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The Relevance of Firms' Knowledge Amount to Their Strategic Positioning to a Consensus Standard: The Case of AUTOSAR in the Global Automobile Industries

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The Relevance of Firms' Knowledge Amount to Their Strategic Positioning to a Consensus Standard: The Case of AUTOSAR in the Global Automobile Industries

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Abstract:

The paper aims at examining how a firm positions itself to the standardization process by a consortium drawing on the case of ECU (electronic control unit) in the global automobile industries. Four archetypes of strategic positioning are found and explicated by firms' knowledge amounts (i.e., the quantity of patents) in the related fields. The result shows that a firm is liable to choose its strategic positioning toward standardization according to its knowledge accumulation. The finding also makes us infer that a firm with sufficient knowledge would face a dilemma between its legacy and the standard.

Keywords: standardization, knowledge amount, strategic positioning

Introduction

This paper attempts to explore firms' strategic positioning toward standardization in terms of firms' knowledge amount. Required to externalize increasing R&D expenditure, firms increasingly get interested in the standardization process through consortia for collaborative standard settings (Chiao, Lerner and Tirole, 2006; Leiponen, 2008). A standard through such collaborative process is often called a "consensus standard," which is shaped through consensus between participant firms to set the common domain and its specifications (e.g., Weiss & Cargill, 1992). In the process from standard setting to implementation, a single dominant player does not determine everything. Rather, relevant multiple players (e.g., OEMs, suppliers, tool manufacturers, and so on), according to their backgrounds, drive for the standardization.

Firms' strategic attitudes toward standardization can significantly influence firms' competitiveness (Bekkers, Duyster and Verspagen, 2002). Nevertheless, open questions on firms' strategic positioning still remain unanswered: what background determinants drive a firm to participate in a consortium for standardization and how the firm copes with standardization.

Participant firms' knowledge amount plays a critical role for the success of standardization (e.g., Bekkers et al, 2002; Rysman and Simcoe, 2008). A consortium for standardization is the field to encourage knowledge exchange and learning between and within participant firms (Leiponen, 2008). On the other hand, a firm's strategic actions are known to depend upon its knowledge accumulation (Katila, 2002; Katila and Ahuja, 2002). These perspectives on firms' knowledge are expected to help us delve into firms' strategies toward standardization.

Led by these perspectives, the study attempts to explore the impacts of a firm's accumulated knowledge on its strategic positioning drawing on the case of a standard of electronic vehicle control system, AUTOSAR (AUtomotive Open System Architecture, the details will be described later). First, the paper reviews past research streams to propose our perspective. Second, the framework to explicate firms' positioning strategies toward a consensus standard is proposed in terms of firms' accumulated knowledge. Following the framework, the study examines the case of a consensus standard, "AUTOSAR." From the empirical findings, the study draws propositions and discusses the implications. Lastly, the conclusions and limitations come.

Review

Firms are oriented to the standardization process through a consortium in order to evade harsh competition between de-facto standards set in market competition (Chiao et al., 2006). Studies on such standardization thorough consortiums are interested in the fruits of standardization: network effects on demand-side and scale-merits on supply side. In the line, IP (Intellectual Property) rights, collaborations with other firms, involvement in other consortia, and the archetypes of involvement to consortium have drawn attentions from researchers (Leiponen, 2008). However, why firms participate in and/or make use of standardization is not sufficiently examined.

One of the major reasons is that past researches which primarily rely on the context of ICT industries. The objects of standardization in ICT industries are mostly related to interoperability between components, devices, and/or sets of equipment. Indeed, in terms of the network externalities related to such interoperability, most of studies on standardization make efforts to propose policies in terms of generic economic welfare and/or elucidate strategic implications from successful standards (e.g., Bekkers et al., 2002; Greenstein and

Stango, 2007; Leiponen, 2008; Stango, 2004). Otherwise, due to the network externalities often found in the industries, firms are presumed to find it rational to shape dominant strategies by actively put their knowledge into standards earlier than their competitors (Leiponen, 2008).

