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Strategy Transformation Through Strategic Innovation Capability

Tomoatsu Shibata
Mitsuru Kodama

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Center for Data Science and Service Research
Graduate School of Economic and Management
Tohoku University
27-1 Kawauchi, Aobaku
Sendai 980-8576, JAPAN

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Tomoatsu Shibata, Ph.D.
Professor of Innovation Management,
Graduate School of Economics and Management,
Tohoku University

and

Mitsuru Kodama, Ph.D.
Professor of Information and Management,
College of Commerce and Graduate School of Business Administration,
Nihon University

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Abstract

This paper presents a theoretical framework under which large companies should be able to bring about strategy transformation. Firstly, we present the concept of “strategic innovation capability,” a corporate system capability to achieve corporate strategy transformation by strategic innovation. Then, we consider strategic innovation capability by comparing it to previous theories (dynamic capability, major innovation dynamic capability, breakthrough innovation capability). Secondly, we present the case example of strategy transformation at Fanuc, a company that holds the top global share in the numeric control (NC) market. In this case study research, we consider and analyze historically how the company aimed for new creativity in the NC market, developed innovative NC technology for the machine tool market, and using that technology energetically commercialized products. From the strategic innovation capability framework, the core theory of this paper, we also analyze and consider how top management made conscious efforts to form a new development organization within the company, and the processes involved in achieving strategy transformation to establish competitive superiority in this field. Finally, we discuss the implications drawn from this case analysis, and the issues for future research.

1. Radical innovation and strategic change

To acquire a competitive edge and sustain it over a long period, it is clearly important that companies constantly create new products, services, and business models (e.g., Jelinek and Schoonhoven, 1990; Morone, 1993; Markides, 2000). Creating and implementing new business models that radically transform conventional products and services and shake up existing business rules induces major strategic change in the historical flow of traditional large corporations. The major transformation of the mobile phone business with NTT DOCOMO's i-mode (e.g., Kodama, 2002; Peltokorpi, Nonaka and Kodama, 2007), Nintendo's DS/Wii game business, and Apple's U.S.-developed music distribution business are examples of the creation of the co-evolution model, which is a new value chain in the ICT industry.

A succession of academic research texts in recent years on radical (e.g., Leifer et al., 2000), breakthrough (e.g., Hargadon, 2003), discontinuous (e.g., Kaplan et al., 2003; Laurila, 1998), and disruptive (Christensen and Raynor, 2003) innovation has provided numerous examples of companies taking on challenges oriented to the strategic changes of exploring new markets and creating technologies, the accompanying difficulties, and the numerous reasons for success or failure. The conclusion is that acquiring the organizational capability to respond rapidly to environmental change, develop new technologies, and promote business development (e.g., Broen and Eisenhardt, 1997; Teece et al, 1997; Tushman and Anderson, 1986) is crucial.

Cases have been reported, however, of traditional large companies that were unable to respond well to environment change in numerous industries, including PC markets (Mitchell, 1989), digital photos (Tripsas and Gavetti, 2000), disc drives (Christensen and Bower, 1996), semiconductor exposure apparatus (Henderson and Clark, 1990), and watches (Glasmeter, 1991), and this significantly impacted their performance and chances of survival. The phenomenon is closely connected to the companies' strong dependence on routines that activate specific path-dependent core competences (Nelson and Winter, 1982; Teece, Pisano and Shuen, 1997). It means, moreover, that the more companies pursue effective business activities to promote the economic activities of expanding scale and scope, the more the existing core competences descend into core rigidities and competence traps, and the more they become unable to respond swiftly to major environmental change (Levinthal, 1991, 1997; Leonard-Barton, 1992; Levitt and March, 1988). Promoting efficient corporate activity restricts task diversity and reduces activities that induce employees to be independently creative (e.g., Sutcliffe, Sitkin, and Browning, 2000; Weick, 1995; Levitt and March, 1993).

In the past, a major source of competitiveness for traditional large corporations came from releasing new version product by exploiting path-dependent capability and incrementally improving existing products for existing markets (incremental innovation), thereby gaining profits. Meanwhile radical and breakthrough innovations were a new paradigm shift of new markets and technologies, giving rise to the dramatic expansion of product function, radical transformation of existing markets, creation of new markets, and major cost reductions (Leifer et al, 2000; O'Connor and Rice, 2001). These kinds of radical innovations leading to new breakthroughs differ substantially from the path-dependent incremental innovations in the past. To achieve radical innovation, a company requires new knowledge distinct from existing skills and expertise (e.g., Dewar et al., 1986; Ettilie et al, 1984; Green et al., 1995).

The reason is that companies and individual projects undertaking radical innovation face uncertainty and discontinuity in markets, technologies, organizations, and resources, and while some projects may be able to ride them out, many others are highly likely to stall or fail mid-way through (e.g., Leifer et. al, 2000). To acquire a radical innovation capability, a company needs different capabilities (including strategy, organization, resources, technology, processes, and leadership) to the practical management elements nurtured through incremental innovation (e.g., Kodama, 2003, 2007a; O'Reilley and Tushman, 2004; Vanhaverbeke and Peeters, 2005).

A large number of prior studies, mostly coming out of Europe and the U.S., looked at the strategic change process and organizational capabilities essential to achieving radical innovation. But many of these studies focused on empirical or proven cases studies of individual research and development or practical projects within companies of all sizes, or else single-item successes or failures from independent venture companies (e.g., Miles and Covin, 2002; Howell and Higgins, 1999; Kuratko, et al., 1990; Greene et al., 1999). Although this accumulated research is highly important, it is undeniable that companies also rely on the success of individual champion projects and the special capabilities of the heroes that implemented these projects. Thus with respect to the capability of large corporations that do not rely on the capabilities of specific individuals to systematically and continuously create radical innovation, research from the viewpoint of strategy and organization becomes increasingly important. Large corporations can deliver the slack to permit or promote the new routines of experimental and trial-and-error learning that startup venture companies find difficult to implement (Floyd and Wooldridge, 1999; Kogut and Zander, 1992). In the past, however, there is little theoretical or empirical research on large corporations that created continuous, systematic radical innovation, and research from the viewpoint of corporate or management systems to promote such innovation needs to progress (e.g., O'Connor, 2008).

Previous research has made several attempts at defining innovation. Henderson and Clark (1990) classified radical, architectural, modular, and incremental product innovation at the development level. Davila et al. (2005) classified mutual transformation of technology and business models as radical innovation, and transformation of either technology or business models as semi-radical innovation. Moreover, O'Reilley and Tushman (2004) used the term "radical" for innovation accompanying discontinuous change and "architectural" for innovation accompanying business process change. Garcia et al. (2002), moreover, uses "radical innovation" for actions causing simultaneous macro- and micro-level changes in markets and technologies, and defines other new product and service innovations as "really new innovation." Again, based on the classifications of Garcia et al. (2002), O'Connor (2008) uses the term "major innovation" for these radical and really new innovations excluding incremental innovations.

Thus the classification of innovation creating new values outside the range of incremental innovation differs from researcher to researcher. This paper seeks to avoid complexity by referring to incremental innovation as meaning the processes of small-scale improvement, such as minor changes to existing products and services (for example, minor improvements to existing technologies, excluding new technology elements) and business process efficiency improvement without major changes. In general terms, this is "strategic innovation" creating new value with regard to technologies and markets arising from new changes, but excluding incremental innovation (a meaning shared by all previous research), as mentioned by Davila et al. (2005), O'Reilley and Tushman (2004), and Garcia et al. (2002). We interpret "strategic innovation" as being almost identical in meaning to "major innovation" as mentioned by O'Connor (2008).

Therefore, strategic innovation involves the continuous strategic creation of new product, service, and business models to acquire long-term, sustainable, competitive excellence. It embraces the radical reform of conventional products and services and the creation of new business models that transform existing business rules. The meaning of "strategic innovation" as defined in this paper corresponds to the major innovations comprising the radical and really new innovations above with the meaning of strategically and continuously creating new products, services, and business models, while "incremental innovation" corresponds to version updates through small-scale improvement of existing products and services. Strategic innovation that strategically and continuously acquires new knowledge to create innovation becomes a key process whereby a company quickly establishes a position in new markets and technologies, which is also a factor for achieving "strategy transformation," the theme of this paper. Accordingly, the core framework of this paper, "strategic innovation capability," may also include the organizational capability to achieve this "strategy transformation" through strategic continuous innovation.

The structure of this paper is as follows. Firstly, the paper will present the concept of "strategic innovation capability" based on the literature review. Here, we would like to derive a basic framework for creating strategic innovation, taking in major companies as well as individual project organizations and independent venture companies. Then, will explain the meaning of strategic innovation and present the concept of "strategic innovation capability," which is the capability as a corporate system to realize a transition in corporate strategy through strategic innovation. Then we will compare this strategic innovation capability with the preceding theories of "dynamic capability" (Teece et al., 1997; Eisenhardt and Martine, 2000), "MI (major innovation) dynamic capability" focused on radical innovation (O'Connor, 2008), and "breakthrough innovation capability" (O'Connor, Leifer, Paulson and Peters, 2008).

Secondly we discuss the research methodology used with this paper. Thirdly, the paper aims to identify, from longitudinal qualitative research into the machine tool business by Fanuc in Japan over the past 56 years, a theoretical framework of "strategic innovation capability" that enables the corporation to establish an ongoing advantageous position in a rapidly changing environment. Lastly, we discuss the implications derived from this research, and future research issues.

2. Strategic Innovation Capability –Literature review and theoretical framework of the paper

2.1 What is strategic innovation?

Markides (1997) defined strategic innovation as the dynamic creation of creative strategic positioning from new products, services, and business models, and emphasized that this framework was a dynamic view of strategy by which a company established sustained competitive excellence. To achieve this, companies must not adhere to existing positioning (existing business), but must always innovate in ways that destroy this positioning. Moreover, Govindarajan et al. (2005) defined it as realizing strategically innovative new business models (including new products and services). This strategic innovation refers to business innovation that transforms established into new business and has a major impact on corporate performance. It is essentially different from the incremental innovation mentioned earlier.

Thus the strategic innovation mentioned by Markides (1997) and Govindarajan et al. (2005)

can be interpreted as having almost the same meaning as the definitions of the term in previous chapter. Strategic innovation, moreover, refers to the realization of strategic change in both the corporate system and in products, services, and business models. Describing the corporate capability, or the "strategic innovation capability," to achieve this kind of strategic innovation is the focus of this chapter. Next, we will consider this capability in relation to previous research on dynamic capability.

2.2 The capability map

The resource-based theories focused on independent capabilities for companies and organizations (e.g., Wernerfelt, 1984; Barney, 1991) have come to develop as strategy theory frameworks from the viewpoints of microeconomics and organizational economics. These resource-based theories and Porter's (1980) competition strategy theory enable a detailed analysis of strategic positioning and the relationship between competitive excellence and the internal resources already owned by companies in slowly changing environments and industries. However, it is difficult to analyze how companies in rapidly changing high-tech industries within competitive environments, such as the ICT and digital sectors, create new competitive excellence. Meanwhile, dynamic capability (Teece et al., 1997) is an attempt to build a dynamic theory on existing resource-based theories, and dynamically integrates and rebuilds competences inside and outside the company in response to environmental change. The word "capability" refers to business processes for integrating and rebuilding assets inside and outside the company for the purpose of competitive excellence. Dynamic capability becomes the process of improving existing routine capabilities for transforming and exploiting existing corporate assets in response to a changing environment (e.g., Zollo and Winter, 2002; Winter, 2003). Process management of existing routines and operations contributes to the incremental innovation of existing business (Benner and Tushman, 2003).

Companies apply dynamic capability and systematically and analytically formulate and implement strategies under relatively stable or slow-moving conditions with little business uncertainty. "Learning before doing" (Pisano, 1994), that is, formulate and implement detailed strategy planning and policies, is a key element of this dynamic capability in market structures with clear corporate boundaries and also can grasp the players in value chains.

