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KNOWLEDGE CREATION IN JAPANESE ORGANIZATIONS: BUILDING THE DIMENSIONS OF COMPETITIVE ADVANTAGE

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PART 1 TOWARDS A DYNAMIC MODEL OF ORGANIZATIONAL KNOWLEDGE CREATION

1.1 Introduction

Although a great deal has been written about the importance of knowledge in theories of technological innovation and business strategy, rather less has been said about how knowledge is created and the way in which the knowledge creation process can be managed. Yet, analyzing organizations from the point of view of their "knowledge creation processes" can provide significant insights into the development of a firm's "dynamic capabilities". The concept of "knowledge creation" has the potential to be developed as a useful mechanism for linking interpretations of organizational change to models of competitive technological innovation and the evolution of business strategies. Organizations are not simply "black boxes" that process information -- rather they are active agents of knowledge creation, linked to the outside world by a wide range and diversity of interfaces. They create knowledge dynamically in concert with developments in their overall operating environment. Knowledge created by organizations might, for example, be articulated as technological innovations that influence broader patterns of change outside the organization. At the same time, organizations form integral components of the feedback mechanisms that arise as consequences of that change. Thus, "intra" and "inter" organizational knowledge creation processes can not be separated in any absolute sense -- rather they represent different aspects of a continuous dialogue.

Members of organizations are part of larger networks, or "communities of interaction", which go beyond organizational boundaries. These communities include social networks and other information exchange activities that shape the way in which organizational members approach problems confronted in their day-to-day work. The media for networking these communities can be

many and various -- ranging from face-to-face meetings, conferences, professional journals, computer databases or whatever means enables individuals to reach beyond their immediate circumstances and access a wider body of knowledge. Such networks permeate organizational boundaries -- thereby enabling organizational members to exploit external sources of knowledge in order to try and articulate new aspects of understanding. These windows on the outside world -- or "organizational interfaces" -- can take a wide range and diversity of forms and influence attitudes at all levels in the organization. Moreover, with the rise of information technology and advances in international communications, knowledge creating networks have an ever-greater potential to function on a global scale.

This report focuses on how organizations create knowledge which is appropriate to supporting their position in a changing operating environment. It develops a dynamic model of knowledge creation and then uses case-studies to show how the ideas proposed relate to actual organizations. While the argument is based on case-study material from Japanese firms, attention is also given to exploring how the business practices involved differ from approaches adopted in the West. Naturally, there are many differences between Japanese and Western business practices which are highly context-specific and, in consequence, can not be easily interchanged between national environments. However, the point about knowledge creation is that it contains some general principles which operate at a more basic level of human interaction. Indeed, many aspects of knowledge creation embrace an ever-increasing global dimension in which Japanese and Western systems have direct interfaces. While the cultural context of business relationships might vary across these interfaces, the principles of "interacting communities" can be found both within and between the different systems. In consequence, the key themes of the report have an applicability that goes beyond the Japanese business practices.

This report is divided into three parts which comprise a theoretical framework, practical case-studies of knowledge creation in Japanese organizations and conclusions. **Part 1** begins by considering the use of knowledge in evolutionary models of technological change and then moves towards the development of a model of organizational knowledge creation. This discussion is developed from principles of organizational knowledge creation presented in Nonaka (1993) and Nonaka and Takeuchi (1994). A management model for promoting effective knowledge creation is then proposed. This model focuses on the critical role that can be played by middle management in knowledge creation and is dubbed "middle-up-down" (MUD) management, which contrasts with traditional notions of "top-down" and "bottom-up" management.

The case-studies in **Part 2** aim to illustrate how the principles of knowledge creation can be used to increase creativity in the pursuit of new, more advantageous ways of "doing things". They focus on three rather different angles of knowledge creation.

In the fist instance, the case of Canon's development of its "Mini-copier" demonstrates how a mature product can be regenerated to capture a new market and, at the same time, draws attention to the company's ability to "learn from past failures" thereby giving further impetus to an effective move towards further diversification away from its established knowledge base in cameras and optical technologies.

The second case-study is concerned with the regeneration creativity at the Nissan Motor Company, which had previously become a "stagnant" organization locked into bureaucratic procedures that mitigated against fresh and original thinking. At the same time, the case-study serves to high-light an important caveat arising from the fact that creativity comes at a cost in organizational resources which can, on occasions, be inconsistent with conditions associated with the prevailing market environment. When Japan's rapidly expanding "bubble" economy burst in the late-1980s, there was a return to price-

oriented competition, which placed Nissan in an exposed position compared to other Japanese auto-makers.