With the prospect of market expansion by a standard (Gawer and Cusumano, 2002), a firm can hit a high-profit by the scale-merit in developing and/or using standardized technologies in advance of its competitors. A firm may also gain revenues from loyalties when IP rights are protected (West, 2003; 2006). Thus, studies on business strategies to drive standardization are mostly interested in firms to lead standardization (e.g., Gawer, 2009; Gawer and Cusumano, 2002). In any case, In the line of studies, strategic actions of a variety of firms other than leaders of standardization are hardly paid attention to. Firms promoting standardization are primary interests of researchers.

In the case of AUTOSAR," the rights of IPs used in the standard are stipulated not to be claimed by inventor firms. Rivalry firms agree to collaborate with each other to set a standardized domain, a non-competitive domain, in order to externalize the R&D cost caused by increasing complexity of software development (Slowak and Itohisa, 2011). Yet, apart from the concept of network externalities, few empirical studies address firms' strategic actions of standardization to cope with increasing complexity.

In the view of knowledge exploration and exploitation (March, 1991), the knowledge accumulation of a firm is presumed to be path-dependent according to the firm's backgrounds: preexisting knowledge (Ahuja and Katila, 2004). The attitude of a firm toward standardization may vary with its specific attributes nurtured in its history. Indeed, while a leading incumbent firm may face the dilemma between its accumulated knowledge and external standardization trends, smaller firms with little knowledge, including new entrants, can rise overwhelming incumbents by taking advantage of standardization. Thus, a firm's maneuver of the exploration and exploitation of standardized knowledge, more specifically its attitude toward other firms and consortia, is predicted to largely depend upon its backgrounds.

Nevertheless, what kind of firms benefit/suffer from standardization as external knowledge creation is still blurred in terms of each firm's knowledge accumulation. By considering firms' accumulated knowledge as their background, this empirical study, attempt to elucidate what kind of firms provide knowledge for standardization and/or take advantage of the standardized knowledge.

Relevance of Strategic Positioning Archetypes to Knowledge Amount

A standard encourages the development and distribution of standardized knowledge across firms (Arora, Fosfuri and Gambardella, 2001; Gambardella, Giuri and Luzzi, 2007). In the sense, relevant to a standard regarded as external knowledge, the strategies of exploration and exploitation are critical issues of firms (Dittrich and Duysters, 2007; He, Limb and Wong 2006; Vanhaverbeke, 2006). A firm faces incompatible requirements: exploring novel knowledge to be standardized and exploiting standardized knowledge (Benner and Tushman, 2003; Katila and Ahuja, 2002; Laursen and Salter, 2006). Under the surge of standardization, a firm would be required to consider either of the exploration to yield novel knowledge participating in a consortium and the exploitation to make use of such standardized knowledge.

With the concepts of exploration and exploitation, the study proposes a framework of four archetypes of strategic positioning toward standardization, which consists of two axes: "the level of commitment to the standard (exploration)" and "the level of introduction of the standardized technologies (exploitation)." On a

consensus standard, the standardization and the diffusion of the fruits are enhanced with the process in which the exploration through the standardization and the exploitation of the standardized fruits each can be conducted by different firms (Yasumoto, 2011). Streamlining such archetypes relevant to the interfirm labor division of exploration and exploitation should help us understand firms' strategic positioning.

The first positioning is the "Promoter": high commitment and high introduction. The Promoter drives the standardization and exploits the fruits of the standard earlier than other firms. The second one, the "Monitor," high commitment and low introduction, though participating in the consortium, is not intent on the exploitation of the fruits from the standardization. The third one, the "Adopter," is characterized with low commitment and high introduction. Though not active in the commitment to the standardization, the Adopter as well as the Promoter attempts to exploit the outcomes from the standardization. Lastly, the fourth called the "Inhabitant," characterized with low commitment and low introduction, neither participates in the standardization nor exploits the fruits.