Later on, a number of researchers amended and reinterpreted their views of dynamic capability. The most relevant was Eisenhardt and Martine (2000), who made adjustments for tautology problems relating to the interpretation of capability, and presented clear interpretations of the relationship between dynamic capability and competitive excellence. They indicated that dynamic capability is the strategic and organizational processes and the routines of companies that use (integrate, reallocate, acquire, and eliminate) internal and external resources in order to respond to, or create, market change, and inductively derived concepts of corporate dynamic capability essential in both slow- and fast-moving market environments. They suggested the importance of "learning by doing" with simple rules to emphasize results rather than prior training and implementation processes, especially in fast-moving environments, where uncertainty rises and an industry's corporate borders become vague (Eisenhardt and Sull, 2001).

This interest in strategy theory has evolved toward a dynamic structure that reflects current corporate activity. Furthermore, O'Connor (2008) respects the dynamic capability theory of Eisenhardt and Martine (2000), and mentions that a large number of major innovations (corresponding to strategic innovations), including the radical innovations mentioned above, developed gradually from slow (or very slow) market environments, and were implemented over a period of several years to several decades. Thus the concept of dynamic capability is described as a theory that can be evaluated and applied around the axes of both market speed and business uncertainty (including risk) characterized by strategic innovation.

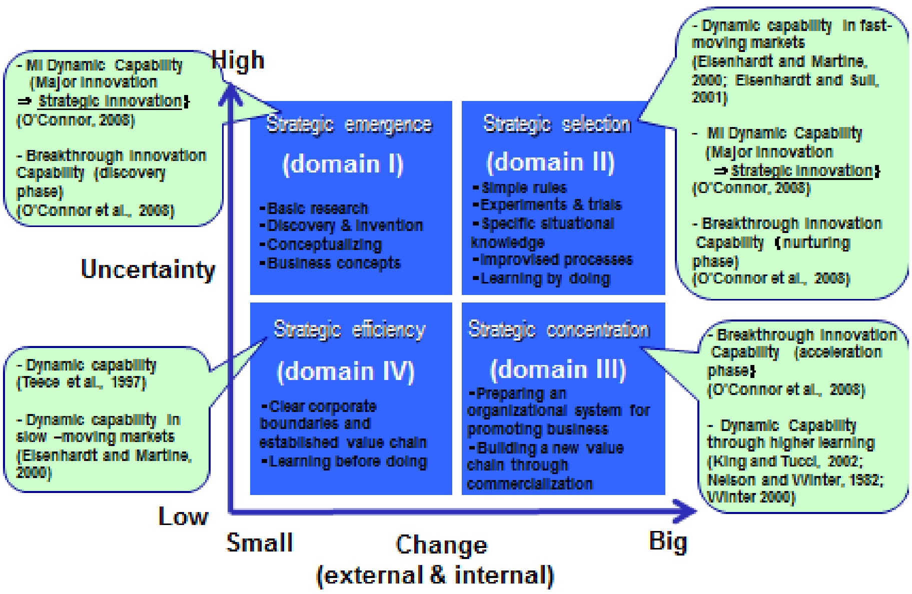
O'Connor (2008) used the term "MI dynamic capability" for capability that promotes the "exploration" process (March 1991) and realizes strategic innovation under conditions of uncertainty and high risk. MI dynamic capability differs from the dynamic capability theory that emphasizes the evolution of the original "exploitation" (March 1991) activity process. MI dynamic capability responds to highly uncertain situations, regardless of the speed of market movement, and embraces the concept of dynamic capability in the high-speed markets (also including high uncertainty) mentioned by Eisenhardt and Martine (2000).

Realistically speaking, many strategic innovations are established through the stages of discovery or invention from slow- and very slow-moving basic scientific research and technological development environments. Later, the developed core technologies and provisional business models based on discovered or invented ideas are adopted and exploited in products and services through improvisation and trial-and-error processes (including the weeding-out process) involving trial manufacture, experiment, and incubation. Product and service markets are gradually established. Then the new products and services anticipated or forecast for the growth markets become the competitive markets for other companies (just when other companies enter the market depends on individual business). The market environment becomes fast-moving, and companies accelerate their investment in necessary resources.

O'Connor and DeMartino (2006) undertook long-term observation and analysis of radical innovation in major U.S. corporations, and indicated the importance of three-phase management (discover, incubation, and acceleration) as a radical innovation (corresponding to strategic innovation) development framework. They then named the ability to implement these processes the "breakthrough innovation capability," and suggested that building this capability into the company is a key management system leading to successful radical innovation (O'Connor, Leifer, Paulson and Peters, 2008).

Previous research, such as dynamic capability and MI innovation capability positioned around the two axes of uncertainty and change led to the situation illustrated in Figure 1's capability map, which shows the relationship between those previous researches and the three development phases of O'Connor and DeMartino (2006), mentioned above. Here, strategic uncertainty beyond the four elements of markets, technology, organization, and resources mentioned by Leifer et al. (2000) also exists, and change is not limited to the external elements of market speed and industrial technology speeds, but also corresponds to the internal elements of a company's own strategy, organizational revamping, and concentration of resources.[1]

Figure 1 Capability Map



Slow or very slow environmental change with a highly uncertain domain (domain I) observed at the initial stage of strategic innovation is the technology creation stage arising from new ideas, business concepts, discoveries, and invention, and corresponds to the "discovery phase" of O'Connor and DeMartino (2006). In this domain, the exploration process is advanced through the MI dynamic (or breakthrough innovation) capability mentioned above. The basic research and creation of ideas that are the source of new strategic innovation require (depending on the field) a longer period of time as the ratio of the scientific element and the degree of technological difficulty rises. The success of this domain relies greatly on the creative thinking and action of middle managers and lower-ranked staff in a company's R&D and business development divisions, but strategic participation and commitment from top and senior management is also great. We call this domain "strategic emergence."

Next, the core technologies and business concepts that migrate from the slow-moving environment of domain I, with rapidly changing of the in-house (or occasionally external) acquisition of human resources and the maintenance and upgrading of organizations oriented to business incubation to a dramatically transforming domain II environment that sustains speed of change and uncertainty. In this domain, the exploration processes arising from dynamic capability (MI dynamic or breakthrough innovation) based on the simple rules mentioned by Eisenhardt and Martine (2000) and O'Connor (2008) are promoted. This domain corresponds to the incubation phase of hypothetical setups, experiments, and assessments mentioned by O'Connor and DeMartino (2006). Learning through trials and experiments also leads to less risk and uncertainty of markets and technologies and greater probability of success for incubations aimed at realizing strategic innovation (O'Connor et al., 2008).[2] Then top and middle management make decisions aimed at selecting and bringing to market the rigorously tested and evaluated product, service, and business models.

O'Connor et al. (2008) confines this incubation domain to trial experiment and assessment models, but in many cases current business activities go beyond trial experiments within the coexistence of uncertainty and dramatically changing, fast-moving environments to the launch of commercial businesses, where companies may boldly undertake risky cases with a high degree of uncertainty. In this domain, numerous cases arise where the excessive trust and commitment of the leaders and managers lead to strategic activities, based on the creation of business through trial-and-error, while it is still unclear whether the newly developed ideas and prototypes are capable of building new business models and value chains.[3] These correspond to the cases in the new online business world where products are both trialed and launched in dramatically changing domains of general high risk and uncertainty. A key point is how to select and implement promising, valuable business. We call this domain "strategic selection."

Then the new businesses (including new products and services) chosen through strategic selection in domain II to have prospects for the future and somewhat reduced uncertainty shift to domain III, where uncertainty is reduced to some extent while external (environmental) and internal change is sustained. Domain III is the stage where the strategic innovation incubated (or partially commercialized) in domain II enters a growth orbit, and corresponds to the "acceleration phase" mentioned by O'Connor and DeMartino (2006). According to O'Connor et al. (2008), this is where the exploitation process is promoted by breakthrough innovation capability. This domain achieves the building and optimization of processes and value chains for the selected new businesses. Then new business functions are wholly or partially transferred to the business divisions appropriate to accelerate commercialization (or else new business divisions are newly established, or made independent as external ventures), and further resources are intensively invested through the strategic commitment of top and middle management. We will call this domain "strategic concentration." In the past, a large number of product and service development projects for major corporations (e.g. Kodama, 2005; 2007d) invested management resources in commercialization through this kind of shift from strategic selection to strategic concentration.

Meanwhile, with the concept of the "strategic innovation loop" (see the next section), companies operating in the strategic concentration domain must strategically and sustainably advance technology and review business models to enhance the value of products and services, and respond to a fast-changing competitive environment. To achieve this, companies must commercialize by shifting new business from domain I through II to III, where a new, constantly updated knowledge integration process appears through new businesses that have migrated from the strategic selection domain and comprehensive upgrades of existing products and services arising from new technological development elements and business models.

This domain III can be interpreted as a capability that should embrace the notion of inherent dynamic capability promoting incremental innovation, perform strongly in response to internal and external change to create profits by evolving and diversifying operating routines through high-level learning (King and Tucci, 2002; Benner and Tushman, 2003; Winter, 2000; Amburgey, 1993; Nelson and Winter, 1982).

Meanwhile, a great deal of existing business is positioned in domain IV, in slow-moving market environments with low uncertainty and a low rate of change. Here, incremental innovation is promoted with the aim of systematically enhancing business efficiency through the exploitation process, which comprises activities to improve existing business using mainstream organizations that demonstrate inherent dynamic capability (Teece et al., 1997; Eisenhardt and

Martine, 2000). Promoting this domain IV process management accelerates an organization's speed of response to achieve incremental innovation (Benner and Tushman, 2003). We call this domain "strategic efficiency."

We would like to consider strategic innovation capability frameworks to sustainably achieve strategic innovation (the main theme of this paper) based on the capability map that comprise these four domains.

2.3 The strategic innovation loop and strategic innovation capability

When considered from the viewpoints of corporate exploration and exploitation processes, strategic and incremental innovation, and the time axis of business contexts, the four domains forms a continuous domain loop (see Figure 2). The strategic emergence and selection domains, which are exploratory processes, are the core processes for strategic innovation processes. "Strategic concentration" is the acceleration phase indicated by O'Connor and DeMartino (2006). This phase rapidly sets up new product, service, and business model markets through the exploratory processes of strategic emergence and selection, and shifts the domain from exploration to exploitation. Strategic concentration becomes the origin of a new path of newly generated strategic innovation that differs from the existing business of the strategic efficiency domain.

In this strategic concentration domain, newly generated business always undergoes major internal or external change in its initial phase. At this stage, it transforms internal elements aimed at building optimal value and supply chains in response to external change. Among these strategic concentration businesses, which are subject to major change, businesses that succeed in establishing themselves in the market and achieving stability as mainstream operations shift to slow-moving (or small) "strategic efficiency" domain while promoting still greater operational and business process efficiency measures, and either become part of the existing mainstream lineup or undergo business integration (which promotes still greater business process efficiency).

However, businesses subject to major external change of markets and technologies following mainstream growth, and major internal changes in areas such as strategy, organization, resources, and operations (for example, ICT industry involving broadband and mobile phones, on-line businesses, and digital consumer electronics) always become positioned in this strategic concentration domain. Put another way, businesses growing in a mainstream direction become deployed in one or both of the strategic concentration and efficiency domains. Although new business in the strategic concentration domain is the "mainstream reserve," this does not mean that all business can grow in a mainstream environment subject to major changes, and some businesses have to withdraw. This is especially true of the ICT industry.

In this way, the flow of strategic innovation for major corporations shifts from domains I to domain II, then domain III (where some businesses undergoing major changes maintain their position), and finally to domain IV (see Figure 2). Amid this movement, existing business in the strategic efficiency domain may become the target for new/old business conversion with the new path of strategic concentration business (or business that shifts from strategic concentration to strategic efficiency domains) arising from strategic innovation. The simultaneous management of existing positions and new strategic positions mentioned by Markides (2001) involves co-establishing in domains III and IV. Transferring from old to new positions involves transferring existing business in domain IV to accelerated, expanded new business in domain III.