Finally, the third case-study in Part 2 deals with an altogether different kind of knowledge creating system which is not concerned with a company but rather with a temporary organization -- in the form of a research institute -- that was, so to speak, built between commercial corporations. This research institute was part of the Ministry of International Trade and Industry's project to develop so-called "fifth generation" computing and was staffed by researchers drawn from rival companies. Although the initiative was directed towards basic, pre-competitive research, the notion of collaborating with members of a rival organization is somewhat "counter-cultural" to the Japanese notion of life-long commitment to a single "family style" organization. The project is of special interest because it shows how, in the case of a high-profile project that also lies outside the sphere of participating organizations' "current commercial interests", the notion of sharing in common "vision" can be used to overcome concerns about creating knowledge with "outsiders". Temporary ventures that are located between organizations are distanced from the hierarchical structures that are used to confer authority within the organization. Building the levels of trust necessary for the effective sharing and creation of knowledge requires the use of mechanisms that can over-ride tensions between loyalty to the project and the interests of the various participating companies.

Part 3 of the report presents observations and conclusions. This includes proposals for a model which articulates the problems that have to be overcome by middle management in to support the implementation of effective knowledge creation. It attempts to link knowledge creation to the organization's need to improve the dynamic aspects of its competitive processes. The are proposals are presented as being analogous to the computing world's use of "hypertext", which allows users to search, compare and contrast large quantities of text, data and graphics by means of a

friendly interface. The objective is to relate concepts and areas of knowledge to allow a problem to be viewed from many angles giving scope for the re-juxtaposition of concepts and the crystallization of knew ways of thinking.

1.2 Knowledge, Technological Innovation and the Pursuit of Competitive Advantage

The analysis of technological innovation and business strategy have often made extensive use of the concept of knowledge. However, many such analytical approaches stop short of issues related to intra-organizational knowledge creation processes and their complex inter-relationships with external developments. By way of background to the models of knowledge creation developed in this paper, it is helpful to review the treatment of knowledge as developed in perspectives that address competitive technological innovation and the pursuit of strategic advantage.

The increasing interest in knowledge as a unit of analysis in the study of technological innovation is partly a reflection of increases in the complexity of advanced technology and the rise of an "information age". In medieval times, innovations were articulated in terms of practical achievements which made minimal use of "book learning". Knowledge networking was largely based on personal contact and shared experience. Apprentices learned from their masters and the diffusion of new techniques depended to some considerable extent on the movement of individuals. The functions performed by the basic elements of prevailing technologies were relatively easy for an onlooker to appreciate. Chance trial and error led to the empirical development of technologies that "worked" long before they were "understood".

During Britain's Industrial Revolution, a rapid expansion in the exploitation of empirically-based technology in the pursuit of

more competitive production processes helped to lead the world into a new era of manufacturing. As markets expanded, technology both filled the gap that stood in the way of more cost-effective production and led to the development of new products. Schumpeter, writing in 1911, identified the discontinuity and imbalance caused by the entrepreneurial investment in inventions as the basic impulse of development for the capitalist economy. Inventions, which had no intrinsic value in their own right, were given economic significance by entrepreneurs who used investment to translate the new ideas into some form of tangible commercial advantage. The entrepreneur has to identify and satisfy the needs of the market: "production follows needs; it is so to speak pulled after them" (Schumpeter: 1911 p12). Yet these needs are subject to constant change and: "...every method of production in use at a given time bows to economic appropriateness" (ibid: p13). Facilitating the "coupling" of knowledge (articulated in terms of products or services) to market needs is at the very core the innovation process. However, the characteristics of knowledge associated with many ares of technology has changed dramatically.

As the twentieth-century progressed, many areas of technology became far more complex and practical "know how" required the support of formal training, book learning and formal records of past progress. At the same time, some aspects of commercial technology became more closely related with science. In certain instances, science had progressed to the point where it could be used to shape the development of practical technologies. For example, the development of the early US electrical industry and the German chemical industry illustrated a distinctive intermingling of science (in the form of "know why") with technological "know how". Certain aspects of scientific knowledge suddenly had a legitimate place in the knowledge creating network. At the same time, the increase in complexity of certain aspects of technology gave rise to a need for research and development departments to promote a greater understanding of corporate technology and provide scope for improving its

reliability and advancing the frontier of best practice performance.

In advancing beyond medieval empiricism and the use of skills derived mainly from personal experience, technology underwent a fundamental change. It became more dependant on formal documentation as a networking medium. The significance of this change is reflected in Brown's (1992) argument that the document as one of the most powerful technologies ever invented. Documents provide a ratchet for mankind's knowledge and enables individuals to extend their reach so that people who not have direct access to each other can interact. The word text comes from the same latin root as the word textile, namely "texere" meaning to weave. Thus documents emerged as both an early and enduring medium for recording and networking knowledge.

In 1943, Schumpeter noted how it had become possible to invest in invention. According to Freeman, the professionalism of R&D represented a "research revolution" in which "high technology" or "advanced technology" became based on a formal and systematic body of learning (Freeman: 1982 p15). After the Second World War, science was held in particularly high regard in the US and leading European economies. The rapid development of nuclear technology, anti-biotic drugs, lasers, radar, synthetic fibers and jet engines promoted a widespread belief in the notion that technological development could be based on the application of scientific discoveries. However, by the 1960s it was becoming increasingly apparent that countries, such as the US and UK which invested heavily in basic science, were not matching the economic growth rates of Japan and Australia where scientific expenditure was significantly lower. A number of empirical studies of innovation conducted in the 1960s and 1970s evaluated the relative influence of "technology push" and "need pull" as sources of innovation. While the results were mixed, a consensus gradually emerged that innovation had multiple sources, with a general emphasis on the pursuit of technologies tailored to the development of anticipated customer needs which, on occasions,

could be tempered or redirected by significant scientific or technological breakthroughs (Langrish et al: 1972).