The factors and conditions to encourage exploration and exploitation in each firm still remain blurred under the huge environmental change by standardization. As each firm has acquired specific attributes in its evolution process, how a firm conducts exploration and exploitation relevant to standardization, more specifically how a firm copes with other firms and consortia, can vary with the firm's background.

The knowledge amount of relevant fields is presumed to have particular impacts on the strategy of the firm. Indeed, a series of empirical studies (e.g., Open Innovation) has shown that small/middle size firms with little knowledge are more positive to explore and exploit external knowledge than large firms with more knowledge sufficient to cover the necessity (Lichtenthaler and Ernst, 2009; Van de Vrande et al., 2009). Moreover, the path of capabilities building or evolution of a firm is directed by accumulated knowledge of the firm (Ahuja and Katila, 2004; Fujimoto, 1997). The line of studies suggests that a firm's interests in external knowledge and its manner of exploration-exploitation can vary according to the level of the firm's accumulated knowledge amount. Accordingly, studies on standardization strategies partly suggest that the exploration through the commitment to a related consortium is relevant to the possession/licensing of related patents (Gandal, Grantman and Genesove, 2007) though the exploitation thorough the introduction of standardized technologies is not examined.

These suggestions make us infer that according to the amount of its accumulated knowledge, a firm would deal with standardization. In other words, depending upon the level of knowledge amount, a firm is presumed to cope with the surge of standardization by the combination of exploration and exploitation. With the prediction, the study investigates into the relationship of four positioning archetypes and firms' knowledge amounts.

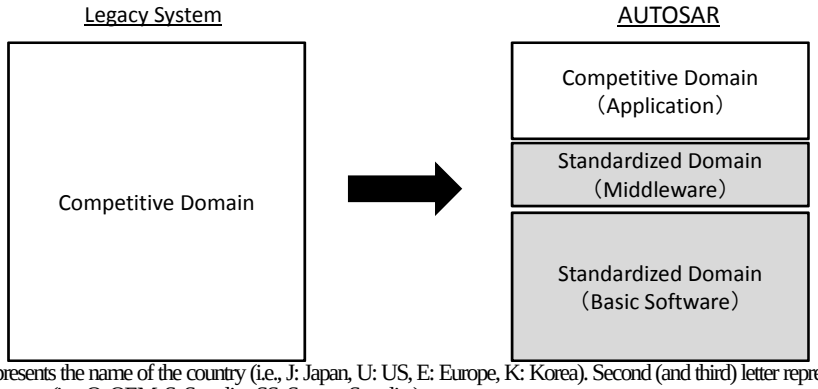
Data

AUTOSAR

The rapid electrification of automobiles has swelled R&D expenditures according to the increase of the size and complexity of ECU (Electric Control Units) software. The standardization of ECU software was planned to cope with such situation. More specifically, a consensus that ECU software which has been developed specialized for each of specific car models would be redesigned into three distinctive layers: BSW (Basic Software) as the standardized domain, application as the competitive domain, and middleware

bridging between these domains (Figure 1).

Figure 1 Layered Architecture of AUTOSAR System



Note 1: First letter represents the name of the country (i.e., J: Japan, U: US, E: Europe, K: Korea). Second (and third) letter represent(s) positioning in business ecosystem (i.e., O: OEM, S: Supplier, SS: System Supplier).
Note 2: Circles in the matrix indicate the transaction between suppliers and OEMs/system suppliers as well as the sources where the data regarding requirement of AUTOSAR were obtained.
Note 3: Only information regarding ES3 was presented due to confidential policy towards transaction partners.

A variety of firms with different backgrounds can be observed in AUTOSAR whose members are 153 manufacturers (Nov., 2011), including OEMs, ECU suppliers, semiconductor manufacturers, software vendors from all over the world, mainly Europe, Japan, and US. Examining the case of firms participating in AUTOSAR will suit to our purpose to understand firms' strategic positioning toward a consensus standard. From 14 ECU suppliers, the study collected data on ECU suppliers and their customer OEMs, which are directly engaged in the partition of ECU software into the competitive and standardized (non-competitive) domains. 36 major OEMs and ECU suppliers were selected through the procedure.