Realistically, however, although major corporations promote various strategically innovative projects, only some of them survive to become success stories after the natural selection process involved in the shift from domains I to III. Amabile & Khaire (2008) note a number of cases where outstanding ideas and business models born in domain I have been diluted and ended in failure after a major corporation employs a different managing organization to realize (commercialize) them.[4] This is one issue surrounding strategic innovation in a major corporation.

The most important inter-domain shift is that from III and/or IV to I. This is the path that creates new strategic innovation (see Figure 2). It corresponds to the process that accelerates environmental and internal interaction and creates new ideas and new technological inventions and discoveries based on high-quality tacit knowledge (Nonaka and Takeuchi, 1995). This knowledge is cultivated through the practice of researchers, engineers, marketers, and strategy specialists in shifting from domains I through IV (accumulating and integrating new practice through existing business practice and strategic innovation) via the "transformational experience" (King and Tucci, 2002; Amburgey et al., 1993) of previously existing business routines and strategic innovation (e.g., Kodama, 2007a). King and Tucci (2002) suggested that the "transformational experience" of practitioners involved in the continual (Katz and Allen, 1982) and large-scale (Tushman and Romanelli, 1985; Amburgey, 1993) organizational innovation of product development teams leads to continuous new product innovation and resets rigid organizational inertia. Put another way, it enhances potential for embedding new capabilities in organization members aimed at creating new routines to transform organizations and realizing strategic innovation.

Although excessive adherence to existing knowledge to create new knowledge integration becomes a hindrance, the absorption of knowledge from different sectors and industries from a scientific, technological, and marketing viewpoint and the knowledge integration process can trigger new strategic innovations (the i-mode business development correspond to this)(Kodama, 2002, 2009). Various innovation theories including the importance of shedding the "mental model" (e.g., Spender, 1990), the focus on "peripheral vision" (Schemaker, 2004) and "boundary vision"(Kodama, 2011), and the challenge of achieving "cross innovation" (Johansson, 2004), and "destructive innovation" (Christensen, 1997) confer precious insights as regards innovators, but more detailed theory building is yet to be undertaken. We consider, as a proposition, that the evolution and diversification of high-level routines through advanced learning in domains III and IV fundamentally promotes sustainable innovation (Christensen, 1997) while inducing a shift from domains III and/or IV to I arising from the sustainable innovation of integrating new knowledge inside and outside the company (Kodama, 2009), and raising the probability of achieving new knowledge integration as a strategic innovation.[5]

We would like to explain the following three new insights obtained from this framework, and use them as a basis for explaining the "strategic innovation capability." The first point is that outstanding companies possessing the dynamic strategic view deliberately (including some emergent elements) drive loops comprising continuous shifts among domains (termed "strategic innovation loops" in this paper [see Figure 2]) from domains I through IV and/or from domain III to I. The dynamic strategy view co-establishes the different modes of the exploratory and exploitative processes and secures long-term corporate growth (e.g., March, 1996; Benner and Tushman, 2003; Tushman and O'Reilley, 1997). These two processes (March, 1991; Holland, 1975) do not employ opposing strategic activities; rather, companies must implement strategy while skillfully balancing the strategic activities in a mutually complementary way (He and Wong, 2004).

Meanwhile, Zollo and Winter (2002) propose a knowledge evolution process based on adjusted evolutionary theory. The continuous routine activity well-considered within this process can become a trigger to shift from the exploitation to the exploration process, and experiential knowledge accumulated from learning activities also becomes an element in creating new dynamic capability (corresponding to a shift from domain IV and/or domain III to domain I). The authors explain how the recursive processes and co-evolution of these different modes simultaneously promote corporate challenges and processes (routines).

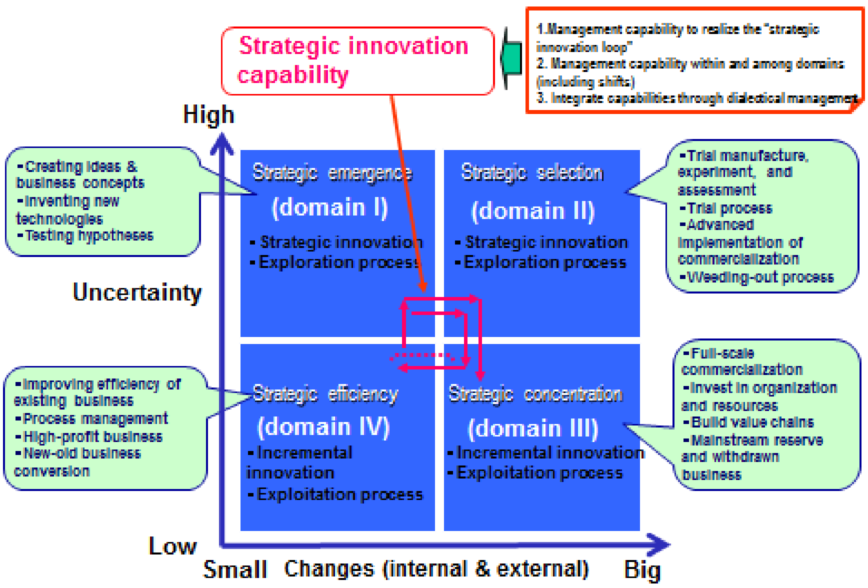
The second point is that observing large corporations at selected times on a time axis indicates the constant presence of each of the domains I to IV possessing different business contexts. With large corporations, multiple projects oriented to strategic innovation function as layered strategic innovation loops on different time axes. Top and middle management must therefore manage appropriately within and among these domains. Management to smoothly implement the domain shift through the strategic innovation loop is also key. Different strategies, organizational structures, core competences, organizational cultures, and leadership are required within each of these domains. An especially important question is how the skills and expertise that create the strategic emergence, which is the new discovery and invention domain, from accumulated experiential knowledge (which arises from diverse high-level routines through transformational experience via the continuous strategic innovation loop [Amburgey et al., 1993; Nelson and Winter, 1982; Winter, 2000]) and absorb and integrate new knowledge outside the company can be created by the knowledge integration process. Moreover, O`Connor and DeMartino (2006) indicate the importance of the relationship between organizational structure and radical innovation capability with regard to the radical innovation development framework of major corporations moving from discovery, to cultivation, to acceleration (corresponding to domains I to III, respectively), and note that a new research area is opening into this topic.

Point three is that analysis of the Fanuc case studies in this paper suggests that the exploration and exploitation processes are especially interactive. It has been argued that organizations within major corporations undertaking radical innovation should either be isolated both physically and organizationally from the mainstream organization, or else operate as independent venture companies (e.g., Hill and Rothaermel, 2003; Benner and Tushman, 2003; Burgelman and Sayles, 1986; Kanter, 1985). But an appropriate interface with existing organizations is also potentially significant for accelerating strategic innovation from the viewpoint of strategy and resource integration (e.g., Heller, 1999; Kodama, 2003). Questions of organizational design (How much should a strategic innovation business integrate with, or separate from, existing businesses? Is it better to have complete separation, complete integration, or something in between?) (e.g., Christensen, 1997; Burgelman and Leonard, 1986; Good and Campbell, 2002; Tushman and O'Reilley, 1997) are arguably more important in achieving strategic innovation.

Much of the previous research discussed management processes and organizations division, such as two distinct archetypes-exploratory and exploitative, or incremental or radical (e.g., Greenwood and Hinings, 1993; Tushman and O'Reilley, 1997) and the ambidextrous organization (e.g., O'Reilley and Tushman, 2004). Little detailed analysis has appeared, however, of the interfaces and interaction among management elements such as strategy, organizational structure, core competence, organizational culture, and leadership, each of which differ for each of these two archetypes (e.g., Kodama, 2003; Kodama, 2007a). Nevertheless, the co-establishment and coexistence of these two archetypes within the same large corporation, and the skillful management of strategic contradiction (Smith and Tushman, 2005), creative abrasion (Leonard-Barton, 1995), and productive friction (Hagel III and Brown, 2005) to create synergies are also important elements of successful strategic innovation. The coexistence of contradictions highlights the important roles not just of the top management (Smith and Tushman, 2005; Tushman and O'Reilley, 1997), but also of middle management and staff (Govindarajan et al., 2005). We call this "dialectical management" (Kodama, 2004; Kodama, 2007a).

Based on the three insights above, strategic innovation capability is a concept that embraces the following three competences: the management capability to implement the spiral strategic innovation loop; management capability within and among domains, including shifts; and integrative competences to achieve the coexistence of two different archetypes through dialectic management (see Figure 2). Moreover, strategic innovation capability embraces the existing dynamic and MI dynamic capability (or breakthrough innovation capability) concepts mapped in Figure 1 while aiming to expand the concept of organizational capability for individual product development projects at large corporations and venture companies in the direction of innovation capability for the corporate or management system. This paper calls the kind of management system that uses strategic innovation capability to activate the spiral of the strategic innovation loop, and continuously co-establishes existing business with strategic innovation business the "strategic innovation system"[6] (see Figure 2).

Figure 2 Strategic innovation system



3. Data and Method

We adopted a qualitative research methodology due to the need for rich data that could facilitate the generation of theoretical categories we could not derive satisfactorily from existing theory. In particular, due to the exploratory nature of this research and our interest in identifying the main people, events, activities and influences that affect the progress of innovation, We selected the grounded theory-based study of data interpretation, which was blended with the case study design and with ethnographic approaches (Locke, 2001).

The research data came primarily from longitudinal study during around 30-year period (1983-2013) examining new knowledge convergence process with respect to new products, services and business development at a large company in competitive high-tech fields. This research paradigm, which was based on in-depth qualitative study, has some similarity to ethnography(Atkinson and Hammersley, 1994) and other forms of research(Lalle, 2003) that derive their theoretical insights from naturally occurring data including interviews or questionnaires (Marshall & Rossman, 1989). Especially, one of the authors of this paper himself serves as a manager of new product development in Fanuc (1983-1994), Japan's largest company. This experience provided the author with direct knowledge and detailed information with which the accuracy of the empirical analyses in this research was enhanced. Research data and insight are gained alongside or on the back of the intervention.

The data collected over the thirty years of the intervention have derived from work with practitioners involved in a large number and variety of customers and outside partner as well as internal organization members. During these interventions, the expressed experiences, views, action-centered dilemmas, and actual actions of participants were recorded as research data in a variety of ways, including notes, internal and outside rich documents, etc. The theory that has emerged from this research has centered on the concepts of "strategic innovation capability".

The data analysis for the research consisted of three stages: 1) developing in-depth case history of a big project's activities from the raw data that We could gain all the information, 2) open coding and subsequent selective coding the in-depth case history for the characteristics and origin of "strategy transformation process", and 3) analyzing the pattern of relationships among the conceptual categories.

In the first stage of the data analysis, we constructed chronological descriptions of the company's activities with respect to strategy transformation process, describing how it came about, when it happened, who was involved, and major outcomes. Through this work, we completed an in-depth case history of the company.

The second stage of analysis involved coding the in-depth case history with respect to its characteristics, origin and effects. This was a highly iterative procedure that involved moving between the in-depth case history, existing theory, and the raw data (Glaser and Strauss, 1967). Data were subjected to continuous, cyclical, evolving interpretation and reinterpretation that allow patterns to emerge.

The grounded theory approach was adopted based upon the researchers' interpretation and description of phenomena based on the actors' subjective descriptions and interpretations of their experiences in a setting (Locke, 2001). This "interpretation of an interpretation" strives to provide contextual relevance (Silverman, 2000). From the in-depth case history, we initially advanced first-order descriptions based on broad categories that were developed from the existing theory, and then refined these categories by tracing patterns and consistencies (Strauss, 1987). The analysis continued with this interplay between the data and the emerging patterns until the patterns were refined into conceptual categories (Eisenhardt, 1989). The third stage of data analysis was to examine the empirical in-depth case results across the selected categories and the theoretical literature, and to develop the logic of the conceptual framework and generate new theory.

