day. (Interviewed by the author)

In order to fix the problem of a lack of human resources, Toyota began to hire more and more chemical and electronic engineers. The percentage gradually thus changed the traditional territory of engineers in the automobile industry. (Figure 2)

Insert Figure 2 Here

A well-established practice at Toyota was to accept engineers from Denso working at research lab temporarily. When its emission control specialized institute, Higashi-Fuji Research lab, was built, Toyota asked Denso to send engineers in compensation for the lack of electronic engineers. Denso deemed this as a potential business opportunity and sent many young and promising engineers. The purpose of sending engineers to another research institute is to spur innovation by facilitating the acquisition and diffusion of knowledge (Gattani, 2006). This approach fostered both sides to seek applications for potential valuable resources. Especially in the life time employment tradition, most of the engineers sent by Denso were highly promoted in the years after, thus strengthened the long term relationship between two companies on research collaboration.

During the last spurt of three-way catalytic converter system development, a multifunctional project team composed of engineers from Toyota, Denso, and Toyota Central Institute was built. Denso took charge of the development process, while Toyota

tested the whole system, then the result was sent to the Central Institute, where the deterioration mechanism was analyzed. In order to accelerate the development schedule, Toyota engineers designed the product line inside Denso plant, checking the details while the oxygen sensor flowing through the lines.

In such a multi-functional development organization, the boundary of task-partitioning (Takeishi, 2001) became vague. Just as many engineers stated, “When an electronic device was put into the engine and the engine test began, we usually were faced the problem that engine did not move. It was difficult to have a clear boundary between mechanical engineers and electronic engineers. The simple thing was that we had to keeping working together until engine moves without any problems.” In such a situation, engineers with different background extended their knowledge boundaries by learning from each other.

Such learning practice played a critical role in extending resources base. In the learning based knowledge spanning, informal process of storing, retaining and retrieving knowledge could be greatly enhanced beyond formal organizational channels (Hargadon and Sutton, 1997). In order to meet emission control enforcement, most engineers were forced to work for long hours. Due to the lack of human resources on engine department, Toyota recalled all of its potential engineer sources from suppliers and dealers to embark on engine test. This informal and intimate atmosphere around TWC development was important in creating a sense of community and fostering exchange of knowledge through multiple channels.

4. 5. Summary and Discussions

The development of the three-way catalytic converter system represents capability

development in the context of knowledge recombination. The findings reveal the consistency of the idea that the development of new technological capabilities must be accompanied by conscious effort to integrate and reconfigure existing resource with various possibilities (Keil et al., 2008). Since dynamic capability is defined as “the ability of an organization to purposefully create, extend, or modify its resource base,” systematically using its internal as well as external resources to bring about change is important for the firm (Markku et al., 2013). Therefore how to direct and renew capabilities into transformative growth is a particularly important in terms of internal and external turbulence.

Regarding to the process of capability development, in this paper, I especially studied how cognitive representation influence firms to extend its resource base into various knowledge paths.

In the case of emission control technology, the knowledge base on electronic control technology was at odds with mechanical knowledge based technology. Engineers in the traditional automobile industry had difficulty in prospecting the electronic engine control based on their mechanical knowledge domains. Electronic engineers, in contrast, understood the electronic-controlled devices and began to leverage its technological knowledge base. This enables them to be capable of realizing a precise control in engine operation system, hence they took the lead in the development at the first stage. In this case, cognitive frames provided a valuable lens through which to understand the interpretative grounds around dynamic capability development. If exploring new technological knowledge is vital for competitiveness, how to tackle with the incongruence of cognitive frames is critical. EFI development implies how to reshape prior cognitive frame into a new direction is important on

formation of developing capabilities.

When facing an unfamiliar technology, actors have the tendency to impose assumptions, knowledge perspectives in terms of their traditional frames, which make different frames incongruent and unlikely to be shared across the task boundaries. In consisting with previous research, the findings here suggest the role of knowledge broker to mediate knowledge transfer between multiple contexts (Hagardon and Sutton, 1997). The electronic engineers with mechanical backgrounds in Denso and also the mechanical engineers with electronic backgrounds in Toyota were critical in knowledge sharing process.