Use and redesign, modification and improvement all promote the development of new ideas and lead technologies to the point where the market judges them to be "mature" in the sense that demand does not have a buoyancy which is sufficient to induce further innovation. This notion of a "path" of related improvement innovations has been referred to by Nelson and Winter in terms of a "natural trajectory" which follows from a particular technological regime. They illustrate this concept with the example of the DC-3 aircraft which was designed in the 1930s and defined a technological regime (identified by the characteristics of metal skin, low wing and piston engine propulsion) which guided aircraft design for more than two decades.

The tendency of technology to evolve within a set of guiding constraints bears some similarities with Kuhn's concept of scientific paradigms (Kuhn: 1970). Dosi (1982) has explored this relationship using the concept of "technological paradigms" which approximate to what Kuhn saw as the stability of "normal science" which guides gradual progress. Occasionally, a new way of doing things will emerge that is sufficiently promising to attract the attention of an enduring group of adherents (the equivalent of a "new knowledge creating network"). Pursuit of research in this new paradigm then follows an agenda that is shaped by accumulated experience, which provides a basis for interpreting the problem and indicating possible approaches to its solution. That is to say, past progress suggests a "line of attack" for future enquiry. In this way, particular avenues of technology acquire a "momentum of development" which can have a powerful exclusion effect over alternative approaches that might well embody a greater long-term potential, but have not been developed to the point where their advantages are clear.

The extent to which there are actual paradigm shifts, as opposed to the cumulative synthesis of what has gone before, is matter

of some debate. At the heart of the problem is the question of what actually constitutes a "breakthrough". For example, while scientific discoveries that subsequently spawn new technologies are often referred to as "radical" advances, the supporting science that led to the discovery is typically the product of successive incremental advances. However, once new trajectories are established (whether by "evolutionary" or "revolutionary" means) they generally have a powerful exclusion effect over alternative approaches which might be promising but are, as yet, unproven. Moreover, as trajectories gather momentum, this effect generally becomes more pronounced as alternative approaches have to overcome a greater barrier.

In evolutionary models of innovation, the development a particular avenue of technology follows is both guided and stimulated by user requirements. Like technology, user requirements change over time and map out, what may be called, a "corridor" of increasing expectations, which rise in concert with parallel improvements in technological performance characteristics (Georghiou et al 1976, Ray et al: 1989). For example, the corridor of user expectations related to transport technologies been extended by both improvements in particular technological regimes -- such automobiles -- and the development of qualitatively different combinations of technology to create a new mode of transportation -- as illustrated by practical realization of aviation. Elevated user expectations both follow in the wake of technological advances and act as an inducement to make further progress. Hence the corridor of evolving user requirements defines an evolving "arena of competition" within which rival firms vie with each other to capture a larger share of the market by producing more innovative products -- thereby bidding up the currency of prevailing best practice technology. This occurs to the point where maturity is reached and further improvements can not be translated into improved competitive performance.

Nevertheless, technological maturity is by no means a fixed

state. New technologies, or established technologies in a hitherto unrelated area, might provide a means of supplying improved performance characteristics -- thereby stimulating the further development of a technology that was considered to be mature. The famous "sailing ship effect" illustrates this principal by drawing attention to the fact that sailing ship performance improved at an accelerated rate in the face of competition from steam ships. Thus, it is quite possible for more than one technology to exist in the same "corridor" or "competitive arena" until a dominant technological regime establishes itself as being more advantageous in terms of meeting user requirements.

A further factor affecting the prevailing status of a given technology is its associated network of complementary technologies and services. As Rosenberg has pointed out, user perceptions of the automobile are affected by complementary activities ranging from a network of service stations to an extensive system of paved roads (Rosenberg: 1976 p110). In consequence, changes in complementary factors might reshape user requirements and thereby shift the relative standing of different products and technologies.

Competitive innovation is about sustained performance in the face of a dynamic changes in the myriad of factors that make up the firm's operating environment. Environmental change can both threaten the core competence of a firm or generate new scope for further dimensions of development -- for example by "bending" a corridor of development in user requirements towards the core competencies of the firm. The dramatic increases in oil prices that took place in 1973 for example "bent" part of the corridor of user preferences for automobiles towards an increased demand for more fuel-efficient cars. In consequence, auto-makers with the greatest competencies in fuel-efficient cars were more favorably placed to exploit this change in the market environment.