Based on the data obtained from field studies, the authors first produced an in-depth case concerning the company. Next, based on this study, they performed analyses and observations from the viewpoint of strategy transformation and strategic innovation capability, etc.. Various scholars (Eisenhardt, 1989; Pettgrew, 1990; Tin, 1994) have discussed the validity of case studies. Case studies make it possible to explain the relevance and cause-and-effect relationships of a variety of observations through deep and detailed insights with consideration given to qualitative information and subjectivity resulting from the peculiarities of individual cases and the difficulties of general analyses. Case studies not only compensate for the weaknesses of generalities but are also indispensable in new, creative theorization.

4. In-depth longitudinal case study of Fanuc[7]

In this chapter, regarding the historical processes that enabled Fanuc, a company born as a venture within Fujitsu, to grow to become the world's leading factory automation (FA) company, and the innovation process mechanisms in that growth process, the paper presents and analyzes the in-depth case study of Fanuc’s strategy transformation based on the concept of “strategic innovation capability”, which is a corporate system capability for companies to achieve strategic change through strategic innovation mentioned in chapter 2. It then suggests the mechanisms by which Fanuc acquired strategic innovation capability, showing how it implemented spiral strategic innovation loops and dialectical management at each stage of past, present, and future innovation processes.

4.1. Overview of Fanuc and the machine tool industry

After 1982, the Japanese machine tool industry was proud to become the most productive in the world with extremely high international competitiveness. The significance of that achievement was not just simply the superior competitiveness in the industry itself, but the strategic characteristics of machine tools as industrial goods. Machine tools are often referred to as “mother machines” because they are machines that create other consumer goods such as automobiles and electrical appliances. Accordingly, competitiveness in the machine tool industry is intimately tied in with the competitiveness of other entire manufacturing industries. For example, The “Made in America” report from the MIT Commission on Industrial Productivity survey states the following: (Dertouzos, 1990)

“NC and NC machine tools give businesses the flexibility and automation needed to provide small amounts of, and a wide range of parts for the automotive, electronics and machine industries etc., just-in-time.”

The Japanese machine tool industry came to have such competitiveness because it was underpinned by the superior functionality of its NC machine tools, i.e., machine tools controlled with NC (Numerical Control) devices. In Japan, compared to Germany or America, the share of NC-type cutting machine tools was extremely large in the cutting machine market, and one of the chief factors that enabled Japan to produce many superior NC machine tools was NC system supplier Fanuc. Japanese machine tool manufacturers left the design and production of NC systems completely up to Fanuc, which enabled them to pour their efforts into innovating the machine tool technology itself. Regarding this, previously cited report states the following.

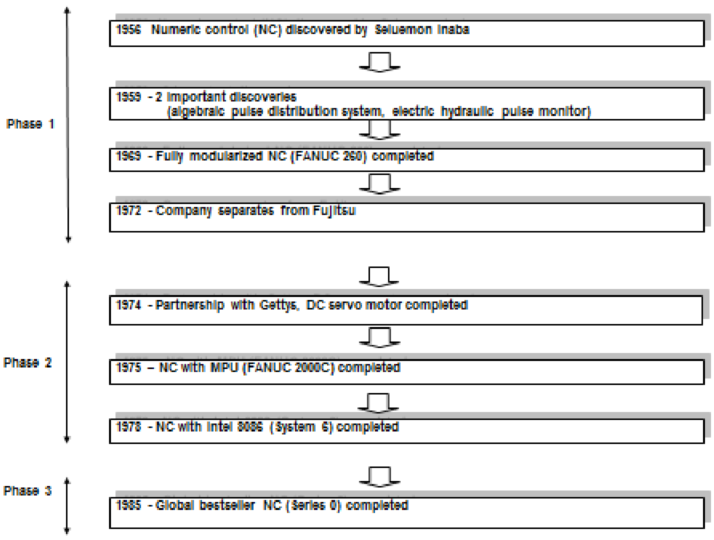
“NC design and production for NC machine tools in Japan is all done by Fanuc, a single company. This is not so that Japan can gain an economic advantage of scale, but to solve the problem of compatibility that has troubled American machine tool users.

Since gaining independence from Fujitsu in 1972, to date Fanuc has achieved close to 50% of the global market share, and has sustained an extremely high business profitability of around 30%. At the same time, the company has proactively proceeded with its global business development engaging in 50-50 joint ventures with major global companies such as GE and GM. GE Fanuc was established in 1986 as a full-equality joint-venture to develop computer numerical control (CNC) and program logic control (PLC), while GM Fanuc was established in 1982 as a full-equality joint-venture involved with robotics.

4.2 Tracing the growth of Fanuc

It's possible to conceptualize Fanuc's growth as 3 historical phases (see Figure 3). Phase 1, from 1956 to 1972, is the phase beginning with the company's inauguration as a venture within Fujitsu to its separation from Fujitsu to become independent. Phase 2 corresponds to the successful technological transformations the company achieved with implementation of DC servo motors and microprocessors, leading to the establishment of its present-day technological systems. This meant the establishment of an NC dominant design (Anderson and Tushman, 1990) corresponding to the period up to 1980. Phase 3 is then the following period of dramatic market expansion in which the company built strategic partnerships with GE and GM, and brought about bestselling NC technology. Following, we described each phase of Fanuc's strategy transformation in sequence.

Figure 3 Stages of Growth at Fanuc



4.2.1. Phase 1 (1956 to 1972)

(1) Creation of an internal venture business

To understand Fanuc's history, we have to look back as far as 1956. Technical director at Fujitsu at the time, Hanzo Omi, made the decision to break into the new field beyond communications of computers and controllers, and appointed Toshio Ikeda and Seiuemon Inaba as those respective project leaders. At the time, Fujitsu was only involved in communications equipment, and Ikeda and Inaba were simply instructed to find out what could be done in those fields.

However, there were many options for control related technologies, and the NC development theme eventually put forth by Inaba was not a simple discovery. In particular, Inaba, a mechanical engineer who had graduated from the school of precision engineering at Tokyo University, had to search for a field dealing with machine controllers that was not the same as the process control field which already had an established market at the time. In the midst of trial and error in which a development theme had been difficult to determine, Inaba suddenly discovered the NC theme when looking at a copy of the MIT report (Dertouzos, 1990).

The first time that Inaba had heard of the MIT report was in October of 1956 at a conference held on automatic control at Waseda University. At the conference, the then California University Professor, Yasuto Takahashi, showed Inaba a copy of the Scientific American featuring an article about NC milling machines. Inaba said the following about his sentiments when he first saw the MIT report.

"Since my roots are in the mechanical engineering, I remember a sense of strong interest in servo mechanisms the moment I first heard about the MIT report, and I immediately got consent from my boss, Director Omi, to set the R&D theme as NC for the machine control team.…Then, the MIT report introduced to me by Professor Yasuto Takahashi became like a bible for our research for sometime… (abbreviated)… because my roots are in mechanical engineering, it was around 1952, that I began to think about what was missing from mechanics, and I was introduced to a new machine tool development, which was the Cincinnati Milacron Hydrotel modified for computer control. When I heard about it, I was extremely interested, and I studied the MIT report which has been lent to me on microfilm by automatic control engineering Professor Takahashi, who was serving at California University at the time[8]."

In this way, Inaba discovered the new field of NC, finished his trial-and-error efforts to find out what could be done, and went on to execute a new business strategy. At that time, Inaba's development project team was a completely separate organization within Fujitsu from the company's existing communications equipment departments, and top management at Fujitsu had given the team a certain level of autonomy and freedom. This organizational system that Fujitsu had adopted at the time was highly similar to the "ambidextrous organizations" identified in previous research (e.g., Tushman and O'Reilley, 1997), in which routine business interaction between new and existing organizations is highly controlled, but where both organizations are overseen by higher management.

(2) The invention of the algebraic electric hydraulic pulse motor

Numeric control began at the Fujitsu Nakahara Factory laboratory with a project team consisting of four or five engineers from both the electric and mechanical fields. At the time, Inaba, a team leader who had only just reached his 30s, pushed forward with development. Thus, the beginning of the project in 1956 corresponds to the domain I "strategic emergence" phase in Figure 4. The first prototype was then achieved in 1957. As previously stated, the critical areas in NC are the computing and servo mechanisms. This prototype adopted a new element called the Parametron invented by Eiichi Goto of Tokyo University, and was an NC system that employed electric servo motors for its servo mechanisms[9].

In 1958, Makino Milling Machine Co and Fujitsu jointly exhibited an NC milling machine at the Osaka International Trade Fair, however it wasn't a machine that could withstand practical application. Then in 1959, Hitachi Seiki and Fujitsu delivered an NC milling machine to Mitsubishi Heavy Industries' Nagoya Aircraft Works. This could have been said to be the first commercialized NC product, but it had a problem in that it blew an average of 1 electronic vacuum tube every day.

In this trial-and-error process, Inaba brought together his own knowledge of mechanical engineering, and Fujitsu's know-how about digital circuitry with the knowledge in the MIT report, and through repeated prototyping experiments with NC machine tools, all of this knowledge accumulated and became embodied as the tacit knowledge of the Inaba team. This stage triggered a shift from the accumulation of Fujitsu's existing communications equipment know-how in domains III and/or IV (core technologies of exchange equipment and transmission devices) back to domain I.

All of this came to fruition with the following epoch-making invention. In 1959, Inaba and his team invented the revolutionary “algebraic pulse distribution system” and the “electric hydraulic pulse motor.” These two technological innovations enabled dramatic improvement in NC performance which was recognized both in Japan and internationally with a number of awards. The organization responsible for this invention was the project team in Fujitsu that the company referred to as “Inaba’s NC Brigade” or the “Inaba Family.” The algebraic pulse distribution system was brought about through joint University-commercial research. Inaba said the following:

“Aiming for devices that can be put to practical use, we would like to produce stability and reliability in both the circuitry and the servos. We were fortunate to have been greatly inspired by electrical engineering Assistant professor Tatsu Motooka of Tokyo University Engineering Department, and his assistant, currently Tokyo University Institute of Industrial Science Professor Kusuo Yamaguchi. We dispatched an engineer from the Automatic Control Department as it was called at the time, which effectively became the brains of the development from where we received guidance[10].”

As a result of this joint research, the invention of the “algebraic pulse distribution circuit” - technology that could calculate the combinations of arcs and straight lines that make up the forms of mechanical parts - came into being. Since its establishment, Fanuc has been extremely proactive in bringing in knowledge from universities in this way.

Fanuc's adoption of open loop electric/hydraulic pulse motors was directly opposite to the closed-loop DC motors adopted in the United States[11]. Electric hydraulic pulse motors consist of an electric pulse motor and a hydraulic servo, in which the output from the electric pulse motor is amplified by hydraulics enabling significant power. Later on, when Fanuc was established, this technology was invented and patented by Inaba himself as the first president of the new company, although he got the idea from the automatic exchange equipment that were being built by Fujitsu at the time. Inaba reminisced on those times as follows:

“I couldn't ask the professors about the servo, so I had to think up something myself, but then I recalled the automatic exchange equipment that Fujitsu had been manufacturing[12].”

From that idea, Inaba imagined driving a motor by inputting pulses, and went on to prototype the electric pulse motor. However, this pulse motor alone was unsatisfactory in that was not able to deliver much torque, so Inaba imagined amplifying the torque by combining the pulse motor with a hydraulic motor. This was the bones of Inaba’s invention. It was the knowledge he had gained from the Tokyo University School of Precision Engineering that was behind Inaba’s idea of amplifying power using hydraulics. Inaba commented as follows:

“The school of precision engineering from which I graduated was known as the school of armory before the war, and as the name suggests, it was artillery that I studied. The gun turrets on warships were driven by hydraulic motors. Using these hydraulic motors with NC servo mechanisms, I tried controlling flow with the electric pulse motor[13].