This paper contributes to prior research by delving into the micro-level process of how dynamic capability is accompanied with cognition conflicts in which specialized expertise cut across areas. As extant research revealed that managerial cognition can compensate for missing capabilities in spurring action (Barr, 1998; Eggers & Kaplan, 2009), thus how to reshape cognition into a new direction is important in guiding actions to develop capability.

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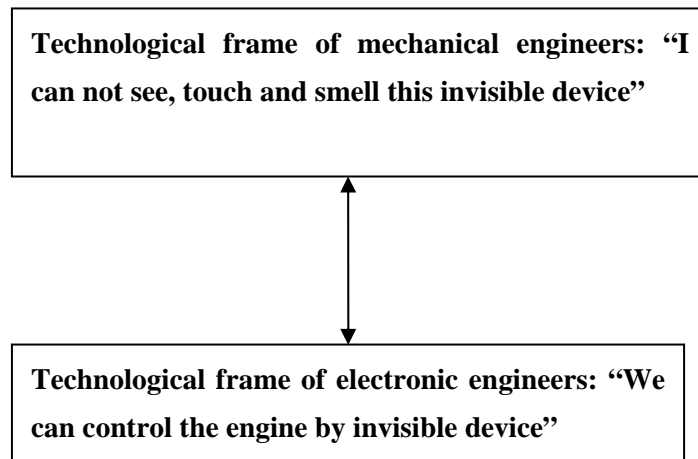
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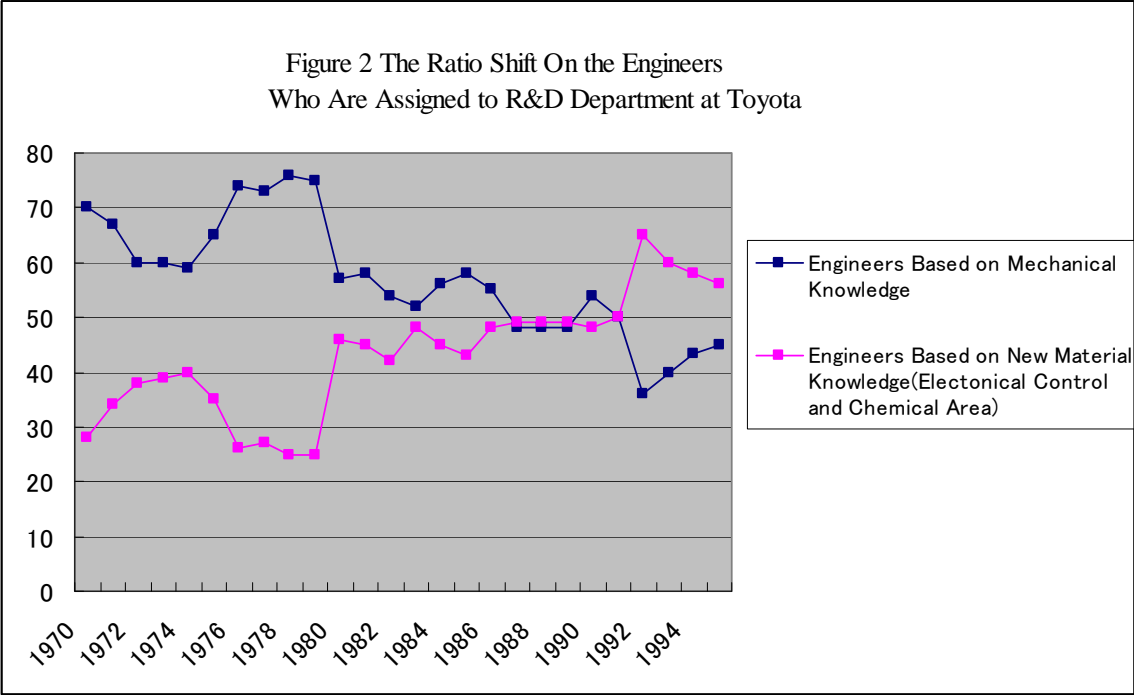
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Fig. 1 Conflicting frames between mechanical engineers and electronic engineers





Source: Based on the documentary materials from Toyota