The study does not intend to specify rigorous causalities by statistical analysis. Yet, the variables which the study attempt to explore are arranged as below. The measurements of these variables and their validities were confirmed in three times of discussions for three hours between 3 software development managers from an OEM, a director from an ECU software firm, and 2 researchers form Jun. to Aug. in 2010 and in a pre-survey into an ECU supplier.

Participation and Introduction

The first axis to classify firms' positioning toward standardization, "the level of the commitment to AUTOSAR," was measured by the public data on the AUTOSAR membership (core member: 4 points, premium member: 3 points, associate member: 2 points, and non-member: 1 point). In many of consortia for consensus standardization, memberships are ranked corresponding to the contribution to the standardization and the authority/responsibility. The AUTOSAR membership is classified into three types: core partner, premium member, and associate member (Table 1). The responsibility for specifications, contribution of knowledge to the standardization, and business development are different by the memberships.

The second one, "the level of the introduction of the AUTOSAR technologies," was estimated with 1-4 points by the data collected in our questionnaire surveys into 14 ECU suppliers in Japan and EU from Oct, 2010 to Feb, 2011 (Table 1). More specifically, the data on "the level of introduction of the AUTOSAR tools" was collected about suppliers while that on "the level of requirement of AUTOSAR in procurement from

suppliers" was about OEMs.

Table 1 Measurement of Commitment and Introduction

Scale	Definition of operations			
	Commitment Level		Intoroduction Level	
4	Core member	・Entitled to make a decision on specification of standards, operations and policy regarding consortium ・Entitled to send members to a working group ・Obliged to offer technological know-how to standardized domain ・Entitled to realize business opportunities	OEM	Specify AUTOSAR as a requirement
			SUP	Use AUTOSAS tools as standard
3	Premium member	・Entitled to access and specify the requirement ・Expected to offer technological know-how to standardized domain ・Entitled to realize business opportunities	OEM	Specify AUTOSAR as a requirement in the foreseeable future
			SUP	Under ramp-up introduction process (AUTIOSAR tool)
2	Associate member	・Entitled to access and specify the requirement ・Entitled to realize business opportunities	OEM	Have possibility to specify AUTOSAR as a reuirement in the future
			SUP	Under pilot introduction process (AUTOSAR tool)
1	Non member	・Have an accessability to fixed specification ・Have availability to use with individual contract	OEM	have no plan to specify AUTOSAR as a requirement
			SUP	have no introductioin planned (AUTOSAR tool)

Table 2 Matrix by Data Source Firms (Vertical) and Collected Data of Firms (Horizontal)

	JO1	JO2	JO3	JO4	JO5	JO6	JO7	UO1	UO2	EO1	EO2	EO3	EO4	EO5	EO6	EO7	EO8	KO1	JSS1	JSS2	JSS3	JSS4
JS1	○		○				○	○						○							○	
JS2				○	○	○	○														○	
JS3			○																			
JS4	○					○	○															
JS5	○				○		○		○			○										
JS6			○																○	○		
JS7			○																			
JS8			○		○		○											○				○
JS9			○					○	○	○	○	○	○				○					
JS10		○	○					○														○
JS11	○	○		○						○	○				○	○	○					
ES1	○	○		○																		
ES2			○																			
ES3																						

The data of OEMs and system suppliers were obtained from ECU suppliers. The reliability of the data from the field research was confirmed in direct interviews with respondents (Clark & Fujimoto, 1991). Afterwards, the data plotted on a figure was confirmed through the triangulation with an AUTOSAR spokesperson, directors and managers in charge of AUTOSAR issues in OEMs, ECU suppliers, semiconductor manufacturers, tool vendors in Europe and Japan. Also the classification by the two axes was statistically validated by the sample firm distribution (χ square test, p<0.0402).