In recent years, interest in the processes by which firms interact with environmental changes has been instrumental in elevating business strategy to the position of being a mainstream management discipline. Effective strategy involves the realization of "differences that make a difference" to a firms ability to compete. It is about the pursuit and exploitation of diversity in order to cope with an ever changing operating environment. As earlier remarks in this paper have stressed, new ways of doing things have to embody some form of advantage, if they are to be selected for retention and survival. Porter has pointed out that, without a unique advantage over its rivals, a business has no reason to exist (Montgomery and Porter: 1991 p6). Yet the criteria for selection are rarely stable and, in turbulent technological and market environments, can represent an ever changing pattern of constraints and opportunities. Meeting prevailing and future patterns of user preferences for particular combinations of product performance characteristics at appropriate prices is an uncertain business. The magnitude and direction of changes in the "corridor" of user preferences are frequently hard to predict accurately. They represent moving targets that can all to often become blurred as previously distinct technologies and markets inter-mingle to redefine the arena of competition. At the time, factors such as regulatory changes, shifts in relative prices and the vicissitudes of fashion can all serve to shape or redirect the evolution of user preferences.

The treatment of knowledge in models of innovation and business strategy have often focused on the institutional sources of knowledge (ie whether it comes from within the firm itself, a competitor, a hitherto unrelated technology, public domain science etc) and the consequences of using particular pieces of knowledge -- ie the "revealed performance" that can be attributed to the exploitation of specific aspects of knowledge. However, they tend to ignore a rather different question which relates to the nature of knowledge creation processes within the institution, together with the related issue of how these

processes can be managed amid a dynamic environment. It is this question of what happens within the organization lies at the core of the present discussion of organizational knowledge creation.

Traditional models of organizations frequently ignore the dynamic interaction between an organization and its environment. Instead, they simply portray organizations as systems which solve problems by processing information. While this approach may be useful in certain circumstances, it can be argued that it embodies a rather static perspective that pays excessive attention to what is given to the organization without due regard to what it creates. In reality, both the organization and the environment are subject to continual change. This change means that the organization has to mobilize the creativity of its members to generate a level of diversity that is commensurate with sustaining the competitive advantages necessary for continued survival. This task hinges on a question of balance. While a stagnant organization might be washed away by turbulence in its technological or market environment, excessive creativity can be inappropriate in a relatively static operating environment. In consequence, organizations have to be selective and build creativity to an extent which is appropriate to their resource base, on the one hand, and prevailing environmental circumstances, on the other. Successful mediation between these two conflicting themes is at the very foundation of effective strategy formation. Knowledge has to be created with regard to the changing patterns of constraints and opportunities that exist in the firm's operating environment.

1.3 Knowledge and Information

Before addressing the development of organizational knowledge creation, it worth taking some time to consider the nature of knowledge. There a widespread tendency to equate knowledge with "information" and view it as a commodity which should be sought with a view to exploitation. Yet, while the terms "knowledge"

and "information" are often used interchangeably, for present purposes it is helpful to consider some of the differences between the two concepts.

Part of the confusion surrounding the nature of information can be traced from a distinction between its "syntactic" and "semantic" dimensions. While the syntactic dimension of information relates to quantity (as measured in the bits and bytes of computer technology or number of words in a book), its semantic qualities are concerned with meaning. This difference can be seen in the case of telephone bills, where the amount charged is related to time taken and distance covered but is independent of the content of the conversation -- three minutes spent exchanging trivia costs the same as three minutes of serious discussion. From the point of view of knowledge creation, the value of information is bound up with its meaning to the individuals concerned (ie semantic qualities) and the extent to which it can be used to build some form of advantage through a deeper level of understanding.

When compared to information, knowledge has more to do with the level of personal understanding -- which need not be in any way proportional to the volume of raw data. Moreover, knowledge creation can be conceptualized in terms of building shared understanding amongst communities of individuals who are concerned with a particular problem or group of problems and depends on the exchange of meaningful information. As Schrage has pointed out, effective communication involves collaboration to share the meanings that can be abstracted from information.

> People have to use words, symbols, images models -- whatever they can get their hands and minds on -- to construct relevant meanings from available information and their individual expertise. Don't forget that the linguistic root of communication is the latin verb communicare -- which does not mean "to communicate" but "to share". Collaboration takes communication back to its

roots.

(Schrage: 1990 p6)

In the present context, information may be seen as a medium for facilitating knowledge creation through collaboration. Deeper understanding can be derived from the acquisition of, what Polanyi has referred to as, "explicit" and "tacit" understanding (Polanyi: 1966). Explicit knowledge relates to things which are "known" and can be shared easily between individuals. Its essential qualities can "captured" in a codified or schematic form that allows its subsequent transfer to other individuals. By contrast, "tacit" knowledge is concerned with an individual's intrinsic feelings which, because of their very nature, are personal and difficult to express in a manner that can be readily understood by others. It represents concepts that are to some extent hidden and it is quite possible that they might even be hidden from the individual involved! That is to say, individuals can draw on tacit understanding without being in any way aware of the complicated information processing procedures that are required to realize such an achievement. Such an understanding might allow tasks to be performed -- like riding a bicycle -- without the individual being aware of the enormous complexity of the mental processes involved. This represents a "technical" aspect of tacit knowledge which involves the "know how" associated with specific skills and crafts. However, there is also a "cognitive" dimension to tacit knowledge that relates to way in which individuals interpret their environment.