As described above, Inaba did not only start out with closed innovation R&D initiatives in an organization within Fujitsu, but also made concerted efforts to bring in technical know-how from outside the company (Tokyo University and the MIT report) and thus promoted open innovation (Chesbrough, 2003), which can be interpreted as significant.

We site page 79 of O'Connor (2006) “radical innovation must be open innovation.” This claim is based on case studies of American companies in which radical innovation has been promoted by open innovation concepts. At the time, the technical development strategy of Inaba’s project was close to this idea. In short, he achieved the first NC system by integrating the different technologies of Fujitsu's communication equipment technical know-how (digital circuitry technologies and so forth), with technology from Tokyo University and the MIT report. Open innovation is an enabler that raises the potential for the creation of new strategic innovation in the shift from domains III and/or IV back to domain I, as shown in Figures 2 and 3.

(3) Creating the NC market

In 1959, through the process of prototyping, experimenting and assessing the 2 inventions, the NC development process shifted from the domain I “strategic emergence” phase to the domain II “strategic selection” phase. In phase 2, the performance of NC was dramatically improved, however market demand did not increase with such speed and the uncertainty of the business became more pronounced. In fact, it was not until 1965 that the NC Department got their finances into the black. In other words, it took nine years from Inaba’s discovery of the NC field in 1956 until the NC business turned a profit, but from then on, Fanuc's shipments of NC products rose dramatically from 388 units in 1965, 483 units in 1968, 1184 units in 1969, to 1684 units in 1970. With the two inventions in 1959, the standard had already been set for NC performance and stability to meet the demands of practical application. Inaba said the following the circumstances at the time:

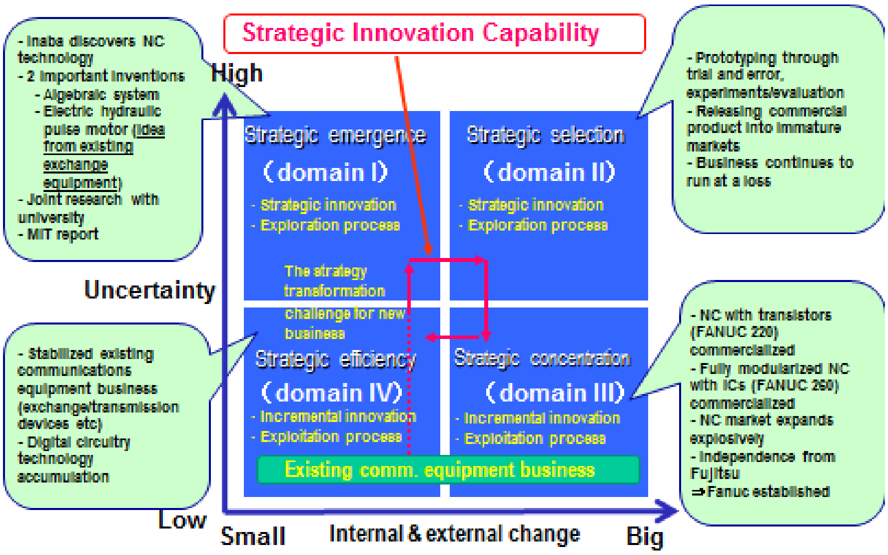
“We had great confidence in the NC technology, but unfortunately the NC machine tool market was still quite small, and it wasn't easy to achieve sales. Therefore, our huge efforts went unrewarded and our monthly accounts remained in the red[14].”

The NC machine tool market had not yet matured, but Inaba understood the characteristics of the market well. In other words, there is some critical point in a market, and until that critical point is reached, demand does not rise very much, but when it is, market demand expands rapidly. Inaba had the following to say about the establishment of the market.

“At a certain time, markets grow explosively. There are many companies that can't wait for that and give up, ending in failure. We endured that period patiently, and once 1966 came around the market for Japanese NC machine tools suddenly took off… (abbreviated)… That means we waited 10 years from 1956 when we first embarked on the development. That explosive growth continued afterwards, but those kinds of issues are things that a company must face[15].”

Even though he was unable to see growth in the market initially, Inaba continued with the NC development and proactively brought in new technologies. In actual fact, Fanuc shipped FANUC 220 using transistors in 1962, FANUC 260 with total integrated circuitry, and by 1969 had succeeded with complete modularization, which accelerated growth in the NC machine tool market in one fell swoop - the number of completely modularized units shipped in 1969 was three times that of the previous year. Fully modularized NC meant that the company could respond to a wide range of customer demands at low cost. In this way, Fanuc's NC business shifted to the “strategic concentration” domain III (and onto the “strategic efficiency” domain IV), when the uncertainty in the NC market in phase 2 in Figure 4 rapidly diminished.

Figure 4 Strategic Innovation System in Fanuc (Phase 1)



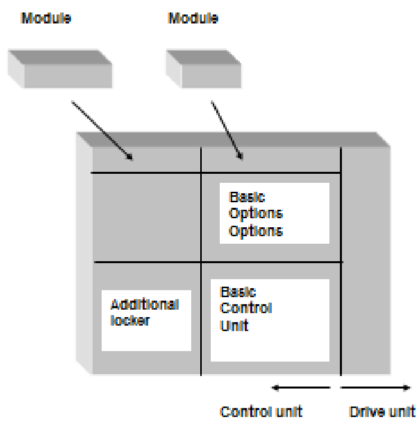
The main reason for the losses the company experienced up to 1965 was custom orders. Custom orders grew vigorously as the sales department took any orders to extend order volume[16]. However, custom-made products cost more than standardized products, and when the company investigated they found all of these orders were making a loss. To bring costs down, companies have to make a wide range of standardized parts, but to respond to the diverse demands of the market, custom-made items are also required, and the way to combine and overcome these contradictory aspects is full modularization. In other words, all the modules that Fanuc produces are standardized, but combining them as required enables the company to respond to various market demands.

For example, the FANUC 260 is a range of functional modules created by analyzing the details of specifications demanded for a variety of machine tools. By mass-producing and stocking these, modules can be assembled to build an NC device to meet the specific needs of individual users. The modules are electronic circuits with specific functions created by combining a range of logical elements such as transistors and memory elements, which are mounted on separate printed circuits and units. See Figure 5 for an example of the FANUC 260 configuration.

FANUC 260 has three types of basic control units, about nine basic options, and about 20 additional options, which means that more than 60 million combinations are possible. Moreover, modules can be connected with screws and cable connectors, enabling completely solder-free assembly using only screwdrivers and spanners. This makes it extremely easy to add functions. Thus, required functions can be added easily without having to do any rewiring on-site with the user. By adopting this completely modularized NC product architecture, Fanuc can respond to a wide range of market demands at low-cost, which in turn greatly contributes to further market expansion.

In the "strategic concentration" domain III where demands for customization are high, there are also hot-selling product lineups, and fierce competition with competitors, and therefore, Fanuc must meet demands with incremental innovation by upgrading and improving its products on a daily basis. In contrast, in the “strategic efficiency” domain IV the product lineup consists of catalogued products, but here it is also important for Fanuc to further reduce costs with incremental innovation.

Figure 5 Structure of fully modularized NC (FANUC 260) (Phase 1)



(4) Breaking away from Fujitsu

As described by the shifts in domains I → II → III (and IV) shown in Figure 4, the new NC market was more creative for Fujitsu. When the NC Department moved into the black in 1965, the number of NC units produced with the expansion of the NC market stabilized, and the department was growing as high earner within the company. In actual fact, Fujitsu's profit ratio in 1970 was 6%, although the NC Department had achieved more than 20%. It was at this point that the investments made into the NC Department over more than 10 years began to bear fruit.

However, in April of 1972, management at Fujitsu decided to separate the NC Department from the company and form a new company, Fanuc. At the time, Fujitsu was facing enormous funding requirements needed to develop the Japanese-made computer. Therefore, since the long-term investments in NC had begun to bear fruit, it seemed like a rational judgment for Fujitsu to take the income from the NC Department and put it in the Computer Department. But looking back over the results, it was obvious that separating Fanuc would prepare the right environment for business growth, which was a significant factor in the leap forward that the NC business took.

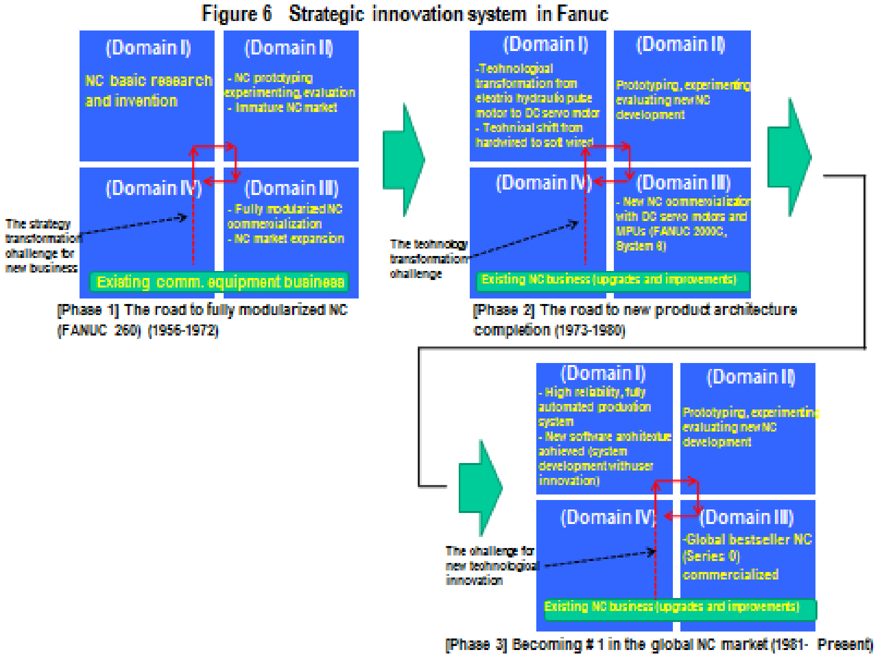
(5) Shifts between domains in phase 1 (see phase 1 in Figure 6)

As described above, Fujitsu was successful in new strategy transformation with the formation of its new NC business, by incorporating knowledge from outside the company into concepts it already had about exchange technologies, while at the same time, the company proceeded with its existing communications equipment business (stable business with exchange equipment and transmission devices etc.). Then, with the "emergent integration" of knowledge from both within and outside the company (Fujitsu's exchange equipment digital circuitry technology and technical know-how from leading universities), and the development project team centered on Inaba, the company was able to develop the world's first NC system using algebraic electric/hydraulic pulse motors. Through this innovation process, the company succeeded greatly with the commercialization of its NC systems and followed the shift in phase 1 through domains I → II → III (and IV).

To achieve new business strategy, Fujitsu converted to a strategy aiming to achieve new NC business, with new exploration processes into the NC business (strategic emergence in domain I, and strategic selection in domain II), by investing development resources (by setting up a development project team centered on Inaba). The company then went on to succeed with the commercialization of NC systems as its new business, during which the NC business shifted through domains I → II → III (and IV).

On the other hand, Fujitsu continued to execute its traditional existing communications equipment businesses in the "strategic concentration" domain III and the "strategic efficiency" domain IV, but the know-how it had accumulated in these domains regarding communications equipment (core exchange and transmission devices technologies) was induced to shift from domains III and/or IV back to domain I. In this way, Fanuc demonstrated dialectical management by coordinating an interface between its old and new organizations using its strategic innovation capability, and promoting explorations processes in its new organizations to achieve new business (domains I and II), while at the same time, continuing with exploitation processes in its existing communications business organizations (domains III and IV) (see phase 1 in Figure 7).

