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Product Architecture, Organizational Design, and HRM Practices: Comparing Japanese, Korean, and Chinese Firms

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Summary

This paper examines the relationship between product development and human resource management practices in East Asian firms. Based on a review of preceding studies, we first posit the following three hypotheses: (1) Firms strategically choose their product architecture, taking into account factors such as internal management resources and external product market conditions; (2) Firms strategically choose their organizational design for product development reflecting their choice of product architecture; (3) There is a complementary relationship between the chosen product architecture and the organization of product development on the one hand and human resource (HR) management practices on the other.

Next, we present our findings from case studies in Japan, Korea, and China, focusing on firms making the same products (cellular phones, liquid crystal televisions, and business information systems), followed by the analysis of data obtained through a questionnaire survey of firms in the manufacturing and software industries in the three countries.

(1) For all three product categories that we focused on – cellular phones, liquid crystal TVs, and information systems – the case studies provided support for the hypothesis that firms strategically choose their product architecture. Each firm deliberately chooses whether it employs an integral or a modular architecture depending on the level of accumulated technological capabilities and skills as well as the product market situation (e.g., whether the firm targets the high-end or the low-end market). Moreover, the questionnaire survey showed that although in China there is a strong tendency toward the use of modular architectures, in all three countries – Japan, Korea, and China – there is considerable variation in the use of modular and integral architectures. No particular product architecture dominates even in the same industry or among firms of a similar size. In other words, we found strong support for the hypothesis that product architecture is not exogenously determined by, for example, industry characteristics, but instead is strategically chosen by firms depending on a number of factors at a particular time.

(2) Regarding the organizational design for product development, the case studies showed that in the case of information systems, where product architectures have a strong modular flavor, product development tends to be organized within functional departments, whereas in the case of cellular phones and liquid crystal TVs, which tend to have a strong element of integral product architectures, product development tends to be organized within cross-functional projects. Moreover, the case studies also showed that the higher the degree of integrality, the stronger the authority of the project manager. The questionnaire survey found that for Japan and China, there appears to be a complementary relationship between integral product architectures and cross-functional project-based product development on the one hand and modular product architectures and product development within functional departments on the other. However, for Korea we did not find such a relationship.

(3) With regard to product architecture and HR management practices, the case studies

showed the following complementary relationships: (a) integral architecture is associated with an emphasis on internal training, skill development from a long-term perspective, and the provision of incentives, and (b) modular architecture is associated with an emphasis on mid-career recruitment and provision of incentives from a short-term perspective. However, we were not able to clearly detect a complementary relationship between the organization of product development and HR management practices in the three countries. Both the case studies and the questionnaire survey showed that at Japanese firms, there tends to be a correspondence between long-term employment and integral architectures, while at Chinese firms, there tends to be a correspondence between short-term employment and modular architectures. On the other hand, for Korean firms, such corresponding relationships seem to be much rarer.

1. Introduction

East Asia is now the center for the research and development (R&D) and manufacturing of high-tech products. The region's economic emergence during the 20th century rested on its role as a cheap base for manufacturing, but since the beginning of this century, East Asia has become increasingly important as a base for research and product development. This is especially the case in the information and communications technology industry, a sector that is typically described as knowledge-intensive. In fact, in this industry, East Asian firms' international competitiveness is strong and many – such as Samsung or Lenovo – are on course to become world leaders in the international division of labor. Therefore, from a global perspective, research on modes of management in East Asian firms is a pressing task.

However, there are few international comparative studies that examine product development activities by East Asian firms, and almost none that compare – from an international perspective – the management of human resources, especially with regard to knowledge creation and the knowledge transfer that takes place during the development process. For example, it is well known that Japanese auto firms, especially Toyota, use product development practices involving long-term employment and the adoption of project-based organization with project managers who have strong authority over the development process. However, we know little about parallel practices in Chinese and Korean firms, leading to several important questions. How do firms in China and Korea organize product development activities? Are there important lessons that other countries' firms could learn from practices in China and Korea – or vice versa? Does Japan's experience hold important lessons for the other two countries?

To begin to answer these questions, we have conducted interviews with managers and a large-scale written survey of firms in information technology-related sectors in Japan, China, and Korea. We focus on the relationships between product development, organization of production, and human relations (HR) management to produce the first systematic report on comparative product development and complementary management practices for the three countries.

2. Previous research and hypotheses

2.1 Findings from previous research

Product development consists of activities undertaken by firms to incorporate a new design, structure, or technology into a product before its market introduction (see Fujimoto 2001, 2002). Researchers have conducted a series of empirical studies on the effective

organization of product development (focusing on issues such as processes, structures, capabilities, and routines) and on the relationship between the organization of product development and outcomes. The pioneering work in this field is by Clark and Fujimoto (1991), whose article remains the basic paradigm for understanding product development. Clark and Fujimoto describe product development as a problem-solving activity, and show what organizational structures and what types of leadership by project managers are effective in advancing product development. They emphasize that product development patterns can be characterized in terms of whether firms employ functional organization structures or project-based structures, and whether their product managers are "lightweight" or "heavyweight."

Although several studies have attempted to measure firms' organizational capabilities with regard to product develop at the firm or industry level (e.g., Clark and Fujimoto 1991; Fujimoto and Nobeoka 2006), there have been few attempts so far to measure organizational capabilities across industries. The major works include Fujimoto and Yasumoto (2000) and Kishi and Fujimoto (2010), who have attempted to measure organizational capabilities but have only partially captured the inter-industry distribution of architectures and organizational capabilities. Moreover, there is also little research on how HR management practices influence firms' product development capabilities.

On the other hand, there are a number of studies on product architecture that have sought to identify the types of product functionality associated with particular types of organizational structure (Ulrich 1995; Baldwin and Clark 2000; Aoshima and Takeishi 2001; Fujimoto 2001). Product architectures, especially in advanced technology-based sectors, are primarily either "modular," with tight relationships between particular functions and particular parts, or "integral," involving more complex relationships between particular functions and parts. With regard to interface design rules, one can distinguish between "open" design rules, which are standardized at the industry level, and "closed" (or proprietary) design rules, where the design rule is limited to a particular firm.

Moreover, with regard to the relationship between the type of product architecture (integral or modular) and the appropriate organization for each (e.g., interdepartmental coordination or inter-firm division of labor), certain complementary patterns have been identified (Langlois and Robertson 1992; Baldwin and Clark 2000; Sanchez and Mahoney 1996; Fine 1998; Aoshima and Takeishi 2001; Fujimoto 2001; Kusunoki and Chesbrough 2001). The usual tendency has been for companies to shift their basic product architecture from integral to modular over time (Baldwin and Clark 2000), but there have been cases where, conversely, product architecture shifts from the modular type to the integral type (Fine 1998). Major factors that induce such change in product architecture include (1) changes in a product's functions (Henderson and Clark 2000; Christensen 1997), and (2) changes in the

technology used to produce the product (Kusunoki and Chesbrough 2001). However, existing discussions of product architecture do not adequately address either the processes through which firms create new product architectures nor the social and institutional constraints they face in doing so. So far, researchers have only examined whether the dominant product architecture observed at a particular point in time compared with that at an earlier point in time has become more modular or more integral.

The product architecture that firms use should actually be considered to be a strategic choice that they make, but to date there are no studies that examine product architecture from this perspective. The reason probably is that although product architecture typically is assumed as something that firms choose themselves as part of their product planning process, in practice, studies invariably treat changes in product architecture as exogenous changes in the external environment to which product development organization needs to adapt (Fukuzawa 2008).

Next, let us take a look at research on HR management issues with regard to the engineers in charge of product development. Because of their role as highly specialized "knowledge workers" in charge of innovation and because their work consists of research and development (R&D), it is difficult to apply standard HR management practices. Studies therefore have focused on the motivation and morale of engineers based on theories of organizational behavior (Peltz and Andrews 1966) or have been conducted as part of more general research on the motivation and commitment of professional researchers (e.g., Kornhauser 1962; Allen 1977). In the field of organizational behavior, there is a growing body of research on areas such as engineers' careers, the relationship between performance and HR management practices, skill obsolescence, the shortage of management posts, and the professional career track system.

Engineers can be divided into two broad categories: those engaged in basic research and development (working at firms, universities, or research institutes), and those engaged in product development (working at firms).[1] Studies focusing on researchers and engineers as highly-skilled human resources and a source of national competitiveness have traditionally concentrated on the former. In contrast, research interest in engineers conducting R&D within firms only started to develop from the 1990s, as the importance of product development grew.

Let us start by looking at research examining engineers' careers and transfers. Imano (1997) broadly divided researchers and engineers within a firm into three categories – production engineers, design and development engineers, and researchers – and showed that transfers

[1] Excluding technicians working in manufacturing departments.

between these categories were extremely rare in Japan; moreover, even within the same field, transfers were largely restricted to those within the basic management unit. Generally, it had been thought that in order to encourage innovation, high mobility of engineers and rotation between departments were necessary, but – as Kusunoki and Numagami (1998) show – relatively few transfers actually take place. Meanwhile, Aoshima (2005), focusing on semiconductor researchers and engineers in Japanese firms, showed that transfers both between and within organizational units (i.e., interdepartmental rotation) had a negative impact on technological development. The above considerations suggest that appropriate organizational management structures and employment conditions that encourage the integration of different kinds of knowledge are necessary to facilitate innovation.

Next, let us consider what determines engineers' pay. Nagano (2002), comparing the determinants of annual wages of R&D personnel at research establishments in Japan, the United Kingdom, and the United States, showed that in Japan, age was a major factor, but that the higher a person's performance, the more s/he hoped that differences in pay based on performance would increase. On the other hand, Miyamoto (2009), focusing on engineers at major electronics firms, examined the impact of performance-based pay, which has become more widespread in recent years, and found that performance-based pay did not directly affect the performance of engineers. Because the introduction of performance-based pay weakened the tendency to collaborate, however, it indirectly hindered the full utilization of engineers' skills.

Finally, a number of studies have focused on product development engineers from an international perspective. Nakata and Denki Soken (2009), for example, showed that Japanese engineers have demonstrated high levels of productivity and innovative ability, as measured in terms of patent applications, but also that engineers in Japan are generally less motivated to contribute to organizations than Japanese workers in other occupations, and that their motivation levels have weakened since the mid-1990s. This probably results in large part from working conditions, including extremely long work hours, that are worse than those of other occupations or of engineers in other countries.