Knowledge Amount Level

We measured each firm's knowledge amount by counting the quantity of patents in the relevant fields in the period concerned. Each firm's knowledge amount was measured by the total quantity of the firm's patents which were registered in the relevant fields of vehicle control system in Japan (JPO), Europe (EPO), and US (UPO). The total amount of the patents amounted to 79,003. Though not rigorous, the quantity of patents can be assumed to approximate each firm's knowledge amount. Incidentally, as for the sample firms, "R&D expenditure" proportionate to "knowledge amount" was positively correlated with "firm scale" at 1% level (Kendoll rank-order, p<0.0037). Considering the limit of our knowledge on related technologies, we asked three managers responsible for software development of the firm mentioned above to choose the categories of patents relevant to AUTOSAR. The patent data, from the database of the firm, was offered by the IP section of the firm. Focusing on the period from 2005 to 2010, we collected the patents of IPC F02D "engine control," IPC B60T8 "brake control," IPC B60K "shift control," IPC B62D 6 "steering control," and IPC B60G 17

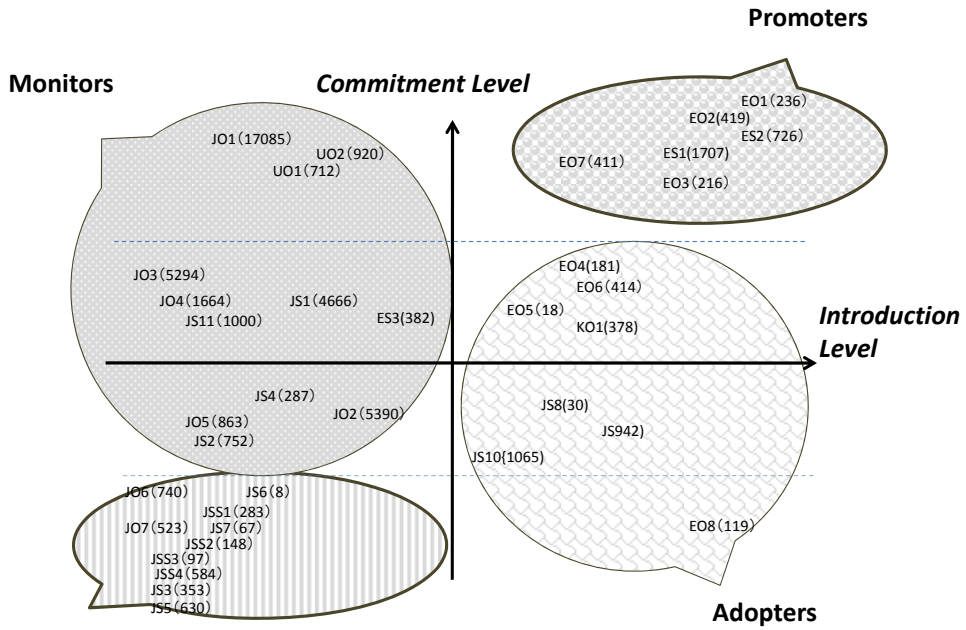
"suspension control" as for the Japanese and European patents and USC 123 "engine control" and USC 74 and USC 280 "body control" as for the US.

During the period, the specifications of AUTOSAR, in view of their implementation, were developed to be completed (The Release 1.0 was released in 2005), which means that each firm was required to decide its attitude toward the standard. Thus, the amount of related knowledge accumulated in each firm during the period should have influence strategies of the firm.

Results

We map the positioning of each firm on Figure 2 by "the level of commitment" to the standardization and "the level of introduction" of the standardized technologies into its product development (the level of commitment and that of introduction are significantly independent (χ square test, p<0.0402) The number in the parenthesis designates the quantity of patent held by the firm concerned. The numbers in parentheses indicate the quantity of patents of the firm concerned. The difference in knowledge amount level (mean of the quantity of patents) between these archetypes are significant (ANOVA and Kruskal Wallis test, p< 0.0016).In consideration of the results of qualitative interview researches, the following shows the characteristics of each archetype of firms' strategic positioning.