Figure 6 Strategic innovation system in Fanuc



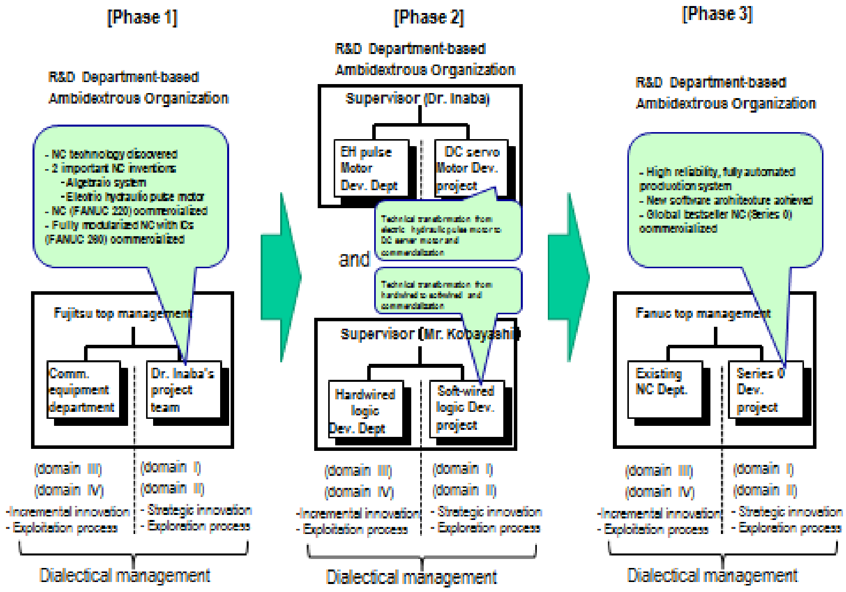


Figure 7 Organizational changes in each phase of Fanuc's strategy transformation

4.2.2. Phase 2 (1973 to 1980)

(1) Technical shift from electric hydraulic pulse motors to DC servo motors

The year after breaking away from Fujitsu in 1972, Fanuc was facing an unforeseen challenge. That was the first oil shock of 1973. As an opportunity, user assessment of the electric hydraulic pulse motors that Inaba had had absolute faith in began to change. There was a hydraulic pump was required to drive the electric hydraulic pulse motors, but the pump was extremely inefficient - for instance it took a 100 hp drive to get a 50 hp output. However, the electric hydraulic pulse monitor was the chief technology that had given Fanuc its unique position, and as mentioned, was invented by Inaba himself. For those reasons, in those circumstances, there was unusual attachment to Inaba's electric hydraulic pulse monitor. In fact, Inaba, said the following his friend at Siemens at the time.

"Taking the electric hydraulic pulse motor away would be the same as taking away my life[17]."

But at the same time however, Inaba had been carrying out various experiments to try to find a new type of motor, which he recalled as follows:

"At the time, I ordered two things, firstly I told Koyama to develop a new electric pulse motor in four months, and secondly I told Endo to investigate American company Gettys[18]."

In other words, firstly Inaba ordered Koyama to develop an oil-free high-power electric pulse motor in January of 1974. The electric pulse motor uses the same open loop method as the electric hydraulic pulse motor, and even though it did not use oil, Inaba was still heavily biased towards the open loop-type pulse monitor. In addition to Koyama developing the electric pulse motor, Endo conducted a thorough survey of the state of American closed-loop DC servo motors as the second approach.

Inaba prepared, just in case, to negotiate for technological partnering on the DC servo motor. Then as instructed, Koyama completed the electric pulse motor development within the allotted 4 months, in May of 1974. However, because the noise of this motor was extreme, Inaba decided it couldn't be used practically, and decided to do away with the open-loop technology of the pulse motor and switch over to the closed-loop DC servo motor.

Once Inaba had made that decision, Fanuc engineers obtained schematics for the DC servo motors from their now technological partner Gettys in the United States, and completed a DC servo motor in a mere two months. Then in September that year, the company exhibited an NC device using DC servos at a machine tool fair in Osaka. This was actually a very important decision for Fanuc. Switching from the pulse motor to the servo motor, and from the open-loop to the closed-loop systems changed basic design concepts. Looking back on those times, Inaba said the following:

"If my decision had been even just a little bit later, the share we now enjoy would probably have ended up with another company.… (abbreviated)… at the time, if I had stuck with the electric hydraulic pulse motor, the Fanuc we see today wouldn't have existed[19]."

Inaba recalls those times as difficult ones when his managers and his engineers were in a pinch. As the inventor of the electric hydraulic pulse motor, Inaba had a strong attachment to the technology, but also as a manager, he was caught between a rock and a hard place of having to look squarely at the limitations of his own technology. And it was from that experience that Inaba began to think that "Technology does have a history. However from the engineers' point of view, there is no past, only creativity."

(2) Technological transformation from hardwired to soft-wired

Later in 1975, Fanuc developed the FANUC 2000C NC equipment with Intel's 3000 series MPU. This was the world's first NC equipment with built-in MPU. The 3000 series was not a one chip-type like those of the present day, but used a micro program method in addition to bit-slice design, and did not have any general purpose characteristics because the program had to be loaded in at Intel's factory.

Nevertheless, the adoption of the MPU meant a shift from control using circuitry built with transistors and diodes, to control using software. In other words, this was a huge shift in NC design thinking from the hardwired to the soft-wired. Because the MPU component is in fact a computer, NC using MPU is called computerized numerical control (CNC), and is often distinguished from conventional NC.

Technical issues that confronted the development of computerized NC were performance and reliability.

"The biggest issue was whether a computer running software could process interpolation. We performed various simulations and actually tried things to find out what was possible and what could be known, but the interpolation issue was the biggest issue.… (abbreviated)… we used semiconductor memory, but the technology hadn't been properly established, and the manufacturer couldn't provide us with the right advice. For example, when using ICs, but we were groping for answers because we had no idea whether ICs could be mounted on printed circuit boards and connected together by etching the copper on the board, and we weren't sure how to increase reliability in terms of noise[20]."

To deal with these technical uncertainties, the company formed a new computerized NC design section in addition to its existing hardwired NC design section, and operated both departments simultaneously. The hardwired NC section was involved in developing NC for mass production using technology that had already been established, and its aim was to develop highly reliable NC at a low cost. On the other hand, the goals of the computerized NC section was to pay attention to the trends in cutting-edge semiconductor technologies and whether they could be incorporated into NC systems, and whether performance and reliability could be improved. Thus the technological and design objectives of both departments were completely different, so the organizations were separated. Director Kurakake said the following about that situation.

"We completely split the troops into separate hardwired and computer sections. There was a departmental head overseeing the sections, and I was put in the computer section but had no lingering attachment at all to the hardwired section. I don't know what would have happened if we had tried to do it together. For my part I had absolutely no regrets about that, because we were able to do something new and get involved with the potential of computers [21]."

In this way both sections worked in completely different directions, but were overseen by one person, director Kobayashi, and organizational consistency was sustained by him.

"The director oversaw both departments, so he knew the limitations of the current version of NC, and thus was able to see what needed to be done next, but there was a serious problem in trying to figure out how to develop beyond the current products which were creating revenue[22]."

In this way, there was tight control over business interaction between the different sections in the organizational system that Fanuc had adopted, and as such, because one manager oversaw both organizations, this structure is very similar to that of an "ambidextrous organization." Ambidextrous organizations are configured so that all business functions in the value chain (R&D, sales and marketing, technology, support etc) are duplicated in old organizations and new organizations. However, Fanuc only clearly split up the roles of its R&D functions, which was characterized by the appropriate setting up of an interface in the business value chain within the company, which is somewhat different than that described by existing research.

Then around 1978, the NC systems using semiconductor technologies had improved to the point where they would surpass the hardwired NC in terms of performance and reliability, and so the hardwired NC design section was absorbed into the computer NC design section. Until that time, the two technological systems of hardwired and soft-wired had existed in parallel, but it was in 1978 when the company technologically integrated the two into the computerized NC only.

In 1978 Intel developed the MPU 8086, a single chip-type IC similar to those that we can still see today, and Fanuc developed its System 6 using the 8086 in 1979. The success of the System 6 made Fanuc the first company in the world to adopt the 8086 for mass produced goods. After that, Intel went headlong into the PC business. However, for Fanuc, the success of implementing the 8086 was a decisive moment for Fanuc's triumph in the NC market. Compared to Fanuc, American NC manufacturers were not as proactive about implementing semiconductor technologies such as MPUs, which was a fatal move on their part.

(3) Shifts between domains in phase 2 (see phase 2 in Figure 6)

As described above, phase 2 did not only involve Fanuc maintaining business by sales activities and improvements and upgrades to existing NC systems with the total modularization of hardwired business that grew out of phase 1, but Fanuc also engaged in serious strategy transformation to deal with economic conditions and structural changes brought on by the oil shock, by technological transformation to miniaturize and raise quality. As shown by phase 2 in Figure 6, this is an example of strategy transformation to bring about new product architecture through new exploration processes (strategic emergence in domain I, and strategic selection in domain II) using Fanuc's development resources (Koyama's mission to develop an electric pulse motor within four months, Endo's survey and technological partnering with Gettys in the US to develop the DC servo motor, and the configuring of the new developmental section system for soft-wired NC systems). The NC system was then successfully commercialized with new product architecture, and the new NC product shifted from domain I → II → III (and IV).

On the other hand, the business of existing NC (hardwired and fully modularized NC systems) was carried out in existing organizations in the "strategic concentration" domain III, and the "strategic efficiency" domain IV, and then that existing NC product development know-how accumulated in domains III and IV was induced to shift to domain I. In this way, Fanuc demonstrated dialectical management by using its strategic innovation capability to coordinate an interface between its old and new organizations for promoting exploration processes (domains I and II) to achieve new product architecture with new organizations, while at the same time, promoting exploitation processes (domains III and IV) with its fully modularized NC systems (see phase 2 in Figure 7).

4.2.3. Phase 3 (1981 to present)

(1) Developing bestseller NC

By shifting design thinking from hardwired to soft-wired in the second phase, the new NC with good product flexibility and expandability caused the market to grow significantly. We described the process of developing product architecture after the implementation of MPUs, as analyzed in the previous section. In this section we present a development case of the Series 0 bestseller NC.

The Series 0 went into mass production in September of 1985, and at the end of July 2004, 350,000 units had been shipped, becoming the #1 global bestseller computerized NC product. There are 2 main factors behind this success, both of which are new technological innovations, the first being the total automation of Fanuc's factory for high reliability, achieved by refined manufacturing and design, and the second being the development of new software architecture by promoting "the customer as the innovator" (CAI) [23] (Hippel, 1998, 2002), and "user innovation" (Hippel, 2009). We describe these 2 factors in sequence.

The Series 0 failure rate is 0.008 per month per unit with its extremely reliable technology. When using industrial goods like NC, the importance of reliability is incomparably higher than consumables, since if industrial goods breakdown, for example in an automobile factory, the production line has to be stopped. The concept behind the Series 0 high reliability was to use technologies accumulated up to that time, and to optimally equip the product with the most compact NC possible. Rather than redesigning to produce cutting-edge technologies, that meant polishing existing products, and finding new ways to assemble them.

High reliability can only be achieved by the continuous down-to-earth accumulation of technology, and will never be achieved in a short space of time. Making new functions and adding them to existing products is one way to go, but products that are highly reliable are not brought about by adding something new, but by unceasingly rethinking the entire product, and in some cases, adding new functions can cause misalignments in entire systems, thus reducing the reliability of a product.

It is also difficult to assess reliability. Functions and performance can be easily evaluated by actually trying them out. Similarly, the cutting speed and precision of NC machine tools can be easily understood by actually using them. However, malfunctions are often caused by on-site unplanned use of equipment, which is why it is difficult to evaluate product reliability.

Kurakake had the following to say about the difficulty of assessing reliability.