Research comparing employment of engineers in Korea, Europe, and the United States suggests that employment conditions for Korean engineers are quite similar to those in Japan in terms of the low levels of mobility, job freedom, satisfaction, and commitment (Ishikawa and Ishida 2002). Unlike Japanese companies, however, Korean companies often encourage engineers to continuously raise skill levels by supporting additional study either overseas or in universities, and they are more willing to offer pay raises in order to keep skilled engineers (Fukutani 2008). Finally, turning to China, the number of engineers there has increased rapidly in recent years, overtaking that of Japan to become second only to that in the United States (Ohara 2009). Research suggests that Chinese firms frequently provide pay

increases and other incentives to keep skilled engineers (Fukutani 2008).

While, as the overview indicates, there is a substantial and growing body of research on HR management issues related to product development engineers, there is very little research on the relationship between product architecture and the organization of product development on the one hand and human resource development on the other. One of the few studies that does deal with product development strategy and human resource management in the organization of product R&D is by Fukutani (2007), but he does not discuss how the two are related.

2.2 Three Hypotheses

Based on the discussion above, the links between product architecture, product development organization, and HR management can be examined from three perspectives that have received little attention in the existing literature. First, whereas existing research has regarded changes in product architecture as exogenous "environmental changes" to which firms' product development organizations must respond, we believe that product architecture, and changes therein, result from firms' strategic choices. Second, and similar to the first point, we believe that firms exercise strategic choice with regard to the organizational design for product development. The two most important factors are whether firms base product development primarily within a designated "functional department" or within a cross-functional project-based structure, and whether the project manager is "lightweight" or "heavyweight." Third and finally, we believe that firms' choices regarding product architecture and organizational design have a complementary relationship with HR management practices. Figure 1 depicts the hypothetical relations. Specifically, given that there have been few attempts, across industries, to measure and understand organizational capabilities at the core of development activity, this study seeks to address these issues both qualitatively and quantitatively through firm-level interviews and a questionnaire survey. Writing out the above considerations in the form of hypotheses yields the following:

Hypothesis 1: Firms strategically choose their product architecture, taking into account factors such as internal management resources and external product market conditions.

Hypothesis 2: Firms' choice of organizational design for product development activity closely reflects their choice of product architecture.

Hypothesis 3: There is a complementary relationship between the chosen product architecture and the organization of product development on the one hand and HR management practices on the other.

3. Product Development and Human Resource Management: Evidence from Case Studies in the Three Countries

This section examines product development and HR management in Japan, South Korea, and China based on case studies through company interviews. In order to conduct meaningful comparative analysis among the three countries, we must utilize same-product cross-national cases. Therefore, we have gathered data from a representative major corporation from each of the three countries in each of the following three fields: cellular phones, liquid crystal televisions (TVs), and business information systems.

3.1 Comparison of the Development of Cellular Phones in the Three Countries

The study on cellular phones covers three major corporations – one from each country – labeled *JA*, *KA*, and *CA*. All three firms have adopted a diversification strategy in the telecommunications field. As for *JA*, most of the company's sales come from the mature domestic market focusing on developing products for, and selling them to, telecommunications carriers. On the other hand, *KA*'s strategy consists of launching in quick succession a variety of models in all market segments in countries around the world. Finally, at *CA*, cellular phones are categorized as transmission equipment accessories and are developed and manufactured to order for equipment customers. The findings from the interviews for the three firms with regard to the three hypotheses can be summarized as follows (Table 1).

First, let us begin by looking at the findings with regard to product architecture. At *KA*, which produces both high-end and low-end products, the product architecture for high-end cellular phones, which incorporate new technology and require performance optimization, is highly integral in nature. On the other hand, the architecture in the case of low-end phones is modular. At *CA*, managers indicated that all products combine modular and integral aspects and that they emphasize striking a balance between the two; excessive modularization makes a product too similar to those of rivals and hurts competitiveness. Finally, in the case of *JA*, irrespective of the product, the product architecture is integral. This is perhaps because the overwhelming share of *JA*'s sales are to the Japanese domestic market and a response to demands from telecommunications carriers. Summing up, the findings support Hypothesis 1 that firms strategically choose their product architecture, taking into account factors such as internal management resources and external product market conditions, except in the case of *JA*, which always adopts integral product architecture.

Second, concerning organizational structure and leadership of development activities, we found the following. A common feature among the three firms is that product development

occurs in horizontal project teams across functional departments ("cross-functional project teams"). However, the degree of authority of project managers was greatest in *KA*, followed by *CA*, and then *JA*. That the authority of the project manager is greater in *KA* than in *CA* is consistent with the fact that the degree of product integrality is greater in the former.

Because *JA*'s product is almost custom-made for specific telecommunication carriers, the need to make the product conform to the end-user's expectations and needs (external integration) is lowest. Therefore, regardless of the fact that product architecture is of the integral type, the authority of the project manager is smallest. In this sense, Hypothesis 2, that firms strategically choose their organizational design for development reflecting their choice of product architecture based on the specific circumstances such as management resources and the particular market for the product, is supported for all three firms.

Third, let us consider Hypothesis 3 concerning the complementarity of HR management practices on the one hand, and the product development strategies and product architectures adopted by firms on the other. Although it is difficult to detect a meaningful relationship between HR management practices and the organizational structure of product development, the hypothesis is largely supported with regards to product architecture, with the partial exception of *CA*. To start with, all three firms, being engaged in the development of products with integral architectures, for which the accumulation of skills within the firm is important, say that they put great emphasis on internal training. However, CA is also placing greater importance on mid-career recruitment and is pushing ahead with the standardization of development tasks and the division of labor. Of the three firms, *CA* strongly emphasizes performance while de-emphasizing skill in determining promotion and pay, *JA* emphasizes skill over performance, and *KA* is in-between. *JA* and *KA* provide incentives for the long-term skill development in their personnel evaluation, promotion, and pay systems, which is consistent with the focus on the development of products with an integral architecture. On the other hand, *CA's* HR management practices put greater stress on job performance, and do not provide strong incentives for long-term skill development. They do not seem to be consistent with the use of integral architecture, and therefore lack complementarity.

3.2 Comparison of the Development of Liquid Crystal Televisions in the Three Countries

The survey on cellular phones covers three major firms – one from each country – labeled *JB*, *KB*, and *CB*. All three firms produce a wide array of electronics products. In the area of TV products, *JB* is a global leader in liquid crystal technology, especially for use in televisions. *KB* manufactures both liquid crystal and plasma TVs, has considerable technological prowess in liquid crystal panels, and holds a large global market share in flat-panel TVs. Finally, although *CB* has no original flat-panel technology, liquid crystal

TVs and plasma TVs make up about one-third of the firm's total turnover. The findings from the interviews for the three firms with regard to the three hypotheses can be summarized as follows (Table 2).

First, let us consider the product architecture. Parts and components of flat-panel TVs are quite modularized, so the technology level of this product is not necessarily high, and development of lower-end products simply involves figuring out how best to assemble the product. That said, high-end products incorporating leading-edge technology still need to be developed and manufactured on the basis of an integral architecture. This means that whether a firm chooses a modular or an integral development approach is greatly influenced by its competitive strategy, its product strategy, and its organizational capabilities. Looking now at the situations of the three firms (and leaving aside for the time being to what extent their strategies actually work) we can say that each firm's choice of product architecture corresponds to its particular circumstances regarding, for example, internal management resources or the product market being targeted. The product architecture used is based on a strategic choice, so Hypothesis 1 is supported.

Second, organization of product development activities and leadership of development activities are both closely related to each firm's product development strategy and product architecture. Moreover, product development at each firm is organized in cross-functional project teams. One important difference, however, is that the product development division tends to take the lead at *JB*, while at *KB* and *CB* the role of the marketing department is also extremely important. There is considerable variation in the degree of authority of product managers across the three firms. The prevalent pattern is that the more integral the product architecture, the higher the rank of the person in charge of product development. Thus, Hypothesis 2, that firms strategically choose their organizational design for product development activity reflecting their choice of product architecture, is also largely supported.

Third, let us look at the complementarity of product development strategy and product architecture on the one hand and HR management practices on the other. Here we find that because *KB* emphasizes the effective implementation of development strategies, it also places great importance on employees' actual capabilities. Therefore, while having an HR system that is based on capabilities, it also puts considerable weight on performance. In contrast, because it always develops new products that contain leading-edge technologies and are based on an integral architecture, *JB* places great emphasis on the accumulation of technological skills and tacit knowledge within the firm. Therefore, the firm' use of an HR system (a skill grade system) that stresses employees' ability to execute professional duties is consistent with its product development strategy. However, in terms of realizing the firm's competitive strategy, focusing only on the skills that engineers have accumulated is not

necessarily adequate. Conversely, *CB*, partly for historical reasons, uses a job grade system, which places great emphasis on job duties, but is not consistent with the company's strategy. In fact, *CB* has become increasingly aware of this issue and is introducing a new product development system (integrated product development or IPD) and a skill component into its personnel evaluation, but so far such efforts have not borne sufficient results. These findings suggest that Hypothesis 3, regarding the complementarity of product development strategy and product architecture on the one hand and HR management practices on the other, is largely supported, except for *CB*, and even CB recognizes the need to alter its HR system.

However, looking at the observed patterns in terms of the effective implementation of product development strategies, it seems that both *JB* and *CB* should move to HR management practices that put greater emphasis on performance (that is, the ability to break down a strategy into specific tasks) than on capabilities and duties. In this respect, they should be able to learn something from Korea's *KB*.

3.3 Comparison of the Development of Business Information Systems in the Three Countries

The case study on business information systems focuses on three representative software and information systems firms from Japan, Korea, and China. Each of the firms provides, in addition to system integration for businesses, services such as consulting and system support. The following is a summary of the results for the three firms in relation to the three hypotheses (Table 3).

First, let us consider the system architecture of each firm. A system architecture basically consists of an operating system, middleware, and applications, meaning that there is a strong element of modularity. That being said, however, if sufficient time and funds are available, *JC* and *KC* sometimes develop new modules and technologies from scratch. Especially in the case of *JC*, which uses a neutral architecture with few elaborations compared to architectures used by firms tied to major manufacturers, using a modular architecture in system development is not a given, but is something that can be strategically chosen depending on the management resources available. In this sense, Hypothesis 1 is supported.