The cognitive elements of tacit knowledge center on what Johnson-Laird (1983) has referred to as the "mental models" used by human beings to create and manipulate images in their minds. These working models include conceptual paradigms and judgements which enable individuals to form "perspectives" for interpreting their environment. As Nesbit has noted: "much of what Michael Polanyi has called 'tacit knowledge' is expressible -- in so far as it is expressible at all -- in metaphor" (Nesbit: 1969 p5). Metaphors provide a powerful tool for building the conceptual

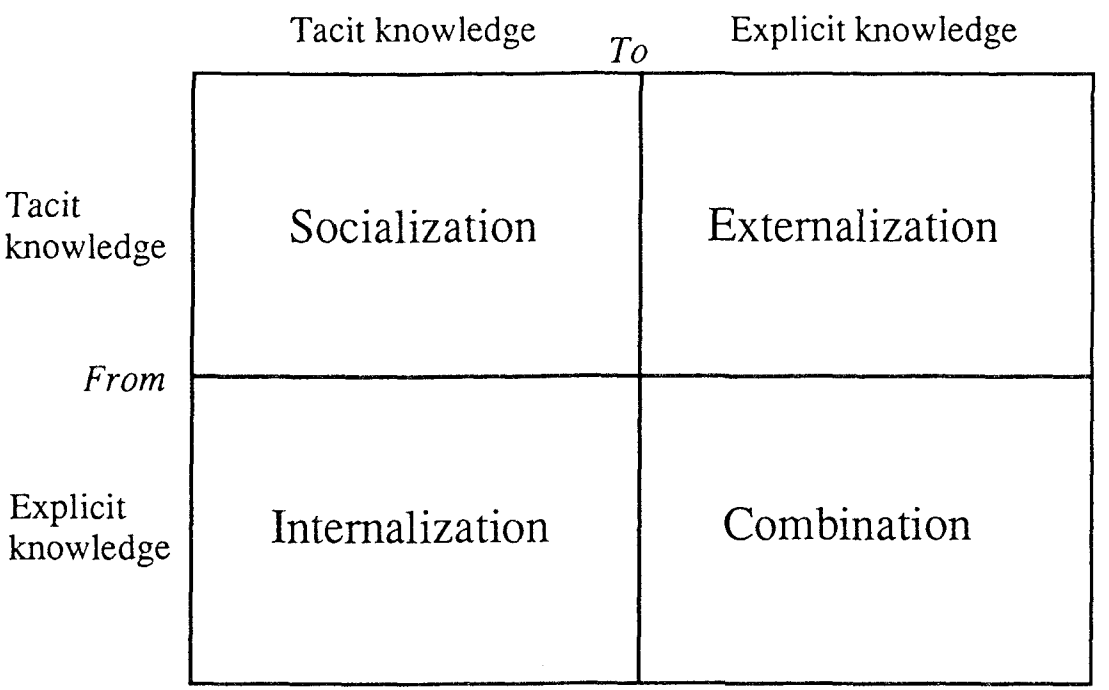
structures that are used to manipulate and develop tacit understanding. In Lakoff and Johnson words: "The essence of metaphor is understanding and the experiencing of one thing in terms of another" (Lakoff and Johnson: 1980 p5). As a method of perception, metaphor uses comparison rather than the synthesis of common attributes -- it is a creative process which links concepts that might ordinarily be far apart in the individual's mind.

Cognitive images can be developed and refined through the use of analogies. While the terms metaphor and analogy are often used as substitutes for each other, it is possible to draw a distinction between their respective meanings. In essence, metaphors are formed through perceptions of images and allow the free association of ideas. By contrast, analogies enable the functional association of new concepts or systems to be explored by reference to mechanisms that are already understood. They provide scope for current problems can be accessed by reference to established knowledge and in so doing bridge the gap between metaphorical images and logic. Thus, while a metaphor might provide scope for the first intellectual "jump", analogies create scope to for offering functional explanations of how things might operate at a system level. Through a combination of metaphors and analogies, individuals use the cognitive dimension of tacit knowledge to form interpretations of contemporary events and visions for the future.

1.4 The Basis of Knowledge Creation

The dynamic thrust of knowledge creation processes center on a continual two-way dialogue between explicit and tacit knowledge. This dialogue occurs both in the minds of individuals and (as the next section will explain) across knowledge creating networks. The tacit-explicit interchange helps to express the hidden dimensions of "frontier" thought processes and thereby allows the

Figure 1 Modes of the Knowledge Creation



articulation of embryonic thoughts that can be shared and developed. Such an interaction between tacit and explicit knowledge can be seen as representing the "epistemological" dimension of the knowledge creation processes. Although it is difficult to classify actual knowledge as being either entirely tacit or entirely explicit, at a conceptual level it is possible to produce a two-by-two matrix which contains four modes of interaction -- or "conversion" -- between tacit and explicit knowledge. This is shown in figure 1 and comprises knowledge conversion: (1) from explicit knowledge to explicit knowledge; (2) from explicit to tacit; (3) from tacit to explicit; and (4) from tacit to tacit.