"You can try making something and pretty much understand performance, but you don't know about reliability. Even on the surface, electrical components are just arrangements of parts, and there is no way that an untrained person can know whether they are reliable or not just by looking at them[24]."

To improve reliability of hardware, it is important to reduce the number of components, and reduce the interdependency between components. For that reason, a range of parts such as custom LSI, hybrid ICs, printed circuits, power sources and display technologies were rapidly developed for the Series 0. And by using a thin display, the depth required for the display was reduced to about one third of that required for a CRT. As a result of these measures, the Series 0 has twice the processing speeds of older equipment with about half as many parts. High reliability is the result of rethinking down-to-earth design based on accumulated technologies.

One more reason for the success of the Series 0 was the accomplishment of a fully automated factory. One of Fanuc's strengths is its ability to substantially reduce costs with factory automation. The Series 0 was the first time the company achieved full automation. For that reason, the Series 0 hardware design had to be reconsidered from the point of view of manufacturing. In short, to achieve fully automated manufacturing consideration must be given from the beginning at the design stage.

With NC manufacturing, firstly components have to be mounted onto printed circuit boards, which is a job done by automated machines. Then, once the components have been mounted onto printed circuit boards, each board must be tested, which is done automatically by a specialized testing machine to raise efficiency. Once testing is complete, several boards are assembled to create a single NC device, which is also done by a robot. Finally, the assembled NC devices are tested in another machine for overall performance. The Series 0 was the first product created with this type of full automation. Kurakake said the following:

"The new thing here was the automated mounting, and automated assembly. Whereas previously factory workers had mounted circuit board components by hand, this was the first time we have achieved 100% automated mounting. The boards are assembled automatically using robots. This was also a new idea [25]."

To achieve fully automated manufacturing like this, design concepts considering manufacturing are needed. Even with aligning components onto printed circuit board, design has to consider everything from component selection, how the robot can grab them, through to how to tighten screws. How big the screws need to be, where should the screw holes be… design has to consider everything down to the tiniest detail. That means right from the initial stages of design, the demands from manufacturing must be taken up, and meetings with manufacturing staff have to be ongoing. Kurakake had the following to say about design considerations.

"For a robot to grab an object, it is necessary to include a hole on the device for the robot to grab. It's only a little modification, but if time is not given over to consider how the robot can grab component in the design, and the robot can't pick things up once the equipment has been built, then you are already losing the race. I put it like this but it is not concurrent engineering, just that the type of equipment deployed was designed in consideration of how to make something[26]."

In this way, the success of the Series 0 was brought about by carefully accumulating technologies up to the time, improving reliability, and cooperation between design and manufacturing.

The second characteristic was the advances in software architecture. The big change in software architecture was the separation of user controlled sections and vendor controlled sections of the software that could be performed in the Series 0, the first generation computerized NC. Why this separation? Because, this type of architecture enables both users and vendors to innovate independently of each other. This kind of architecture enables users to satisfy their own demands by themselves, and vendors to satisfy their own needs independent of the user. Here, we describe the background of this kind of modularization.

Fanuc's Series 0 is the world's bestselling computerized NC system[27]. One of the drivers that brought about this bestselling computerized NC system was the need to provide customized functions called custom-made macros to meet the diverse needs of end users. Using these customizable functions, machine tool manufacturers, or end users could freely innovate independently from Fanuc, which was enabled by Fanuc rebuilding its software architecture.

Fanuc holds a 70% share of Japanese NC equipment. Therefore, for machine tool manufacturers, the big challenge is how to bring about product differentiation while using Fanuc's virtually ubiquitous NC equipment. Conventionally, to give machine tools individualized characteristics they were customized, but machine tool manufacturers asked Fanuc to develop new functions, which the company would do and then provide to the machine tool manufacturers. With this method, machine tool manufacturers would often demand further modifications, additional functions and once again ask Fanuc to make corrections or developments, which meant that all of the work ended up back at Fanuc. In short, machine tool manufacturers could not modify or add functions by themselves. Not only was this a huge inconvenience for both the machine tool manufacturers and Fanuc, but it also cost money. Regarding this situation, Kishi (Executive Director, November 1996), said the following:

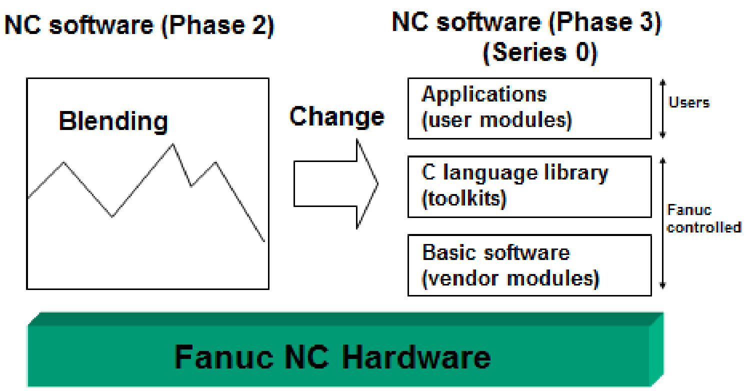
“Trying to get individual characteristics like that, machine tool manufacturers asked Fanuc to develop functions to certain specifications, and when those requests came we had to provide quotes for them, including how much time it would take. It meant that if the machine tool manufacturer wanted to add or modify a function to create their own features, there was no way that they could do it without us helping them[28].”

The main reason for this was the basic software involved with control hardware and control application software involved with the user were blended together in the conventional NC software, which meant that basic software and application software both had to be modified to meet customization requests. As machine tools are often called mother machines, and are characterized as machines that make other consumable machines such as automobiles and electronic goods, the application software was basically custom-made for individual users. But to provide application software, Fanuc had to listen to the demands of machine tool manufacturers and create the software, which cost money and took time, and then there is also the effort involved with precisely conveying user needs to Fanuc so that the company could understand them. Put differently, because application software is highly sticky information regarding user needs, that stickiness was ending up as costs for Fanuc.

It was for that reason that Fanuc decided to think about providing software tools and packages with a lineup of basic functions needed to operate machine tools, and that would enable the users themselves to add functionality to deliver unique features to their machines. Fanuc saw that such a move would release the company from some of the NC software responsibility enveloping it at the time, and give it over to the machine tool manufacturers themselves. Kishi said the following about those times.

"We thought we could provide the basics needed to run a machine tool, and also provide tools to give machine tool manufacturers the ability to create uniqueness in their products by adding functionality. Basically we just said 'Fanuc will make you some tools and then you, the machine tool manufacturer, can use those tools to add functions however you like to create your own unique products.' That means, even though the machines may look identical, company A's machine tools or company B's machine tools can all have their functionality modified to bring out individual characteristics using the same NC devices [29]."

Figure 8 Evolution of software architecture



To execute this, the company modularized the software architecture into application sections that could be controlled by the user, and basic software section that could be controlled by the vendor as shown in Figure 8, and set up a C language library between them. The C language library is a software toolkit that for instance contains functions to display characters on screen or read keystrokes, and a range of internal NC input-output control functions for parameters and current cutting tool position and so forth. Machine tool manufacturers were thus able to freely assemble functions with the C language library to create their own screens, and display their own unique information. Without having to rely on Fanuc, they became able to add functions as they pleased.

Recreating architecture this way enables the machine tool manufacturers as NC users and Fanuc as the NC vendor to independently innovate in parallel with each other. Fanuc was released from the diverse demands of machine tool manufacturers and end users, and was able to focus on improving its core technologies such as hardware and basic software. While on the other hand, machine tool manufacturers and end users were no longer affected by hardware and basic software changes made by Fanuc, and gained the ability to create unique functionality themselves.

What are the factors that dictate the need to restructure software architecture in this way? If application software with a lot of sticky information related to needs (Hippel, 1998) could be developed by users, it would be advantageous both for the user and Fanuc. And that was enabled by recreating architecture modularized with user controlled and vendor controlled sections. In short, promoting user innovation is a factor that influences software architecture restructuring processes.

As described above, development projects were set up as new organizations separate from the existing NC department to create high-quality NC, with high reliability and automated production systems, and to drive development of software architecture with the customer as the innovator (CAI).

(2) Strategic partnership with GE

Phase 3 was a period of significant development in terms of globalization, for instance the company's formation of a strategic partnership with GE. In 1986, GE and Fanuc set up a full equality joint-venture, each with 50% capital investment to work on CNC and PLC called GE Fanuc Automation Corporation (GE Fanuc). Headquartered in Charlottesville, Virginia in the United States, the company oversees 3 subsidiaries in North America, Europe and Asia. The extremely broad scope of this partnership extends across cooperation in development, manufacturing and marketing. To make it known that this was a partnership of full equality, Inaba suggested that the company should be called "GE Fanuc," for "GEF" would not have sufficed. For this he gained understanding from GE. Anybody could easily guess what the initials GE stand for, but the F for Fanuc would be completely unknown. Obviously, personnel would come equally from both companies, and one person from GE and Fanuc each was sent to preside over the new company in a joint chairmanship system.

Fanuc's globalization concepts are clearly apparent in this partnership with GE. Rather than relying purely on the company's own resources, its partnerships with trusted local companies for R&D, manufacture and marketing are horizontal cooperative relationships. For such relationships to be enabled, partners must be fully equal. Accordingly, mergers with local companies must on principle be based on 50-50 capital expenditure, regardless of whether they're in the West or in Asia. In building a cooperative relationship through a fully equal partnership with another company, Fanuc is able to help out with local production training, and aims to go beyond simple exporting as part of its globalization concepts.

(3) Shifts between domains in phase 3 (See Phase 3 in Figure 6)

As described above, in phase 3, business was not only driven with improvements and upgrades and sales activities for the existing MPU and DC servo motor NC business (FANUC 2000C, System 6) which had been commercialized from phase 2, Fanuc also undertook major technological transformation to respond to technical innovations for the new user innovation software architecture development with CAI, and automation of production systems by unifying design and development with manufacturing. Described as phase 3 in Figure 6, Fanuc switched to strategies to turn towards development resources as new exploration processes (strategic emergence in domain I, and strategic selection in domain II) to achieve the new software architecture as well as full automation in its factories for the commercialization of the innovative Series 0 NC product, and, thanks to the new technological transformation, the commercialization of the NC system (Series 0) was a success, and the company's new NC business once again shifted from domain I → II → III (and IV).

Meanwhile, the company's existing NC product (FANUC 2000C, System 6) business was carried out in existing organizations in the strategic concentration domain III and strategic efficiency domain IV, but the NC machine development hardwired and soft-wired know-how accumulated in the past was induced to shift from domain III (and/or IV) back to domain I. In this way, Fanuc engaged in dialectical management by using its strategic innovation capability to coordinate an interface between its old and new organizations for promoting exploration processes (domains I and II) to achieve new product architecture, while at the same time, promoting exploitation processes (domains III and IV) to upgrade and improve its existing NC systems in its existing organizations (see phase 3 in Figure 7).

5. Implications

From this case of strategic innovation, we describe newly extracted implications.

5.1 Strategic innovation capability by forming a strategic innovation loop

In analyzing this case, we have described the history of changes to Fanuc's business strategies as changes through three historical phases as the birth of new products and businesses (strategic emergence in domain I), their cultivation (strategic selection in domain II), their acceleration (strategic concentration in domain III) and business stabilization (strategic efficiency in domain IV), as illustrated by strategic innovation loop in Figure 2. In each three phases, as in Figure 6, NC systems were developed through the strategic innovation loop (domains I → II → III and/or IV and back to domain I).

In phase 1 in Figure 6, Fanuc continued to provide its existing communications equipment services in domains III and IV, while it achieved commercialization (domains I → II → III and IV) through trial and experiment to develop NC and achieve new business. Then, in phase 2, the company engaged in the development of new NC systems with new product architecture for new strategy transformation needed to meet circumstantial and technological changes. Fanuc was successful in operating its existing NC business (domains III and IV) while at the same time, commercializing new NC developments in parallel (domains I → II → III and IV). Moreover, the company followed similar innovation processes in phase 3 as phase 2.