Second, let us consider each firm's organization of system development and the role of the project manager. It can be conjectured that as product architecture gets closer to the modular type, product development – because the need for adjusting interfaces of parts (modules) to each other decreases – tends to be organized within functional departments with a high degree of autonomy. The role of the project manager in this case is to coordinate activities to ensure smooth progress in the development process. *JC* is the firm that most closely matches this prediction. *KC* relies on an entirely different set-up from *CC* and *JC*. Instead of

assigning engineers to departments, *KC* pools them, entrusting the project manager with complete authority over personnel selection and evaluation as well as progress management. The likely aim of this organizational structure is to use human resources – especially engineers – rationally by building systems that overcome divisional boundaries and facilitate cooperation. The project manager enjoys strong authority because engineers are pooled, making it difficult for the general manager to manage and supervise all activities. In contrast, a notable feature of *CC* is that, on the one hand, the project manager has to report to his superiors (making his role akin to that of a "lightweight" project manager), while, on the other hand, his authority includes the assessment of personnel (making his role akin to that of a "heavyweight" project manager). Thus, the role of the project manager at *CC* falls somewhere between *JC* and *KC*. In sum, even though the product architecture in the three firms is fairly similar, each firm has strategically developed its organizational structure for product development and the defined the role of the project manager in response to specific situations.

Third, let us consider the HR management practices in each firm. *JC* employs a skill grade system, *KC* employs a hybrid skill grade-job grade system, and *CC* employs a job grade system. It is possible that as the modularization of product architectures proceeds, the need for the "bouncing off" of ideas and for internal training decreases. However, due to the expansion of information systems in recent years and the increase in replacement demand, there is considerable need for personnel, and in all three firms a trend toward internalization of employees and the expansion of new hiring can be observed. This can be seen in the fact that although separation rates at all three firms are not high, they all have a high share of mid-career recruits. In addition, the firms need to increase knowledge specialization during employee skill development. *KC*, in addition to providing off-the-job training for skill development, offers online training and the like. Finally, *JC* is relatively weak in the acquisition of specialist expertise because job rotation is widespread as a result of integrated system development activity in the past and because the number of days of off-the-job training is relatively short. If knowledge on individual modules is more important than the exchange of knowledge between those working on different modules, it should become easier to measure engineers' knowledge levels, and performance might be enhanced by providing individual incentives. From this perspective, both *KC* and *CC* provide individual engineers with incentives, including pay and promotion systems that reflect individual performance, and, at the other extreme, pressure on low performers to resign. At *JC*, too, individual performance is reflected in wages, but only to a comparatively small extent.

The above factors suggest that HR management at *KC* and *CC* is more consistent with the system architecture chosen than at *JC*. In this sense, Japan can learn from Korea and China.

3.4 Summary of Case Study Results

Summarizing the findings of the interviews and what they mean for the posited hypotheses, we can say the following.

Hypothesis 1, which states that "firms strategically choose their product architecture taking into account factors such as internal management resources and external product market conditions" was supported for all three product categories, that is, cellular phones, liquid crystal TVs, and information systems. Each firm has consciously chosen an integral or modular product architecture with the exception of firm *JA*, which always employs an integral product architecture in response to the level of accumulated technological and human capabilities and the particular product market it aims at (e.g., high-end or low-end).

Hypothesis 2, which states that "firms' choice of organizational design for product development activity closely reflects their choice of product architecture" was also supported for all three product categories. In the case of information systems, which have a strong element of modularity, product development tended to be organized within functional departments, whereas in the case of cellular phones and liquid crystal TVs, which have a strong element of integrality, product development tended to be organized based on cross-functional project teams. In addition, it was found that the higher the degree of integrality, the stronger was the authority of the project manager.

Finally, with regard to Hypothesis 3, which states that "there is a complementary relationship between the chosen product architecture and the organization of product development on the one hand and HR management practices on the other," the results are less clear. We were able to confirm that there is a complementary relationship between product architecture and HR management in that the following pattern holds: integral product architecture tends to go hand-in-hand with an emphasis on internal training, skill development from a long-term perspective, and provision of incentives; on the other hand, modular product architecture tends to be accompanied by an emphasis on mid-career recruitment and the provision of incentives from a short-term perspective. However, we were not able to clearly confirm a complementary relationship between the organizational structure of product development and HR management.

4. Product Development and Human Resource Management: Evidence from a Questionnaire Survey in the Three Countries

The preceding section compared product architectures, organizational structures for product development, and HR management issues through a series of interviews with representative firms from each of the three countries examined here. Such interviews provide important

anecdotal evidence to better understand patterns in Japan, Korea, and China. In addition, we also conducted a firm-level questionnaire survey in order to examine these issues quantitatively. The survey questionnaire was identical for all three countries, and the actual survey was conducted after a pretest.

4.1 Survey methodology

The target firms in Japan were private-sector firms with 185 or more employees belonging to the manufacturing and software industries. Firms were chosen from across Japan, with sample firms drawn from the business information database of Tokyo Shoko Research, Ltd. The survey was conducted as a postal survey between March 1 and March 12, 2010. Details on the number of firms contacted and the number of firms responding are provided in Table 4(a).[2]

Target firms in Korea consisted of private-sector firms in manufacturing (with 300 or more employees) and the information and communication industry (with 150 or more employees).[3] Firms were chosen from across Korea, with sample firms drawn from the 2008 *Basic Survey of Establishments*. The survey was conducted in the form of interviews and the survey period was July 8 to October 4, 2010. Details on the number of firms contacted and the number of firms responding are provided in Table 4(b).[4]

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[2] The response rate at 3% is extremely low. There are likely to be two reasons for this. The first is that a considerable number of firms contacted (especially small and medium ones) probably do not have internal product development capabilities and, strictly speaking, should have been screened out. According to the 2008 *Report on the Survey of Research and Development* (Statistics Bureau, 2008), the percentage share of firms that "not only conduct so-called 'research' but also engage in activities aimed at technological improvements and the development of products as well as production and manufacturing processes" was 12.8% in the manufacturing sector (11.5% for firms with 1-299 employees, 54.0% for firms with 300-999 employees, and 81.8% for firms with 1,000 or more employees). For the information and communications industry, the overall average was 6.7% (6.1% for firms with 1-299 employees, 12.3% for firms with 300-999 employees, and 56.7% for firms with 1,000 or more employees). The second possible reason is that the questionnaire consisted of two steps, where, after the head of the personnel department had replied to the section on the personnel system and HR management, the questionnaire needed to be forwarded to the head of the product development department to reply to the section on product development. Due to this complication, it was probably difficult for large firms with functions divided among different locations (for example, firms whose headquarters were in Tokyo but product development department in Osaka) to reply to the questionnaire.

[3] It should be noted that because the 2008 *Basic Survey of Establishments* which we used to draw our sample is the 2008 edition and because of subsequent changes in the number employees, the sample of manufacturing firms contains firms with fewer than 300 employees.

[4] The average response rate was 19.0% and therefore considerably higher than in Japan. The reason is that the

In our survey on China, unfortunately, we were unable to cover the entire country due to budget limitations and therefore focused on firms in Shanghai, Beijing, Guangzhou, and Shenzhen. Sample firms were drawn from the *Year Book of Chinese Companies* for Shanghai and a list of companies provided by the State Administration for Industry and Commerce for Beijing, Guangzhou, and Shenzhen. Firms were chosen on the basis of random sampling. The survey was implemented in the form of interviews at the firms conducted by interviewers specializing in company surveys. The survey period was August 14 to October 15, 2010. Details on the number of firms contacted and the number of firms responding are provided in Table 4(c).[5]

4.2 Hypothesis 1: Firms strategically choose their product architecture taking into account factors such as internal management resources and external product market conditions

As mentioned, product architectures can be distinguished in terms of whether they are "modular," where there is more or less a one-to-one relationship between a particular function and a particular part, or "integral," where the relationship between particular functions and parts is more complicated. Moreover, with regard to interface design rules, one can distinguish between "open" design rules, which are standardized at the industry level (i.e., beyond a particular firm), and "closed" design rules, where the design rule is limited to a particular firm.

While such distinctions are simple in theory, finding appropriate indicators that can be used for empirical analysis is not easy. Therefore, in our questionnaire survey, we included the following two questions:

(1) "*In the development of your main product or information system, what is the*

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survey was conducted through company visits by interviewers specializing in company surveys. The structure of the questionnaire, asking the head of the HR department about the personnel system and HR management and the head of the product development department about product development, was the same as in Japan.

[5] The response rate is extremely low. The reason is that – because of budget limitations, and because the number of potential firms to contact is enormous – we chose the sample observations through random sampling, and once we had obtained roughly the same number of responses for each region, we aborted the survey. Moreover, we adopted a survey structure where, after asking the head of the product development department about product development, we asked him/her about the personnel system and HR management. The reason is that in the case studies, which we conducted before the questionnaire survey, we discovered that the authority of HR departments in Chinese firms is limited and that the head of the product development department tends to have a good grasp of HR issues at the establishment level.

approximate percentage of man-hours, as a share of overall development man-hours prior to the start of mass production, spent on optimizing the design parameters of the 'key component'? "– The aim of this question was to determine whether the costs were relatively low, in which case the relationship between the function and the part is relatively simple, indicating a modular architecture, or whether they were relatively high, suggesting that the relationship between the function and the part is relatively complex, indicating an integral product architecture. More specifically, we divided the distribution of answers into quartiles and classified firms falling into the first and second quartiles as employing a modular-like architecture and those falling into the third and fourth quartiles as employing an integral-like architecture.

(2) "*Roughly what percentage of the interface (connection) standards connecting the key component of your main product or information system with other components are your company's proprietary standards?*" – The aim of this question was to find out whether a firm relied mainly on open or closed interfaces. As in the case of question (1), we divided responses into quartiles and classified firms as using "open" or "closed" interfaces.

Table 5 provides an overview of the responses in terms of whether firms used a modular or integral product architecture and open or closed interfaces. As can be seen, in Japan and Korea, firms were more or less evenly divided between those employing a modular and those employing an integral architecture. On the other hand, in China, more firms employed modular architecture. Moreover, in Japan and China, the share of firms employing mainly open or mainly closed interfaces was again evenly balanced, whereas in Korea, more firms used open interfaces.

Next, let us have a look at the determinants of product architecture. Starting with Japanese firms (Table 6), we find that firms using integral product architecture tend to be firms that choose cross-functional project teams for product development. On the other hand, firms using a modular architecture tend to be firms from the software industry, firms engaged in make-to-stock production,[6] firms using open interfaces, and firms that organize product development within the functional department.