Figure 2 Firms' Positioning toward AUTOSAR



Note: Strictly speaking, a group of firms in the same cell of the matrix, plotted by the data of 1-4 point(s), converges into a point. Yet, the study adjusts the position of each firm by a series of discussions with respondent managers.

Promoter

The "Promoter" is the group of firms with "middle-amount" of knowledge on the related fields (mean: 619 patents). The archetype consists of the EU manufacturers including suppliers: ES1 and ES2. AUTOSAR derived from a R&D consortium called EAST-EEA. The major purpose of the consortium was how to cope with increasing complexity of ECU software. Inheriting the purpose, the group attempts to standardize and

diffuse the middleware and BSW in order to externalize increasing R&D cost.

Monitor

The "Monitor" is the group of firms with "affluent knowledge" in the related fields (mean: 3,965 patents). Typified by JO1with predominant number of patents (17,085 patents), the Japanese manufacturers (JO3 with 5,294 patents, JS1 with 4,666patents) and the US manufacturers (UO1 with 712 patents and UO2 with 920patents) are included in the group. In a static sense, these firms which are competitive by their existing legacy systems would rather suffer the loss (i.e., introduction cost, including switching cost, as well as sunk cost for existing proprietary systems) from the shift to AUTOSAR:.

However, as is the case of PC and mobile phone industries, once the standard gets rooted, a variety of players become to participate in the standard resulting in drastic cost reduction and quality improvement. Such a dynamic point of view reveals that any firms cannot disregard the benefit of standardization. Stuck in the middle between specific legacy systems and standard, many of Monitor firms are inactive in the standardization though committing to the standardization.

Adopter

The "Adopter" consists of firms with "little knowledge" in the related fields (mean: 281 patents). The group includes new entrant manufacturers (e.g., KO1 with 378 patents) and electronic suppliers independent of the automobile Keiretsu (e.g., JS8 with 30 patents, JS9 with 42 patents). The European OEMs in the group also hold relatively little knowledge (e.g., EO8 with 119 patents, EO4 with 181 patents). By actively exploiting the fruits of the standardization, firms of the group attempt to acquire technologies and search new business. While not necessarily predominant in the existing structure in automobile industries, the group can be equal to the trend of the standardization since not prepossessed with the past tie with their legacy systems.

Inhabitant

The "Inhabitant" is a group of firms with "little/middle-amount of knowledge" on related fields (mean: 766 patents). The group includes the Japanese OEMs and suppliers, particularly suppliers in Keiretsu relationships with OEMs characterized with low levels of AUTOSAR introduction. Firms of the archetypes neither commit to the standardization nor introduce the standard. Amongst all, suppliers in close relationships with OEMs less intent on the introduction of AUTOSAR are prominent in the group. Yet, a few firms in the group prepare to adopt the standard soon after the standardized domain gets reliable.

Asymmetric Diffusion of Firms by the Archetypes

In Figure 3, the classification of the archetypes is warped. As for firms with 3-4 point introduction level, only firms with 4 point commitment level are classified into Promoter while firms with 1-3 point commitment level are classified into Adopter. On the other hand, as for firms with 1-2 point introduction level, firms with 2-4 point introduction level are classified into Monitor while only firms with 1 point introduction level are classified into Inhabitant. According to introduction levels, the borders to divide the senses of commitment levels are variable.

For instance, for firms intending to introduce AUTOSAR, the difference between core members (4

points) with the rights to drive the consortium and decide specifications and premium members (3 points) without these rights is significant. Yet, for firms not interested in the introduction of AUTOSAR, rather, the difference between associate members (2 points) partly participating in the standardization and non-members (1 point) would be significant. Indeed, if intending to monitor the standardization, a firm can access the specifications earlier by participating in the working groups as an associate member. The classification is validated in the feedbacks for participants of the survey: 14 ECU suppliers.