The first mode of conversion involves the assimilation of existing explicit knowledge to produce new explicit knowledge as for example might occur in the case of a report which is produced on the basis of information collected from a library. This form of knowledge conversion will be referred to here as "combination", since existing knowledge is being combined to produce something new through a process of sorting, adding and re-configuring existing explicit knowledge.

In the second knowledge conversion mode, explicit knowledge is "internalized" by individuals. This is a form of learning process where individuals have access to explicit knowledge and, as a consequence, are able to extend their tacit understanding. In such a case, explicit knowledge might trigger an association of tacit ideas and advance the frontier of the individual's overall tacit knowledge. (This mode of conversion approximates to notions of "learning" and, from a theoretical point of view, represents the common ground between models of "organizational learning" and the more wide-ranging concept of "organizational knowledge creation" which contains a further three modes of knowledge creation.)

The opposite of internalization is "externalization" which occurs in the third mode of knowledge creation as individuals seek to

translate their tacit understanding into tangible concepts which can be articulated in terms of explicit knowledge. Such a challenge can be a major problem for the producers of so-called "expert systems" -- which aim to capture the expertise of an expert in a computer program. The performance of such systems is governed by the extent to which the expert's knowledge can be externalize and codified in the program.

The final form of knowledge conversion centers on the sharing of tacit knowledge and is in many ways one of the most challenging aspects of knowledge creation. Although ideas are formed in the minds of individuals, interaction between individuals can be crucial to the mobilization and exchange of tacit knowledge. This is a social process and the conversion process is one of "socialization". Social "communities of interaction" form the means by which tacit knowledge is shared and created. An apprentice learns from the craftsman not simply be words but through observation, imitation and practice. In business, "on-the-job-training" uses a similar principle.

Tacit knowledge creation is an a continuous activity that embodies what Bateson has referred to as an "analogue" quality (Bateson:1973). Sharing tacit knowledge involves a continual struggle to build mutual understanding and might make frequent reference to metaphors and analogies. It is driven the by sharing of ideas that are the forefront of creativity. This involves a kind of "parallel processing" so that different dimensions of the knowledge being shared can be processed simultaneously. It has a "living quality" associated with the unfolding of new dimensions of understanding. By contrast, explicit knowledge has a packaged "digital" quality. It is "free-standing" and can be used when required on a sequential basis. However, without a common environment, it tends to be difficult for one person to put themselves, so to speak, in another person's shoes and gain a full appreciation of the knowledge.

Brown (1992) has argued that: "The organizations of the future will be 'knowledge refineries' in which employees will synthesize understanding and interpretations from the sea of information that threatens to flood them from all sides." He subsequently goes on to suggest that, in a knowledge refinery, workers need to collaborate with both the present and the past. While collaboration with the present is about sharing tacit knowledge, collaboration with the past draws on experience gained from previous ways of doing things.

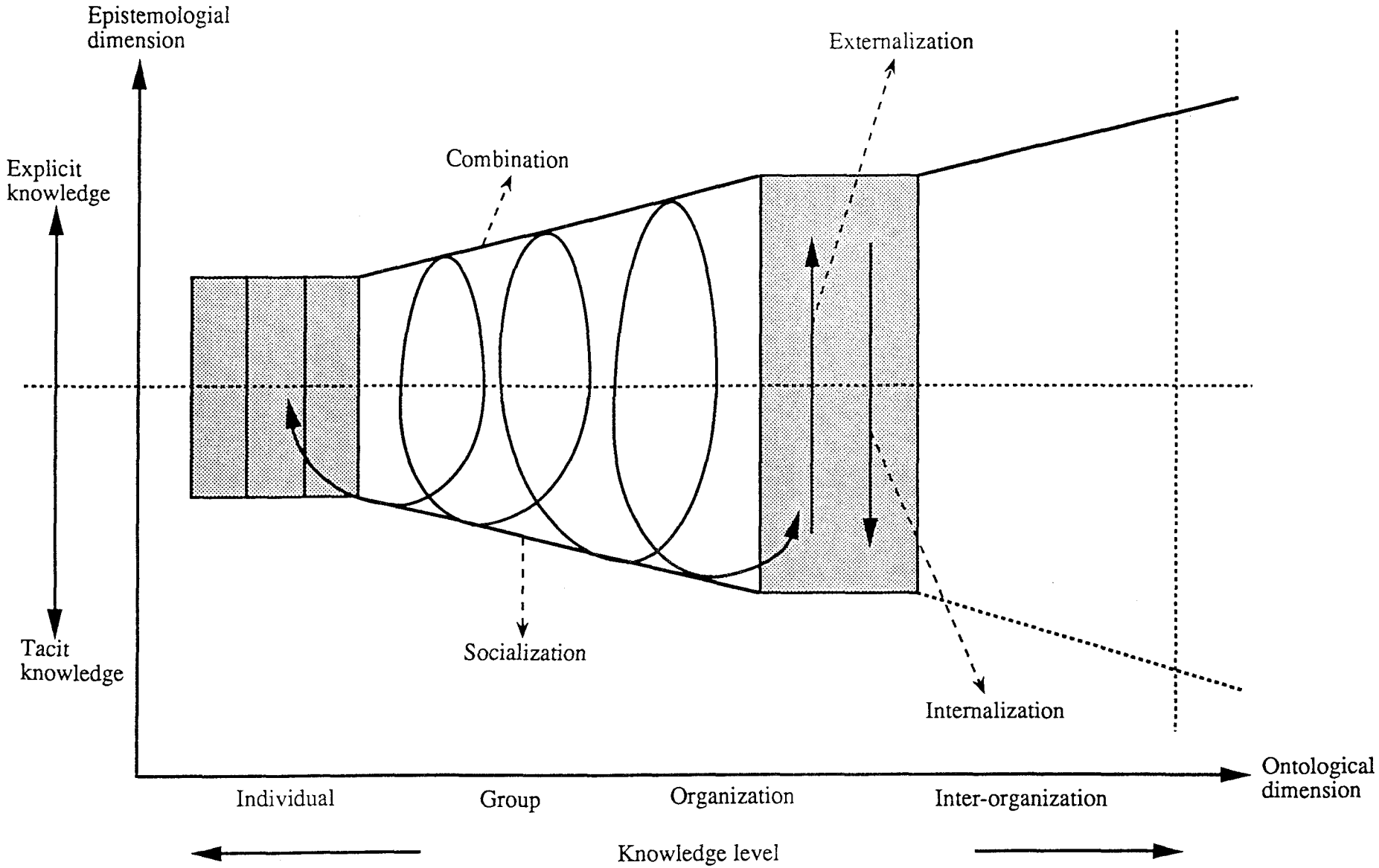
Building links with the past relies on the use of explicit, codified knowledge articulated in documents mixed with the distilled judgement of past experience. This information is accessed on a sequential basis by consulting sources such as archives, libraries and data bases. In the process, old memories might be triggered and help to build a fresh interpretation of current events.