The pattern for Korean firms is reported in Table 7. In Korea, whether or not firms belong to the machinery-related manufacturing sector has no bearing on whether they adopt an integral architecture. On the other hand, firms using closed interfaces tend to adopt integral product architecture. Conversely, firms that adopt modular architecture tend to be firms

[6] However, this does not mean that firms engaged in make-to-order production are more likely to use integral architectures. Rather, these firms tend to be relatively evenly split between using integral or modular architectures.

using open interfaces.

In China (Table 8), firms with an integral architecture tend to be manufacturing firms other than machinery-related ones, firms using closed interfaces, and firms where product development is organized in project teams either within or across functional departments. Conversely, firms with a modular architecture tend to be firms in the software industry, firms using open interfaces, and firms where product development is organized within functional departments.

What are the implications of the above results? First, the findings suggest that in Japan and Korea, firms with a modular product architecture and firms with an integral product architecture are relatively evenly split, whereas in China, a larger share of firms employ a modular architecture. The finding that Chinese firms show a strong inclination toward open interfaces closely matches Fujimoto and Shintaku's (2005) hypothesis that manufacturers in China tend to use quasi-open architectures. Second, however, we find that in China, as well as in Japan and Korea, even in the same industry and among firms of the same size, there is considerable variation in the use of modular and integral architectures and it cannot be said that a particular product architecture is dominant. That is to say, product architecture is not something that is exogenously determined by, for example, industry characteristics, but instead is strategically chosen by firms depending on a number of factors at a particular time.

4.3 Hypothesis 2: Firms' choice of organizational design for product development activity closely reflects their choice of product architecture

Next, let us have a look at the product development organization structure. The prevailing view is that at Japanese manufacturing firms, as epitomized by the auto industry, product development proceeds through the establishment of a project-based structure consisting of members from different functional departments (see, e.g., Nobeoka 2006). However, as can be seen in Figure 2, in the survey results on Japan, this kind of project-based organization across functional departments can be found in only 15.9% of all firms. Moreover, even when a project group is established, this is mainly done within a functional department (34.1%), but the most frequent pattern is that the functional department itself is in charge of development (50.0%).

The survey results for Korea also show that it is typically the functional department that is in charge of product development. That is to say, 51.4% of firms organize their product development within the functional department, 36.4% use a project-based approach within the department, and only 12.1% employ a project-based approach across functional departments. In China, the orientation toward the functional department is even stronger:

71.3% of all firms organize their product development within the functional department, 18.7% use a project-based approach within the functional department, and only 4.0% rely on a project-based approach across functional departments. Comparing the results for the three countries suggests that the importance of a project-based approach across functional departments is greatest in Japan, followed by Korea, and then China. Thus, although cross-functional project-based product development is not as prevalent in Japan as one would expect based on the literature, there does seem to be stronger tendency to use this kind of product development organization in Japan than in the other two countries.

Next, let us explore the determinants of the organizational structure in product development. The results for Japanese firms are presented in Table 9. Many firms in machinery-related manufacturing industries answered that product development is organized in cross-functional projects. Looking at the relationship with product architecture, we find that, as expected, the share of firms with a cross-functional project organization is particularly high among firms with an integral product architecture, while for firms with a modular product architecture, the share that organizes product development within functional departments is particularly high. However, with regard to interfaces, we were unable to confirm the expected relationship that product development within functional departments was associated with open interfaces and product development in cross-functional project teams with closed interfaces.

Looking at the relationship between product architecture and product development organization for Korean firms (Table 10), we find that although for firms with a modular architecture, the share of firms organizing product development within functional departments was high, it cannot be said that the share of firms with cross-functional project teams was particularly high for firms with an integral product architecture.

The most frequent pattern among Chinese firms (Table 11) is that the functional department is in charge of product development, which is far more often the case than in Japan and Korea. Looking at the results in more detail, product development organized in cross-functional projects was more frequent among firms with an integral product architecture, while product development organization within functional departments was more frequent among firms with a modular product architecture.

The above findings indicate that firms strategically choose the structure of their product development organization. The principal pattern of product development organization is within the functional department (for example, the product development department). However, in Japan, when the product architecture is integral in nature and the combination of various kinds of specialist knowledge is required, product development tends to be conducted in cross-functional project teams. Similarly, in China, although product

development within functional departments dominates, firms that adopt integral product architecture show a greater tendency to use cross-functional project teams. The patterns for Korea are generally similar to those in Japan, with one important exception: No clear results regarding the adoption of cross-functional project teams could be observed. Overall, the results for Japan and China are consistent with Aoshima and Takeishi (2001) and Nobeoka's (2006) argument concerning the complementarity of integral product architectures and cross-functional project-based product development on the one hand, and modular product architectures and functional department-based product development on the other. However, why we were unable to see this relationship in Korea is at present unclear.

4.4 Hypothesis 3: There is a complementary relationship between the chosen product architecture and the organization of product development on the one hand and HR management practices on the other

Let us begin by looking at the relationship between product architecture and HR management practices at Japanese firms (Table 12). Firms where the average number of years of engineers' employment with the firm is long tend to use integral product architecture, while firms where engineers' average employment is short tend to use modular product architecture. This suggests that long-term employment is associated with integrated product architecture. Next, let us look at Korean firms (Table 13). In Korea, only a relatively small percentage of firms where engineers' average tenure is long have an integral product architecture. In addition, more generally, it is difficult to discern a clear relationship between product architecture and HR practices at Korean firms. Finally, for Chinese firms (Table 14), we find that firms with a relatively young average age of engineers and a relatively short average employment duration tend to use modular product architecture, although the opposite – that firms with relatively older engineers and a relatively long employment duration tend to utilize integral product architecture – does not seem to be the case.

The pattern that emerges concerning the relationship between the product architecture and HR practices thus is that at Japanese firms, long-term employment and integral architectures tend to go in hand, while at Chinese firm, short-term employment and modular architectures go hand in hand. However, at Korean firms, such a clear correspondence is rare. A possible explanation is that – as the case study revealed – Korean firms tend to use mixtures of long-term and short-term employment, and of integral and modular architectures, as the situation requires rather than exhibiting one predominant pattern

Let us look at the second part of the hypothesis, that is, the relationship between the organization of product development and HR management practices. Although, to conserve space, the tables are not shown here, our results indicate that for Japan, no clear relationship between the organization of product development and HR practices has emerged. Therefore,

we instead looked at the type of project organization used and the authority of the leader of the product development organization (i.e., the project manager, or PM for short). Specifically, we focused on whether firms had a project manager whose authority was as great as, or even greater than, that of functional department heads when it came to deciding on product development-related issues – everything from the product concept to personnel evaluation. In short, we wanted to determine whether firms had a "heavyweight PM." We found that firms were more likely to have a heavyweight PM if they organized product development in cross-functional project teams than if they organized it in project teams within the functional department.

Korean firms, like their Japan counterparts, exhibited no clear relationship between the organization of product development and HR management practices. Therefore, we again examined whether Korean firms have a heavyweight PM and found that, as in Japan, firms organizing product development in cross-functional project teams were more likely to have a heavyweight PM. In contrast to Japan, however, firms more often replied that the PM had greater authority than the head of the product development department than that his authority was the same. That is, once a Korean company sets up a project, there is a strong tendency to delegate authority to the project leader.

Finally, for Chinese firms, it is difficult to say anything with regard to the factors that influence project organization because product development is overwhelmingly organized within the functional department. The authority of the project manager to decide on product development-related issues such as the product concept or personnel evaluation is typically smaller than that of the head of the functional department, even in the case of firms that have set up cross-functional projects. In other words, Japanese- or Korean-style heavyweight PMs are still rare in China.

In sum, we were not able to find a clear complementary relationship between the organization of product development and HR management practices. While the reason for this is not clear, a possible explanation is that whereas the three countries have in common that the principal pattern is that the functional department is in charge of product development and cross-functional project organization is relatively rare, there were clear differences between the three countries in terms of HR management practices.

5. Conclusion and Implications

Let us summarize the results of the analysis in terms of the three hypotheses posited.

For all three product categories that we focused on – cellular phones, liquid crystal TVs, and

information systems – the case studies provided support for the hypothesis that firms strategically choose their product architecture. Each firm deliberately chooses whether it employs an integral or a modular architecture depending on the level of accumulated technological capabilities and skills as well as the product market situation (e.g., whether the firm targets the high-end or the low-end market). Moreover, the questionnaire survey showed that although in China there is a strong tendency toward the use of modular architectures, in all three countries – Japan, Korea, and China – there is considerable variation in the use of modular and integral architectures and no particular product architecture dominates even in the same industry and among firms of a similar size. In other words, we found support for the hypothesis that product architecture is not something that is exogenously determined by, for example, industry characteristics, but is instead strategically chosen by firms in response to several factors existing at a particular time.

The case studies showed that in the case of information systems, where product architectures have a strong modular flavor, product development tends to be organized within functional departments, whereas in the case of cellular phones and liquid crystal TVs, which tend to have a strong element of integral product architectures, product development tends to be organized within cross-functional projects. Moreover, the case studies also showed that the higher the degree of integrality, the stronger is the authority of the project manager (i.e., there is a heavyweight project manager). The questionnaire survey found that for Japan and China, there appears to be a complementary relationship between integral product architectures and cross-functional project-based product development on the one hand and modular product architectures and product development within functional departments on the other. However, we did not find such a relationship for Korea.

With regard to product architecture and HR management practices, the case studies demonstrated the prevalence of two complementary relationships: (a) integral architecture is associated with an emphasis on internal training, skill development from a long-term perspective, and the provision of incentives, and (b) modular architecture is associated with an emphasis on mid-career recruitment and provision of incentives from a short-term perspective. However, we were not able to detect a clearly complementary relationship between the organization of product development and HR management practices. Both the case studies and the questionnaire survey showed that at Japanese firms, there tends to be a correlation between long-term employment and integral architectures, while at Chinese firms, there tends to be a correlation between short-term employment and modular architectures. On the other hand, for Korean firms, such corresponding relationships seem to be much rarer.

The above summarizes our results in terms of whether they accord with the posited hypotheses. However, our results also include findings that are not directly related to the

hypotheses but have important implications. First, for Japanese firms, we can see a clear complementarity between integral product architectures and cross-functional project organization on the one hand, and modular product architectures and product development within the functional department on the other; furthermore, in the former case, product development is typically led by a heavyweight project manager. The importance of this complementarity is not recognized in Korea and China, so if Japanese firms enter strategic partnerships with, or offer consulting services to, firms from these countries in the future, an important aspect will be the transfer of know-how on organizational complementarity from the Japanese side.