Discussion

The study finds a definite relationship between firms' strategic positions and their knowledge amounts. The finding is summarized as below.

Proposition 1 : Firms with affluent knowledge are liable to monitor the trend of standardization. (commitment ○, introduction×)

Proposition 2 : Firms with middle-amount of knowledge are liable to drive the trend of standardization. (commitment ○, introduction○)

Proposition 3 : Firms with little knowledge are liable to adopt the fruits of the standard concerned. (commitment ×, introduction○)

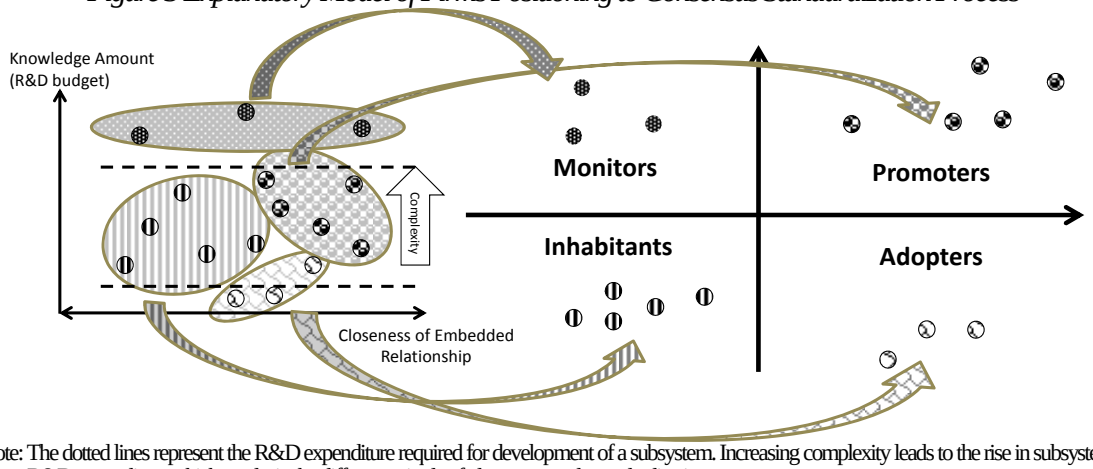
Proposition 4 : A part of firms are liable to resign themselves to the *status quo*.(commitment×, introduction×)

It is firms with middle-amount of knowledge that are intent on establishing a consortium to lead the standardization while firms with little knowledge are more to devote themselves to exploit the standard (e.g., Lichtenthaler and Ernst, 2009; Van de Vrande et al., 2009). Thus, the Propositions 2 and 3 would be consistent with past findings. On the other hand, the study brings a novel finding that a firm with affluent knowledge is likely to monitor the standardization activities: Proposition 1.

The propositions above may indicate the formation process of a consensus standard resulting from increasing system complexity (Figure 3). As R&D cost increases, relatively small firms cannot cope with additional R&D cost. Though such small firms cannot lead standardization, middle-size firms collectively attempt to standardize an indifferent common domain. As Gulati (1998) and Doz et al. (2000) suggest, the early stage of such consortium formation are driven by embedded interfirm relationships. In the case of AUTOSAR, a group of the European firms with middle-amount of knowledge leads the standardization.

Such a group of firms devotes themselves to diffuse a standard set by them in order to externalize R&D cost. On the other hand, firms with little knowledge which are not fettered with the superiority of their existing proprietary systems are willing to exploit the outcomes from standardization In contrast, firms with affluent knowledge are liable to hesitate adopt the new standard since their legacy systems as the sources of their competitiveness should be replaced by the standard.

Figure 3 Explanatory Model of Firms Positioning to Consensus Standardization Process



Note: The dotted lines represent the R&D expenditure required for development of a subsystem. Increasing complexity leads to the rise in subsystem's R&D expenditure which results in the different attitude of players towards standardization.