The strategic innovation capability that brings about shifting between these domains - the “strategic innovation loop” - was acquired through unrelenting innovation activities carried out over time and with patience in R&D processes through the companies more than 50 year history, and lead to processes of commercialization starting from the NC technology R&D at Fanuc, just as presented in detailed case studies. As cited in the theoretical framework discussed in section 2, realistically much of strategic innovation comes from the stages of discovery and inventions in environments in which basic scientific research or technological development is sluggish.

Domain I, where slow environmental changes and high uncertainties are observed, is the stage where new ideas and business concepts, and new technologies are created from new discoveries and inventions. And, as basic research and the emergence of ideas is the source of new strategic innovation, depending on the technical field like those found with NC technologies, the more weight there is on scientific factors or the higher the level of technical difficulty in a particular field, the longer the amount of time required for the process, as can be seen in phase 1. Thus, in achieving its NC technology, Fanuc spent many years on hardware and software product development, commercialized products providing uniformity with its hardware and software and automating its production systems as its most fundamentally important research themes (Fanuc is still continues research in these fields). In particular, the company’s achievements in domain I were due to the emergent ideas and actions of middle management in Fanuc's R&D department, the strategic contribution and commitment of leaders such as Inaba and other top management and senior managers who ran both new and existing organizations (described in phase 2) was also an important factor for success.

Furthermore, in domains I and II, there were wide ranging patterns of the knowledge integration process including open innovation elements that transcended the company internally and externally to enable R&D into the NC equipment (within the company itself, with other companies and with universities, etc). Traditionally, many large, hierarchical companies have mainly promoted closed innovation in internal R&D organizations. Closed innovation processes were important for developing innovation with path-dependent knowledge accumulated through the company history. However, to develop the NC technology in Fanuc's R&D department, even though closed innovation was the main consideration, Fanuc proactively pursued joint development within and outside itself with other companies (e.g. GM and GE) and major universities.

Furthermore, Fanuc's R&D department developed prototype experimental systems based on its core technologies developed in domain I, which it put to work in the domain II stage with experiments in a number of fields related to the new NC equipment. In this domain, by upgrading and improving prototype systems, the prototype systems were drawn closer to completion as a commercially viable services in the R&D department. Through the processes in domain II, a range of machine tool markets for application of NC technology gradually became established, and the shift to the genuine commercialization of domain III (and IV) took place. In particular in domain III, market environments rapidly changed with competition from other machine tool manufacturers, and Fanuc quickly invested resources required for exhaustive incremental innovation for its NC products. Meanwhile, thorough efficiency was promoted for NC products using stabilized (or perhaps dying) technology in domain IV.

As described above, it is clear that Fanuc used the 3 factors of strategic innovation capability as cited in Chapter 2. The first of these is the capability to achieve a strategic innovation loop to shift from domain I → II → III and/or IV and back to domain I. Fanuc achieved this in each phase of its strategy transformation. The second of these factors is the ability to execute “sift management” between domains and within each domain. Fanuc achieves shifts within and between domains in each phase of its strategy transformation with the emergence of a new product or business (strategic emergence in domain I), then engages in cultivation (strategic selection in domain II), acceleration (strategic concentration in domain III), and stabilization (strategic efficiency in domain IV), and then shifts back to the creation of new business (domain I). As described by Figure 7, the third factor in each phase of strategy transformation is the demonstration of integration of competencies to execute dialectical management to combine exploration and exploitation processes in the differing archetypes of new and existing organizations.

5.2 Promoting strategic innovation with the creation of new development organizations

In each phase, Fanuc's execution of strategic innovation to create new businesses or technologically transform was characterized by the creation of new development organizations within the company centered on top management (see Figure 7). Being formed from new members, development organizations received support from top management deployed within the organizations, which were given significant authority to set down and execute business and technical strategies for the future. As seen in Fanuc, innovative leadership is required to guide such organizations, and organizational members must be afforded flexibility and autonomy, while future business and technical strategies must be allowed to emerge, and experimentation and incubation must be driven continually. There is also a need in large companies for human resources strategies that enable drastic personnel selections to form new organizations when facing strategic innovation[30]. For this, leadership by the top management team is key (Fujitsu's top management at the time or Inaba of Fanuc).

Fanuc's strategic innovation capabilities promoted synergies between the exploration and exploitation processes in its old and new organizations, brought about the appropriate interface between the new and old organizations, integrated technical strategies (new and existing technologies), organizational structures (new and existing organizations) and competencies (e.g. hardware and software technology know-how), and thus brought about major achievements by achieving strategic innovation to realize new product architecture and establish new NC business. Moreover, as shown in Figure 7, Fujitsu and Fanuc were able to configure ambidextrous organizations from the two different archetypes using dialectical management, which is an extremely important part of strategic innovation capability, to skillfully manage new and existing technologies with combination and coexistence within the same company, and bring about synergies between the old and new organizations, an important factor for success in achieving strategic innovation in large companies.

6. Conclusion and Future Research

In this paper, we have touched upon previous research, and presented the concept of strategic innovation capability as a corporate system capability that achieves strategy transformation by strategic innovation in a large company. We have verified this theoretical framework through the detailed case study of strategy transformation at Fanuc, a company that holds the top share of the global NC market. In this case study, we have presented the innovation processes in which Fanuc demonstrates its strategic innovation capability, proactively achieves innovative NC technologies and products, and establishes competitiveness in this field. We have obtained knowledge of the importance of acquiring strategic innovation capability in which top management consciously creates new development organizations within a company to simultaneously manage exploration and exploitation processes through the operations of existing and new organizations to achieve strategy transformation.

Above, we have described a theoretical framework for strategic innovation capability. The theory of strategic innovation systems will grow more detailed as time goes on, and a new research approach will be required. One aspect is that much of the strategic innovation research done up to now has emphasized correlations between specific management elements of specific organizations and projects (including strategy, organizational structure and culture, competence, and leadership) with results, and has been limited to analyses of some of the subsystems that comprise the corporate system. However, strategic innovation in the large corporation has a great impact on success or failure, due to complex interaction among the subsystems comprising the corporate system.

It is therefore necessary to specify the individual subsystems that influence strategic innovation based on strategic innovation systems as corporate systems, and analyze in depth the interactive relationship (such as existing organizations versus strategically innovative organizations) between these features (whether, for example, they are open or closed systems) and subsystems, and the dynamic situational changes (balanced or unbalanced) of individual subsystems with the overall (corporate) system responding to internal and external change. System theories (e.g., von Bertalanffy, 1960; Capra, 1996) and complex adaptation theories (e.g.

Morel and Ramanujam, 1999; Stacey, 1996) are capable of inclusively handling the points above. O'Connor (2008) explains how system theory is effective in clarifying a large corporation's radical innovation system, and demonstrates some propositions with respect to the relationship among a number of subsystems.

The second aspect is the research approach from the knowledge-based theory of firm (Nonaka and Takeuchi, 1995; Grant, 1995). Companies that achieve sustainable strategic innovation can be said to be implementing a new knowledge creation (or integration) chain through a layered strategic innovation loop (see Figure 2). But research is required into "knowledge integration dynamics" that asks such questions as how strategic innovation capability can change or realize this knowledge innovation process occurring within and among domains (including shifts) (see Figure 2); how strategic behavior and organizational structure change; and what patterns form the optimal knowledge integration process for realizing strategic innovation. This research, which needs to progress from a theoretical, actual, and practical viewpoint, forms the true theme of this paper.

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Notes

[1] Transformational elements involve external and internal change, and affect management elements that build corporate systems, such as strategy, organization, culture, competence, and leadership. See Raynor (2006) for research regarding strategic uncertainty.

[2] Campbell and Park (2005) indicate that since reducing organizational and resource uncertainty is difficult, projects that are high-risk in terms of organization and resources should be rejected after screening

[3] The likelihood of experiencing a certain amount of failure in the strategic selection domain rises with outstanding leaders and managers. This is also a working hypotheses from my own office experience.

[4] This is due to the existence of the knowledge boundaries between the product planning divisions that supervise the creation of business concepts and ideas, the development divisions that realize them, and the production and manufacturing divisions. See Kodama (2007a).

[5] Numerous studies (e.g., Nonaka and Takeuchi, 1995) exist regarding the theoretical frameworks relating to the creation of knowledge such as breakthrough or new ideas. Analysis from various viewpoints will be the subject of future research topics. One such example relates to the creative process for business concepts arising from the synthesis of market and technology paradigms (see Kodama, 2009).

[6] We would like to note the points of difference between the "strategic innovation system" and the "management system" arising from "breakthrough innovation capability" (O'Connor et al., 2008). One such point is that since O'Connor's model is sequential-it shifts from discovery through cultivation to acceleration-it is weak on the positive feedback process of reflection on, and practical application of, the practical knowledge and accumulated transformational experience of in-house expertise, skills, and routines acquired through executing breakthrough innovation and existing business. Another is that the sequential model provides a weak framework for shifting to a strategic emergence domain that gives rise to discovery, invention, and creativity. Third, it provides a weak dynamic strategy view framework for a company to acquire and sustain new strategic positions over many years. With regard to this, the strategic innovation system in this paper (see Figure 2), comprehensively considers the three points above while creating corporate and management system models for sustainable strategic innovation.

[7] This case study was created with reference to interviews with persons involved, books, papers and published materials. In particular, we received a lot of help in the form of information and interviews provided to us by Fanuc. We would like to express our gratitude here.

[8] Refer to Inaba (2003).

[9] Op.cit., 8

[10] Op.cit., 8

[11] The pulse monitor is characterized as follows: Firstly, it has applications in a wide range of areas including large-size machine tools, and a diversity of NC control applications. Secondly, the electric hydraulic pulse monitor can be combined with machine tools by cogs and feed screws to create NC machine tools extremely easily.

[12] Op.cit., 8

[13]Op.cit., 8

[14] Op.cit., 8

[15] Op.cit., 8

[16] Op.cit., 8

[17] Op.cit., 8

[18] Interview with Seiuemon Inaba on 14th of July 2003 (Honorary Chairman at the time)

[19] Op.cit., 8

[20] Interview with Mitsuo Kurakake on 7 December 2000 (Executive Director at that time)

[21] Op.cit., 20

[22] Op.cit., 20

[23] Hipple (1998, 2002) pointed to toolkits that have been developed for customers in certain industries (custom LSI, CTI field, etc), and how these enabled problem-solving to be shifted to the customer, by enabling the customer to freely modify products and applications using these tools. Custom LSI toolkits are devices that enable customers to achieve desired functions by programming content electronically at the logical circuit level, and are called field programmable gate arrays (FPGA) that are, in the case of LSI, application-specific ICs (ASIC) in the narrow sense - tools that enable the customer to develop prototypes and functions, and perform evaluations. Because these programs are rewritable, they enable customers to freely check performance of prototypes. Currently only performed in a limited number of fields, "customizing as innovator" releases product development and manufacturing staff (in a company) from the work involved in understanding the details customer needs accurately, and instead the innovation tasks related to those needs are shifted onto the customer (prototype design, prototyping, simulations and assessments etc). As a result, this toolkit approach can dramatically reduce costs associated with transferring sticky information by separating product and service development task into two subtasks, i.e., subtasks related to customer needs and subtasks related to companies solutions. This means that companies no longer need to understand the highly sticky details of customer needs and can focus on routine works, while at the same time, customers can efficiently engage in trial and error processes through practical learning using toolkits to achieve exactly the functionality that they require.

[24] Op.cit., 20

[25] Op.cit., 20

[26] Op.cit., 20

[27] This recognition came from an interview with Hajimu Kishi on 21st of November 1996 (at the time Executive Director and Director of FA sales).

[28] Op.cit., 26

[29] Op.cit., 26

[30] Similar to the i-mode development case. Refer to Kodama (2003) for details.