The integral product architecture employed by Japanese firms is closely linked with HR management practices focused on the long term. While this itself is evidence of complementarity, it is possible that HR practices treating long-term employment as an "unshakeable premise" have generated a reverse causality in which employment practices become one of the main reasons for choosing integral product architectures. That is, it may reflect a situation where firms adopt integral product architecture because they have a high level of technology accumulation and numerous employees with strong technical skills gained through long-term employment practices.

Emphasizing long-term employment and integral product architectures may have been a viable strategy when the domestic economy was growing strongly and competition from abroad was limited, but such favorable conditions no longer exist. With Japanese firms confronting changing product market conditions and the emergence of Korean and Chinese rivals, it appears to be time for a strategic adjustment of product architectures and HR management practices. In addition to choosing their product architecture more flexibly – using either integral or modular architecture as the situation demands – Japanese firms can learn from Korea's global players about combining mid-career recruitment with the hiring of new graduates, as well as about mixing short-term and long-term employment practices.

With regard to Chinese firms that wish to increase the sophistication of their products and adopt integral architectures, we suggest that they take a long-term perspective on skill development, improve employee retention, and provide better incentives – in other words, institutionalize an internal labor market. In fact, with labor laws and regulations currently being revised, employment practices in China are in transition from an emphasis on fixed-term contracts toward indefinite employment, as is the norm in Japan. Thus, Chinese firms will need to adopt HR management practices that take a long-term perspective (especially with regard to retention policy).

Korean global players have performed very well in recent years, but they also face a number of challenges. First, when conducting product design with integral architecture, coordination

between product development and manufacturing needs to be strengthened, while identification and resolution of problems needs to take place earlier during product development (front-loading). The interviews we conducted suggest that there were problems in coordination between development and production departments. The likely reason is that present incentive systems reward the achievements of individual departments, thus promoting opportunistic behavior by department managers. This problem needs correction. Second, project managers (PMs) in Korea generally tend to have substantial authority, but to some extent this reflects the fact that PMs have to take on duties beyond their normal responsibilities. Put simply, in order to compensate for the lack of personnel, PMs often have to take on the work of other employees. In consequence, many shoulder excessive workloads, to the point that not enough people are willing to be PMs. Thus, Korean firms need to improve their HR practices with a view to nurturing future project managers.

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Figure 1. Causal Loop Diagram: Product Development and HR Management

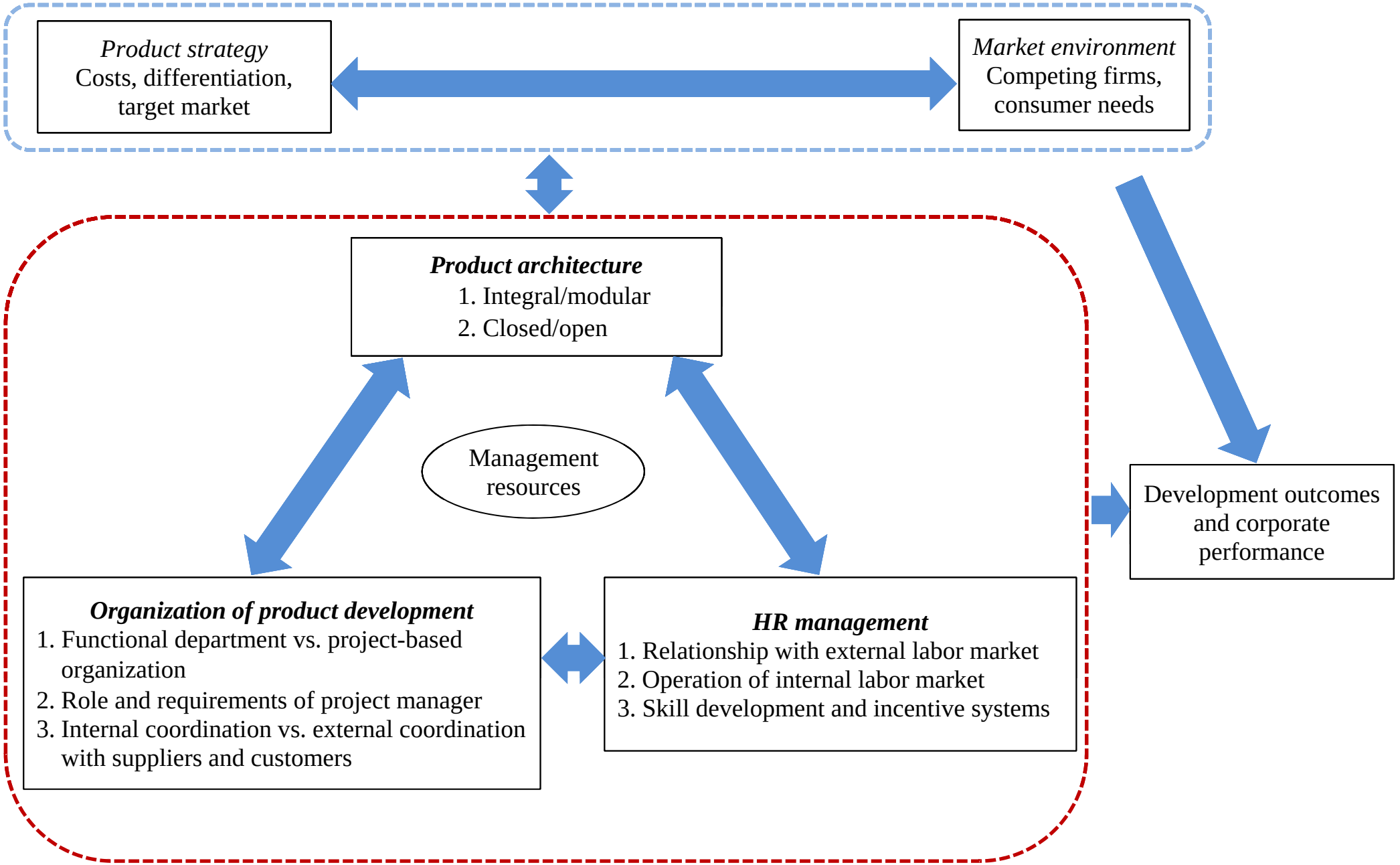

Table 1. Product Development and HR Management in Japan, Korea, and China: Cellular Phones

	Firm *JA*	Firm *KA*	Firm *CA*
Hypothesis 1 : Firms strategically choose their product architecture taking into account factors such as internal management resources and external product market conditions.			
Product development strategy	Starts development on request from telecommunications carrier. The flow is "proposal → competitive bidding."	Four types of strategy, reflecting who leads development effort (*KA* itself or telecommunications carrier) and market where product is to be launched (specific region only or globally).	The firm started out by developing testing equipment for the telecommunications industry. At present, it is also engaged in made-to-order production.
Product architecture and determinants	Integral product architecture regardless of whether it is a high-end product or not. Customer requests determine product architecture (telecommunications carrier/mature domestic market).	For high-end products, product architecture typically integral, for low-end products typically modular. I.e., product architecture clearly determined by product market and product strategy.	Uses both modular and integral parts and emphasizes striking a balance between the two. I.e., product architecture clearly determined by product market and product strategy.
Hypothesis 2 : Firms strategically choose their organizational design for product development activity reflecting their choice of product architecture.			
Organization of product development (relationship with functional department)	Relatively weak matrix organization vis-à-vis functional department.	Relatively strong matrix organization vis-à-vis functional department.	Relatively strong matrix organization vis-à-vis functional department.
Role and requirements of project manager	No budget or personnel decision-making authority. Also no authority over personnel evaluation. Most important requirement: managerial capabilities.	Has budget and personnel decision-making authority. Budget constraints weak. No authority over personnel evaluation. Importance of managerial and technical capabilities: 50:50. Project manager her/himself is key person in the development process.	Has budget and decision-making authority. Were unable to confirm where personnel evaluation authority lies, but PM can give opinion on evaluation. Emphasis of technical and managerial capabilities.
Hypothesis 3 : There is a complimentary relationship between the chosen product architecture and the organization of product development on the one hand and HR management practices on the other.			
Relationship with external labor market	Low employee turnover (2008: 1.7%). Basic policy is recruitment of new graduates. Mid-career recruitment ratio was 42% in 2007 and 20% in 2008.	Intermediate employee turnover (2008: 3.5%). Basic policy is recruitment of new graduates. Mid-career recruitment ratio was 5.9% in 2007 and 7.7% in 2008.	High employee turnover (2008: ca. 5%). Basic policy is recruitment of new graduates, but putting increasing emphasis on mid-career recruitment. Mid-career recruitment ratio is about 50%.
HR system	Skill grade system.	Close to skill grade system.	Job grade system.
Personnel evaluation	Biannual evaluation based on management by objectives (MBO). Long-term efforts and throughput are also evaluated.	Annual evaluation based on management by objectives (MBO). Objectives with regard to projects are not included.	Quarterly evaluation based on management by objectives (MBO).
Skill development	Fundamental policy is internal training. The standard is on-the-job training; proportion of off-the-job training courses is low when compared with other firms.	Focus is internal training. Up to 10% of all engineers recruited mid-career. Focus is on on-the-job training.	Emphasized internal training in the past, but increasingly emphasizes external recruitment.
Determination of base pay	Base salary = Seniority wage + position salary. Increases in the seniority wage depend on performance evaluation and tenure. Position salary increases with performance evaluation. Pay reflects not only short-term performance evaluation but also the consideration of throughput.	Pay consists of: Annual salary = Monthly salary + Performance-based compensation + Special incentives. The monthly salary consists of: Monthly salary = Base salary + Salary based on skill. The performance-based compensation distributes profits to each business unit. The special incentive has the aim of retaining workers. Project performance is not reflected in individual pay.	Wage based on job evaluation. For ordinary employees and factory managers, base salary mainly determined by performance; for higher-level employees, potential development capability and strategic contribution to company also taken into account.
Promotion policy	The superior makes an application for promotion based on a performance evaluation and competency review. Capabilities not reflected in short-term performance are also taken into account.	Promotion based on evaluation of performance and competence. Firm has a system of fast track promotion and a system of weeding out lowest performers.	Promotion according to evaluation of performance.