Making sense of contemporary events involves rapid parallel processing of multiple information sources. Such skills enable familiar faces to be recognized in an instant. A first impression of complex pictures can be formed long before points of detail are assessed.

1.5 A Spiral of Knowledge Creation

In addition to the epistemological interaction between tacit and explicit knowledge, it is also possible that there will be an expansion in the "community of interaction". If new knowledge is relevant to the needs of the organization, it is likely to permeate through groups and divisions and thereby extend the community of interaction dealing with that knowledge. New knowledge that has a potential to support more advantageous ways of doing things is likely to be retained as a subject for further debate within the network and may also lead to an extension of the community of interaction. For example, what eventually

Figure 2 Spiral of Organizational Knowledge Creation



proves to be a successful product might emanate from a R&D department and gradually acquire a greater circle of interested parties within the organization as the dimensions of its potential impact become more clear. As news of the emerging product travels beyond the organization, the circle will grow still wider embracing competitors, customers, firms dealing with complementary technologies and so on. Thus the network will go beyond the original "hard core" of knowledge creators to include those that are in some way affected by the exploitation of that knowledge.

This growth in the community of interaction represents what can be called an "ontological" dimension to knowledge creation and forms the horizontal axis to the spiral shown in figure 2. However, it should be emphasized that in reality there is no reason to suppose that there will be linear sequence of expansion -- starting from the individual, then progressing to the group and subsequently to the organization and beyond. The community of interaction could span departmental and organizational boundaries from the outset. Possible members of this community such as suppliers, customers and competitors might all enter the knowledge creating spiral at any time. In this connection, Brown and Duguid (1991) have drawn attention to the remarkable disparity that frequently exists between the way individuals actually collaborate with each other and the patterns of communication that are articulated in terms of official organizational charts and management handbooks detailing "appropriate procedures". Their point is that actual communication networks center on "evolving communities of practice" which reflect the way people actually work on a day-to-day basis.

From the point of view of managing organizational knowledge creation it is important to be aware of the true location of participants in the relevant community of interaction. Some form of "map" of actual communication channels is needed, which details what really happens as opposed to theories presented in

organizational flow diagrams and so on. The next step is then to build an appropriate mechanism to facilitate the sharing and creation of knowledge. Nevertheless, this is all too often easier said than done. As Schrage has noted:

> ...to a disturbingly large degree, most organizations lack the collaborative infrastructures that enable people to share their talents in ways that satisfy the individuals need for expression and the organization's imperative for results.
>
> (Schrage: 1990 pxxiii)

We will now turn to a consideration of how appropriate collaboration mechanisms can be established to manage the process of organizational knowledge creation.