The mechanism above is presumed to encourage firms with middle-level knowledge to shape a consortium. Involving relevant firms, the attempt would develop into a consensus standard[7]. Indeed, in a series of our interviews, in order to diffuse AUTOSAR, promoter firms are found to hold meetings with the Chinese auto-manufacturers, emergent firms with little knowledge, at the pace of once in a month (from the interview with an AUTOSAR spokes person, Oct, 12 2011).

Once the number of adopters gets over the critical-mass necessary for the diffusion, the cost of the standardized system starts to decrease. As a result, the consensus standard evolves to the dominant global standard. In the process though monitoring the standardization, firms with affluent knowledge may get stuck between their existing knowledge on legacy systems and the standards, and thereby would go behind the standardization.

Furthermore, firms' competitiveness would largely depends upon the attitude toward such standardization which encourages to shape a business ecosystem (e.g., Gawer & Cusumano, 2002; Iansiti & Levien, 2004; Slowak & Itohisa, 2011). In such a case, the delay of a firm with affluent knowledge in the trend of standardization should be fatal. The competitiveness of a firm with affluent knowledge can be overturned by those of standardization-leaders with middle-level knowledge and standard-adopters with little knowledge.

Conclusions

The study proposes a framework to understand the positioning of firms facing standardization, which consists of four archetypes, "Promoter," "Monitor," "Adopter," and "Inhabitant," by the levels of the commitment to standardization and the introduction of standardized technologies. Based on the framework, the study explores the relationship between firms' strategic positioning toward standardization and their knowledge amounts drawing on the case of AUTOSAR.

As a result, the study finds positions for monitoring and adopting a standard by the combination of the exploration (commitment) and exploitation (introduction) of knowledge showing the mutual independency between them. The study contributes to finding such multiple positions by making a distinction between the commitment and the introduction. Moreover, the novelty of the study is also found in the sense that the amount of a firm's knowledge amount is liable to explicate the firm's position. Several strategies can be

proposed according to each firm's background: knowledge accumulation.

Though suggesting the criticality of standardization, antecedents have not sufficiently explored the multiplicity of firms' effective strategies toward standardization. Rather past empirical researches are primarily interested in dominant strategies (e.g., platform leadership) of standardization with the creation of business ecosystems or clusters (e.g., Baldwin & Clark, 2000; Gawer, 2009; Gawer & Cusumano, 2002; Iansiti & Leviene, 2004). In contrast, the study shows the significance of each firm's strategy toward standardization according to the firm's background: accumulated knowledge. The perspective of the study may open the gate to recapture the creation and evolution of a business ecosystem from the view of a variety of firms each with specific background.

Practical implications are also drawn. Few empirical studies considers the effect of complexity reduction through the standardization, which means that whether or not a firm can benefit/suffer from the standard is still blurred. When external knowledge is widely available, a firm with relatively little knowledge can get chances to rise by taking advantage of the knowledge (e.g., He et al.,2006). On the other hand, a leading incumbent firm with sufficient accumulation of its firm-specific legacy knowledge may face a sort of dilemma between its accumulated knowledge and external shifts of technologies by standardization (Christensen, 1997). Combined with these past findings, the results of this study indicate that each firm's path-dependent background (Fujimoto, 1998), which are scarcely considered in a line of studies on standardization and platform, has critical impacts on the firm's strategic attitude toward standardization.

The limitation of the study is found in the fact that the sample used in the study is limited to the case of AUTOSAR. The generalizability should be further examined in consideration of the differences in factors and conditions by standardization consortia. On the other hand, other factors at firm level, the scope of knowledge (Brusoni, 2001), embedded relationships between participant firms (Gulati, 1998), reciprocities between participant firms (Doz et al., 2000), and positions in existing interfirm networks (Yasumoto, 2011) may influence firms' strategies. The relevance of these factors to firms' strategic positions should be closely examined furthermore. These questions, including the strategies of implementation to exploit a standard, are left to future researches.

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