Table 2. Product Development and HR Management in Japan, Korea, and China: Liquid Crystal TVs

	Firm *JB*	Firm *KB*	Firm *CB*
Hypothesis 1 : Firms strategically choose their product architecture taking into account factors such as internal management resources and external product market conditions.			
Product development strategy	Product development strategy focuses on being a market leader by creating demand for new products.	Product development strategy focuses on highest image and sound quality even if this means market introduction is slightly later than that of rivals.	Development strategy focuses on gauging consumer needs and launching product as quickly as possible in the market while paying attention to the behavior of competing firms.
Product architecture and determinants	Integral and modular product architectures exist side by side. Integral architecture for new products seeking to create new demand; modular architecture when aiming for cost reductions, increased delivery speed, and turning a product into a series.	Integral and modular product architectures exist side by side. Integral architecture for development of new platforms; modular architecture for revision of platform.	Product architecture essentially modular; no proprietary liquid crystal panel technology. However, also develops integral architecture required for multifunctionality and to link modules, focusing on software.
Hypothesis 2 : Firms strategically choose their organizational design for product development activity reflecting their choice of product architecture.			
Organization of product development (relationship with functional department)	Cross-functional projects based on product development center, but the influence of the functional department is relatively strong.	Product development activities are divided into grades depending on the characteristics of the new product. Cross-functional projects are formed accordingly, but the influence of the functional department is relatively strong.	Has cross-functional projects formed through integrated product development (IPD) method, but final decision-making lies with the project manager.
Role and requirements of project manager	Project manager does not have to belong to a particular job category or have a particular job rank, but often is a section manager. Role consists of leading product development cycle. Responsibilities consist of ensuring objectives in terms of product functionality, time frame, price, product quality, market segment, etc., are met. Has less authority than department head, but is required to have greater technical capabilities.	Rank of project manager depends on the grade of the project. Responsibilities range from choice of part suppliers to resolution of problems in development process and hand-over to production stage. However, project manager has little authority and usually has to report to the head of the department he/she belongs to. Required to have greater technical capabilities.	There is a clearly laid-out career ladder for project managers. Project manager frequently comes from marketing department. Role consists of overall organization and management of project, including overseeing the decomposition and achievement of objectives. Managerial ability such as coordination required.
Hypothesis 3 : There is a complimentary relationship between the chosen product architecture and the organization of product development on the one hand and HR management practices on the other.			
Relationship with external labor market	Almost all employees recruited after graduation. Separation rate of engineers is 0.5%.	Use of recruitment of graduates and external recruitment depending on strategic priorities and organizational capabilities. Overall mid-career recruitment rate in recent years is 40%. Separation rate is 7-8%.	Emphasis on recruitment of graduates, but also considerable mid-career recruitment, especially of highly skilled employees. Mid-career recruits make up about 25%. Separation rate is 5%.
HR system	Skill grade system. There is dual ranking structure based on position and skill grade.	While there are job classifications, wages are linked to capabilities and the system comes close to a skill grade system. However, there is only a single (and not a dual) ranking structure based on position.	Essentially close to a job grade system, but also has skill grades. There is therefore a dual ranking structure based on position and skill/job grade.
Personnel evaluation	As part of management by objectives (MBO), ability, behavior, and performance are evaluated. For managers, greater emphasis on performance; for regular employees, greater emphasis on ability. Behavior is also assessed.	Implemented using a framework similar to MBO. Performance evaluation focuses mainly on quantitative assessment of performance with regard to objectives in the same financial year. Ability assessment emphasizes general abilities required across job categories (knowledge, skills, morale).	Linked to MBO, but evaluation of engineers differs from that of managers and is conducted for each project, emphasizing assessment relative to other projects.
Skill development	Basic approach is internal training emphasizing on-the-job training, but has periodic training courses by type of skill. Also has internal job posting system.	Internal training and external acquisition of skills decided based on strategic priorities and organizational capabilities. Internal training focuses on on-the-job training, but for engineers and R&D leaders there are also various training courses. Staff transfers are also used.	When recruiting employees, firm sets up a career plan and provides training. Emphasizes on-the-job training and provides new employees with a mentor responsible for providing guidance.
Determination of base pay	Wages of managers consist of a monthly performance salary based on the results of a performance evaluation, and of a monthly salary reflecting job grade. Wages of regular employees consist of a base salary (salary for job category + supplementary salary + basic salary) plus various allowances. Salary mainly reflects results of evaluation of ability and behavior.	Base salary is determined on the basis of educational attainment and work experience at the time of entering the company. Thereafter, most important determinant is individual performance. Emphasis of incentives for outstanding individuals through incentive wage plan offering considerable sums.	Pay consists of base salary (70%) and incentive bonus (30%). Pay is determined based on three criteria: position (50%), ability (15%), and performance (35%).
Promotion policy	When engineers recruited upon graduation are promoted to their first managerial position, they take a written examination. In technical jobs, promotion is typically to supervisory positions and promotion to managerial positions is very rare.	Promotion takes into account performance and general ability assessment of preceding three years as well as assessment of abilities with regard to specific job. About 10% of those promoted in the firm overall, and 20% of those promoted in the R&D organization, are promoted through selection.	Assessment results of past two years are considered in promotion. For promotion to managerial post, interview selection through higher-level managers. Each year, conducts preliminary selection at group company level and provide training for potential promotions to managerial level.

Table 3. Product Development and HR Management in Japan, Korea, and China: Information Systems

	Firm *JC*	Firm *KC*	Firm *CC*
Hypothesis 1: Firms strategically choose their product architecture taking into account factors such as internal management resources and external product market conditions.			
Product development strategy	Conduct product development carefully considering budget, time, and technology available.	Conduct product development carefully considering budget, time, and technology available.	Conduct product development ensuring system stability while also considering how it can be applied in a variety of industries.
Product architecture and determinants	Currently use a relatively neutral architecture when compared with rivals affiliated with major IT hardware companies (probably because time and money have become tight).	Modular in nature due to reuse of modules and existing technologies reflecting maximum priority given to costs and time.	With an eye on the efficient use of resources, developed a system architecture which is modular in nature and is based on middleware which can be used for a variety of projects.
Hypothesis 2: Firms strategically choose their organizational design for product development activity reflecting their choice of product architecture.			
Organization of product development (relationship with functional department)	Relatively weak matrix organization vis-à-vis functional department.	Relatively strong matrix organization vis-à-vis functional department.	Relatively strong matrix organization vis-à-vis functional department (somewhere between *JC* and *KC*).
Role and requirements of project manager	Expect managerial capabilities. No authority to evaluate project members. Project manager reports to superiors and obtains authorization at critical junctures of development process.	Expect managerial capabilities. Project manager has overall responsibility and authority for use of budget within the constraints of the size of the order. Has authority to choose project members and evaluate personnel, and when project starts.	Expect managerial capabilities. Has authority to select project members and evaluate personnel. Project Management Office (PMO) audits the process and outcome of the project.
Hypothesis 3: There is a complimentary relationship between the chosen product architecture and the organization of product development on the one hand and HR management practices on the other.			
Relationship with external labor market	Emphasis of internal training can be seen in overall separation rate of only 1.37%. However, the ratio of graduate recruits to mid-career recruits is about 5:1, so that the emphasis is not only on recruitment of new graduates.	Separation rate of engineers is 4-5% and the firm emphasizes the recruitment of new graduates and internal training. However, at the same time, the ratio of graduate recruits to mid-career recruits is between 3:1 and 4:1, indicating that the firm also actively uses the external labor market.	Separation rate of engineers is 5% (overall separation rate: 16%) and the firm emphasizes the recruitment of new graduates and internal training. However, at the same time, the ratio of graduate recruits to mid-career recruits is 3.5:1, indicating that the firm also actively uses the external labor market.
HR system	Skill grade system. There are no differences between job categories.	Mixture of skill grade and job grade system (with differences in base salary depending on job category).	Job grade system.
Personnel evaluation	Annual general evaluation (until 2010, performance 70%, behavior 30%, since April 2010, 50:50) and biannual performance evaluation based on MBO.	Emphasis of performance evaluation consisting of annual performance assessment (MBO) and annual competency evaluation.	Assessment considers skill and performance, but most important criterion is performance.
Skill development	On-the-job training forms the basis. In addition about 10 days a year of off-the-job training. Frequent job rotation due to past practice; e.g., pattern of transfer from management to product development and back to management not unusual.	About 10% of work time used for skill development (online training). Detailed competence grades for skill development defined and experience, knowledge, and qualifications necessary for rising to the next level clearly shown.	Implement tests to encourage technical learning by engineers. Job rotation is rare and is at the discretion of the senior manager.
Determination of base pay	Base pay consists of (1) a wage reflecting skill grade, (2) a supplement reflecting individual performance, and (3) a regional supplement. Assessment reflected in bonus based on performance assessment as well as in base pay performance supplement and promotion based on general assessment. However, almost no differences based on ability.	Salaries are paid on the basis of an annual salary system consisting of 12 equal monthly salaries. Salaries consist of a base salary reflecting job rank (60%), an individual performance component based on performance assessment (15%), and a job ability component based on competency assessment (25%).	Salaries are paid on the basis of an annual salary system. Salaries consist of a base salary reflecting job rank (40%), an individual performance component (30%), and an ability component (30%). There are large differences between salaries even for those having worked for the company for the same number of years.
Promotion policy	Seniority-based characteristics remain and early promotion is rare. At the same time, there is no system of weeding out lowest performers.	Although for each job rank, a standard number of years of experience are usually required, early promotion is also relatively frequent. On the other hand, non-performing employees are transferred to another job or are recommended to leave. Promotion policy emphases individual ability and performance.	Company has 35-year old executive vice-president, indicating that early promotion is perfectly normal. On the other hand, lowest-performing employees are weeded out. Among the firms from the three countries, puts greatest emphasis on individual performance.

Table 4. Details of Questionnaire Surveys

(a) Japan

		Population	No. of responses	Response rate
Total		3,504	104	3.0%
No. of employees	Fewer than 300	1,345	50	3.7%
	300-499	882	24	2.7%
	500-999	666	18	2.7%
	1,000 or more	611	12	2.0%
Industry	Manufacturing	3,115	89	2.9%
	Machinery	1,353	44	3.3%
	Other than machinery	1,762	45	2.6%
	Software industry	389	15	3.9%

Notes: 1. Sample firms were drawn from the business information database of Tokyo Shoko Research, Ltd.
2. Firms with 185 or more employees only.

(b) Korea

		Population	No. of responses	Response rate
Total		738	140	19.0%
No. of employees	Fewer than 300	69	38	55.1%
	300-499	354	34	9.6%
	500-999	194	40	20.6%
	1,000 or more	121	28	23.1%
Industry	Manufacturing	656	121	18.4%
	Software Industry	82	19	23.2%

Notes: 1. Sample firms were drawn from the 2008 *Basic Survey of Establishments.*
2. Firms with more than 300 employees (manufacturing sector) and 150 employees(software sector) only.

(c) China

Region	Industry	Population	Firms contacted	No. of responses	Response rate
Shanghai	Manufacturing	5,558	487	35	7.2%
	Software	188	57	5	8.8%
Beijing	Manufacturing	9,792	403	30	7.4%
	Software	206	132	10	7.6%
Guangzhou	Manufacturing	27,481	528	35	6.6%
	Software	117	52	5	9.6%
Shenzhen	Manufacturing	17,215	341	30	8.8%
	Software	9	0	0	-

Notes: 1. Sample firms were drawn from the *Year Book of Chinese Companies* (Shanghai) and a list of companies provided by the State Administration for Industry and Commerce(Beijing, Guangzhou, Shenzhen).
2. Firms with more than 300 employees (manufacturing sector) and 50 employees (software sector) only.

Table 5. Product Architecture and Interfaces

(a) Modular vs. integral architecture — Unit: %

	No. of responses	Modular (1st and 2nd quartile)	Integral (3rd and 4th quartile)	Average
Japan	75 (100%)	50.7	49.3	41.5
Korea	132 (100%)	50.0	50.0	47.6
China	150 (100%)	57.3	42.7	43.1

(b) Open vs. closed interfaces — Unit: %

	No. of responses	Open (1st and 2nd quartile)	Closed (3rd and 4th quartile)	Average
Japan	68 (100%)	50.0	50.0	46.7
Korea	131 (100%)	57.3	42.7	54.6
China	150 (100%)	52.0	48.0	44.4

Table 6. The Determinants of Product Architecture - Integral vs. Modular: Japan

Unit: %

		No. of respondents	Modular		Integral		Average
			1st quartile	2nd quartile	3rd quartile	4th quartile	
Total		75 (100%)	32.0	18.7	30.7	18.7	41.5
Number of employees	300 or fewer	35 (100%)	34.3	11.4	37.1	17.1	41.9
	300-499	16 (100%)	43.8	18.8	18.8	18.8	36.9
	500-999	16 (100%)	18.8	25.0	37.5	18.8	43.4
	1,000 or more	8 (100%)	25.0	37.5	12.5	25.0	45.6
Industry	Manufacturing	64 (100%)	31.3	17.2	31.3	20.3	42.4
	Machinery	33 (100%)	27.3	24.2	21.2	27.3	43.5
	Other than machinery	31 (100%)	35.5	9.7	41.9	12.9	41.3
	Software industry	11 (100%)	36.4	27.3	27.3	9.1	36.4
Make-to-order/Make-to-stock	Make-to-order (including OEM)	53 (100%)	26.4	24.5	28.3	20.8	42.7
	Make-to-stock	22 (100%)	45.5	4.5	36.4	13.6	38.6
Main product average annual sales (FY2007-09)	Less than 100 mill. yen	27 (100%)	37.0	18.5	29.6	14.8	39.4
	100 to 300 mill. yen	13 (100%)	61.5	7.7	23.1	7.7	28.5
	300 to 1,000 mill. yen	14 (100%)	7.1	42.9	21.4	28.6	47.5
	More than 1,000 mill. yen	16 (100%)	25.0	12.5	37.5	25.0	48.4
Year that product development commenced (Main product)	1960 and before	16 (100%)	25.0	18.8	25.0	31.3	46.9
	1961-1980	16 (100%)	43.8	25.0	18.8	12.5	32.2
	1981-2000	17 (100%)	47.1	11.8	23.5	17.6	37.6
	2001 and later	23 (100%)	17.4	21.7	47.8	13.0	46.1
Open/Closed	Open (1st and 2nd quartile)	33 (100%)	27.3	24.2	30.3	18.2	44.7
	Closed (3rd and 4th quartile)	34 (100%)	32.4	17.6	32.4	17.6	40.4
Form of development organization	Functional department	36 (100%)	36.1	11.1	27.8	25.0	43.9
	Project-based within functional department	25 (100%)	36.0	32.0	28.0	4.0	32.8
	Project-based across functional departments	11 (100%)	9.1	18.2	36.4	36.4	53.6

Table 7. The Determinants of Product Architecture - Integral vs. Modular: Korea

Unit: %

		No. of respondents	Modular		Integral		Average
			1st quartile	2nd quartile	3rd quartile	4th quartile	
Total		132 (100%)	27.3	22.7	27.3	22.7	47.6
Number of employees	300 or fewer	36 (100%)	27.8	25.0	27.8	19.4	47.2
	300-499	32 (100%)	25.0	18.8	31.3	25.0	48.9
	500-999	39 (100%)	25.6	28.2	20.5	25.6	47.7
	1,000 or more	25 (100%)	32.0	16.0	32.0	20.0	46.2
Industry	Manufacturing	114 (100%)	27.2	22.8	28.1	21.9	47.5
	Machinery	72 (100%)	23.6	26.4	25.0	25.0	49.2
	Other than machinery	42 (100%)	33.3	16.7	33.3	16.7	44.7
	Software industry	18 (100%)	27.8	22.2	22.2	27.8	48.1
Make-to-order/Make-to-stock	Make-to-order (including OEM)	88 (100%)	20.5	26.1	28.4	25.0	50.1
	Make-to-stock	44 (100%)	40.9	15.9	25.0	18.2	42.6
Main product average annual sales (FY2007-09)	Less than 1,000 mill. won	15 (100%)	33.3	33.3	13.3	20.0	41.2
	1,000 to 3,000 mill. won	13 (100%)	30.8	38.5	15.4	15.4	38.6
	3,000 to 10,000 mill. won	31 (100%)	25.8	16.1	29.0	29.0	51.0
	More than 10,000 mill. won	62 (100%)	24.2	17.7	35.5	22.6	51.5
Year that product development commenced (Main product)	1960 and before	4 (100%)	25.0	25.0	25.0	25.0	53.8
	1961-1980	30 (100%)	26.7	20.0	26.7	26.7	49.7
	1981-2000	58 (100%)	32.8	22.4	25.9	19.0	44.4
	2001 and later	33 (100%)	21.2	24.2	27.3	27.3	50.6
Open/Closed	Open (1st and 2nd quartile)	74 (100%)	32.4	25.7	27.0	14.9	42.0
	Closed (3rd and 4th quartile)	53 (100%)	22.6	15.1	28.3	34.0	55.0
Form of development organization	Functional department	68 (100%)	29.4	26.5	22.1	22.1	44.9
	Project-based within functional department	47 (100%)	23.4	17.0	36.2	23.4	51.8
	Project-based across functional departments	17 (100%)	29.4	23.5	23.5	23.5	46.7

Table 8. The Determinants of Product Architecture - Integral vs. Modular: China

Unit: %

		No. of respondents	Modular		Integral		Average
			1st quartile	2nd quartile	3rd quartile	4th quartile	
Total		150 (100%)	32.7	24.7	18.7	24.0	43.1
Number of employees	300 or fewer	11 (100%)	36.4	63.6	0.0	0.0	33.2
	300-499	99 (100%)	28.3	21.2	22.2	28.3	44.7
	500-999	25 (100%)	48.0	24.0	8.0	20.0	41.0
	1,000 or more	15 (100%)	33.3	20.0	26.7	20.0	43.7
Industry	Manufacturing	130 (100%)	33.1	22.3	20.0	24.6	43.2
	Machinery	31 (100%)	32.3	25.8	29.0	12.9	41.3
	Other than machinery	99 (100%)	33.3	21.2	17.2	28.3	43.8
	Software industry	20 (100%)	30.0	40.0	10.0	20.0	43.0
Make-to-order/Make-to-stock	Make-to-order (including OEM)	91 (100%)	37.4	26.4	12.1	24.2	41.5
	Make-to-stock	59 (100%)	25.4	22.0	28.8	23.7	45.6
Main product average annual sales (FY2007-09)	Less than 0.5 mill. yuan	26 (100%)	53.8	26.9	11.5	7.7	33.8
	0.5 to 1 mill. yuan	47 (100%)	34.0	17.0	19.1	29.8	44.0
	1 to 2 mill. yuan	24 (100%)	29.2	29.2	20.8	20.8	43.0
	2 to 5 mill. yuan	31 (100%)	29.0	25.8	16.1	29.0	46.0
	More than 5 mill. yuan	22 (100%)	13.6	31.8	27.3	27.3	48.4
Year that product development commenced (Main product)	1999 and before	25 (100%)	12.0	16.0	32.0	40.0	54.0
	2000-2002	31 (100%)	25.8	41.9	9.7	22.6	43.1
	2003-2005	59 (100%)	45.8	10.2	22.0	22.0	40.9
	2006 and later	35 (100%)	31.4	40.0	11.4	17.1	39.1
Open/Closed	Open (1st and 2nd quartile)	78 (100%)	41.0	32.1	14.1	12.8	37.4
	Closed (3rd and 4th quartile)	72 (100%)	23.6	16.7	23.6	36.1	49.3
Form of development organization	Functional department	116 (100%)	37.1	24.1	20.7	18.1	41.1
	Project-based within functional department	28 (100%)	17.9	28.6	10.7	42.9	50.0
	Project-based across functional departments	6 (100%)	16.7	16.7	16.7	50.0	50.8

Figure 2. Organization of Product Development for Main Product or Information Service

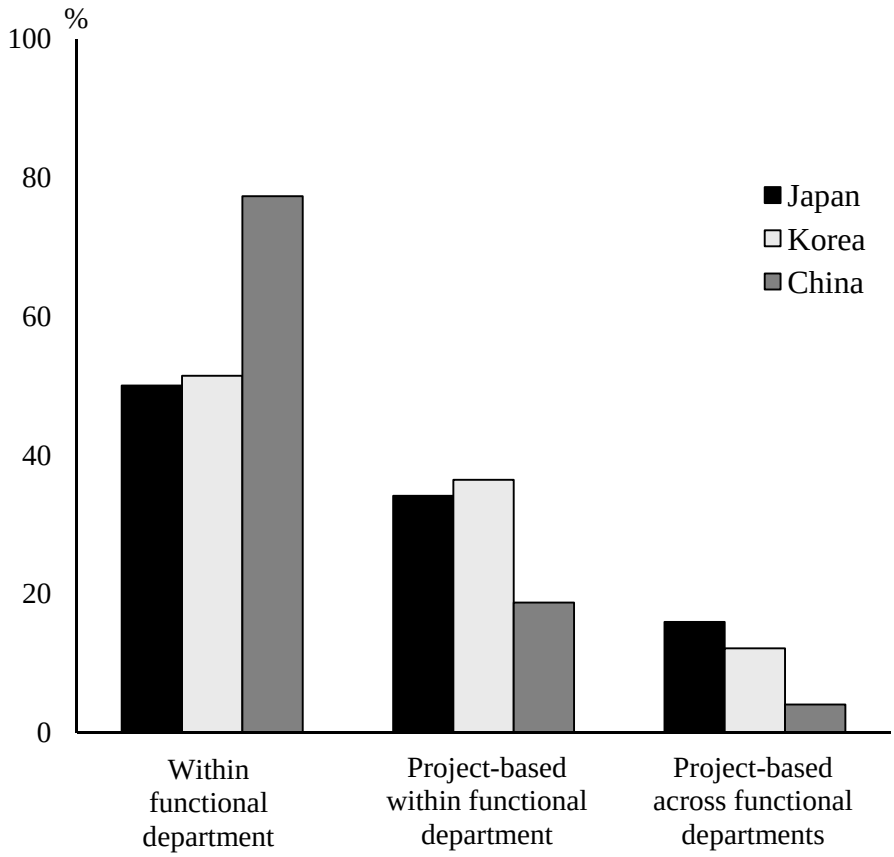

Table 9. Determinants of Product Development Organizational Structure: Japan

Unit: %

		Number of respondents	Functional department	Project-based within functional department	Project-based across functional departments
Total		88 (100%)	50.0	34.1	15.9
Number of employees	Fewer than 300	38 (100%)	44.7	39.5	15.8
	300-499	22 (100%)	63.6	31.8	4.5
	500-999	16 (100%)	43.8	25.0	31.3
	1,000 or more	12 (100%)	50.0	33.3	16.7
Industry	Manufacturing	74 (100%)	51.4	29.7	18.9
	Machinery	38 (100%)	47.4	26.3	26.3
	Other than machinery	36 (100%)	55.6	33.3	11.1
	Software industry	14 (100%)	42.9	57.1	0.0
Make-to-order/Make-to-stock	Make-to-order (including OEM)	62 (100%)	46.8	35.5	17.7
	Make-to-stock	23 (100%)	60.9	26.1	13.0
Modular or integral	Modular (1st and 2nd quartile)	37 (100%)	45.9	45.9	8.1
	Integral (3rd and 4th quartile)	35 (100%)	54.3	22.9	22.9
Open or closed	Open (1st and 2nd quartile)	33 (100%)	39.4	36.4	24.2
	Closed (3rd and 4th quartile)	33 (100%)	54.5	36.4	9.1

Table 10. Determinants of Product Development Organizational Structure: Korea

Unit: %

		Number of respondents	Functional department	Project-based within functional department	Project-based across functional departments
Total		140 (100%)	51.4	36.4	12.1
Number of employees	Fewer than 300	38 (100%)	50.0	36.8	13.2
	300-499	34 (100%)	47.1	50.0	2.9
	500-999	40 (100%)	57.5	27.5	15.0
	1,000 or more	28 (100%)	50.0	32.1	17.9
Industry	Manufacturing	121 (100%)	52.9	35.5	11.6
	Machinery	73 (100%)	49.3	38.4	12.3
	Other than machinery	48 (100%)	58.3	31.3	10.4
	Software industry	19 (100%)	42.1	42.1	15.8
Make-to-order/Make-to-stock	Make-to-order (including OEM)	92 (100%)	52.2	38.0	9.8
	Make-to-stock	48 (100%)	50.0	33.3	16.7
Modular or integral	Modular (1st and 2nd quartile)	66 (100%)	57.6	28.8	13.6
	Integral (3rd and 4th quartile)	66 (100%)	45.5	42.4	12.1
Open or closed	Open (1st and 2nd quartile)	75 (100%)	53.3	30.7	16.0
	Closed (3rd and 4th quartile)	56 (100%)	53.6	41.1	5.4

Table 11. Determinants of Product Development Organizational Structure: China

Unit: %

		Number of respondents	Functional department	Project-based within functional department	Project-based across functional departments
Total		150 (100%)	77.3	18.7	4.0
Number of employees	Fewer than 300	11 (100%)	63.6	36.4	0.0
	300-499	99 (100%)	76.8	19.2	4.0
	500-999	25 (100%)	92.0	4.0	4.0
	1,000 or more	15 (100%)	66.7	26.7	6.7
Industry	Manufacturing	130 (100%)	79.2	16.2	4.6
	Machinery	31 (100%)	74.2	19.4	6.5
	Other than machinery	99 (100%)	80.8	15.2	4.0
	Software industry	20 (100%)	65.0	35.0	0.0
Make-to-order/Make-to-stock	Make-to-order (including OEM)	91 (100%)	72.5	20.9	6.6
	Make-to-stock	59 (100%)	84.7	15.3	0.0
Modular or integral	Modular (1st and 2nd quartile)	86 (100%)	82.6	15.1	2.3
	Integral (3rd and 4th quartile)	64 (100%)	70.3	23.4	6.3
Open or closed	Open (1st and 2nd quartile)	78 (100%)	80.8	16.7	2.6
	Closed (3rd and 4th quartile)	72 (100%)	73.6	20.8	5.6

Table 12. The Relationship Between Product Architecture and HR Management Practices: Japan

Unit: %

		No. of respondents	Modular		Integral		Average
			1st quartile	2nd quartile	3rd quartile	4th quartile	
Total		75 (100%)	32.0	18.7	30.7	18.7	41.5
HR system	Skill grade system	16 (100%)	43.8	25.0	12.5	18.8	35.0
	Role grade system	8 (100%)	37.5	25.0	25.0	12.5	35.0
	Job grade system	22 (100%)	31.8	9.1	40.9	18.2	43.0
	Combination of skill grade and role grade and/or job grade system	25 (100%)	24.0	20.0	32.0	24.0	47.6
Average age of engineers	Below 35 year	13 (100%)	30.8	15.4	38.5	15.4	41.2
	35-39 years	38 (100%)	26.3	26.3	31.6	15.8	40.3
	40 years and over	23 (100%)	43.5	8.7	21.7	26.1	43.5
Average number of years of engineers' employment with the firm	Less than 10 years	18 (100%)	38.9	27.8	22.2	11.1	36.1
	10 years and more and less than 15 years	33 (100%)	24.2	18.2	33.3	24.2	44.5
	15 years and more	23 (100%)	39.1	13.0	30.4	17.4	41.1
Hiring and training of engineers	Emphasis of internal training of new graduates	35 (100%)	31.4	22.9	34.3	11.4	38.9
	Internal training of new graduates and mid-career recruitment of persons with experience are of similar importance, or emphasis of mid-career recruitment of persons with experience	40 (100%)	32.5	15.0	27.5	25.0	43.9

Table 13. The Relationship Between Product Architecture and HR Management Practices: Korea

Unit: %

		No. of respondents	Modular		Integral		Average
			1st quartile	2nd quartile	3rd quartile	4th quartile	
Total		132 (100%)	27.3	22.7	27.3	22.7	47.6
HR system	Skill grade system	68 (100%)	26.5	25.0	23.5	25.0	47.5
	Job grade system	31 (100%)	22.6	12.9	32.3	32.3	54.2
	Skill and job grade system applied differently for managerial and non-managerial positions	33 (100%)	33.3	27.3	30.3	9.1	41.6
Average age of engineers	Below 35 year	36 (100%)	25.0	33.3	25.0	16.7	44.7
	35-39 years	61 (100%)	27.9	21.3	26.2	24.6	48.8
	40 years and over	32 (100%)	31.3	15.6	25.0	28.1	47.6
Average number of years of engineers' employment with the firm	Less than 10 years	83 (100%)	27.7	27.7	26.5	18.1	45.0
	10 years and more and less than 15 years	32 (100%)	31.3	9.4	21.9	37.5	52.9
	15 years and more	14 (100%)	21.4	28.6	28.6	21.4	48.5
Hiring and training of engineers	Emphasis of internal training of new graduates	61 (100%)	29.5	23.0	27.9	19.7	45.8
	Internal training of new graduates and mid-career recruitment of persons with experience are of similar importance, or emphasis of mid-career recruitment of persons with experience	71 (100%)	25.4	22.5	26.8	25.4	49.1

Table 14. The Relationship Between Product Architecture and HR Management Practices: China

Unit: %

		No. of respondents	Modular		Integral		Average
			1st quartile	2nd quartile	3rd quartile	4th quartile	
Total		150 (100%)	32.7	24.7	18.7	24.0	43.1
HR system	Skill grade system	37 (100%)	40.5	32.4	10.8	16.2	40.0
	Job grade system	70 (100%)	41.4	22.9	20.0	15.7	39.3
	Skill and job grade system applied differently for managerial and non-managerial positions	43 (100%)	11.6	20.9	23.3	44.2	52.1
Average age of engineers	Below 30 year	53 (100%)	20.8	30.2	20.8	28.3	45.9
	30-34 years	70 (100%)	42.9	18.6	17.1	21.4	41.1
	35 years and over	27 (100%)	29.6	29.6	18.5	22.2	43.0
Average number of years of engineers' employment with the firm	Less than 5 years	59 (100%)	39.0	22.0	15.3	23.7	41.9
	5-6 years	63 (100%)	28.6	27.0	20.6	23.8	43.8
	7 years and more	28 (100%)	28.6	25.0	21.4	25.0	44.3
Hiring and training of engineers	Emphasis of internal training of new graduates	12 (100%)	16.7	41.7	25.0	16.7	43.8
	Internal training of new graduates and mid-career recruitment of persons with experience are of similar importance	69 (100%)	33.3	21.7	18.8	26.1	44.1
	Emphasis of mid-career recruitment of persons with experience	69 (100%)	34.8	24.6	17.4	23.2	42.1