1.6 The Management of Organizational Knowledge Creation

In the final analysis, knowledge creation depends on individual creativity, the organization has to support the quality of knowledge held by individuals and increase their potential for creativity which can be used to develop organizational performance. A lack of variety can mean that the individual simply does not gain the tacit experience that is necessary to promote original thinking. For this reason, Japanese companies often adopt a policy of job rotation to enable employees to see the organization from a variety of perspectives. However, simply raising the level of variety in an individual's activities may achieve little if the experiences are completely unrelated and there is little opportunity for them to be "fused" to form new concepts. Rather, enhanced tacit knowledge is more likely to result from the individuals ability to "indwell" in the experience held by members of the organization that are engaged in relevant tasks. The individual has to be in a position to access the relevant "knowledge creating networks" and "communities of interaction" so that what is observed does not

exist as mere information but instead has context and meaning that can be assimilated into accumulated personal experience. In essence, the individual has to go beyond being a distanced, passive observer of new circumstances and instead achieve a level of familiarity that is capable of supporting active involvement in the new issues and challenges. Active participation generates the potential for the individual to form "new perspectives" and thought processes associated with what Schon has described as "reflection in action" (1983) whereby reflecting whilst undergoing new experience can stimulate the crystallization of new ideas. As Schon observes: "When someone reflects while in action, he becomes a researcher in the practice context. He is not dependant on the categories of established theory and technique, but constructs a new theory of the unique case" (Schon: 1983 p68).

An important dimension to the production of knowledge in Japanese firms is "redundancy of knowledge". Redundant knowledge is shared by individuals can provide a "common currency" that enables one person can enter person's "arena of thinking" and offer advice. The reduction of information differentials enables individuals to interact on more equal terms, which makes organizational knowledge more fluid and easier to put into place. Examples of "learning by intrusion" are common in Japanese organizations. Thus, in addition to knowledge that is, to use a military metaphor, on "active service" in an individual's day-to-day activities, there is a passive "reserve army" of knowledge that can be deployed, should appropriate circumstances arise. Japan's tradition of lifetime employment with the same organization is instrumental in building high levels of trust between organizational members. Knowledge can be shared on a long term basis and so the creation of "redundant knowledge" might be deployed over a period of several years -- making it a potentially more worth-while investment than would be the case in conditions of high staff turnover. Moreover, it is unlikely that the corporate "knowledge pool" will leak to other organizations on account of an individual changing jobs.

(Gaining knowledge by "poaching" employees is rare in Japan and generally considered to be unethical.) The concept of the "the group", which permeates every level of Japanese society, is held together by the "glue of shared knowledge" and, in this context, redundant knowledge is a form "reserve binding force", which might be brought in to play if environmental circumstances change. Thus, redundant knowledge gives the group greater resilience in the face of an adverse or unexpected turn of events.

Product development in successful Japanese firms often involves overlap and extensive collaboration between different sections of the organization. Moreover, team members might move with the project "rugby style" as it progresses from conception towards fruition -- in some cases staff might actually follow a project through all the departmental locations associated with its development: thereby increasing the chance that solutions to be current problems can be triggered by reference to first-hand experience of earlier difficulties. By contrast, Western approaches often involve considerable demarkation between departments which have rigid boundaries. There is wide-spread support for the idea that procedures should be well documented and less reliant on tacit knowledge which could be lost with the movement of a key individual. Product development can be characterized as being more analogous to a "relay race" in which the "baton" of project development is handed over from department to department with minimal interaction. Since "socialization" is impeded by such a rigid division of labor, the degree of tacit knowledge that can move with the project is relatively limited.

Redundant knowledge and "rugby style" development can contribute to the speed at which Japanese firms are able to develop new products. It promotes good communication channel between departments which can used to smooth the project's progress and bring a range of expertise to the solution of problems that might occur. For example, insights from the marketing department might be able to provide an input to the way in which a production

problem is solved, thereby eliminating the delays that would otherwise follow from waiting for the production department to act independently prior to offering feedback. This type of collaboration between departments provides flexibility and enables concepts to be realized quickly, although the lack of strict specifications at each stage means that there is a need to guard against the risk of confusion that might be caused by design changes or other alterations.

If knowledge creation is to proceed effectively, there is a need for some form of "focusing force" to channel creativity towards prevailing commercial requirements. This channelling effect can be seen in terms of "creative chaos" of the type that is generated naturally when the organization faces some form of crisis, such as a decline in performance due to a shift in market requirements or the improved performance of competitors. The sense of urgency associated with a real crisis can be generated artificially when leaders of an organization present their staff with challenging goals. Creative chaos can increase tension in the organization and focus attention on forming and solving new goals. Visions from senior management can be used to stimulate the construction of new problems and objectives. This might be implemented by "internal competition" between rival approaches to exploring a particular problem in an attempt to identify the most relevant approach.

The balance between "redundant knowledge", which is an expansive entity that can grow without any natural limit, and "creative chaos", which is a compressive, focussing force, can be articulated by Ashby's notion of "requisite variety" (Ashby: 1956). This relates to the notion of an appropriate degree of diversity which varies according to prevailing environmental circumstances. In models of organizational knowledge creation, requisite variety represents a idealized "best case" level of diversity which strikes an appropriate balance between creativity and commercial imperatives.

1.7 Self-organizing Project Teams

Articulating new concepts formed by individuals to produce knowledge which is useful at the organizational level can be achieved by the formation of a self-organizing project team or "task force". Such teams are a common method of developing new products in Japan and represent an attempt to create interdisciplinary groups that comprise representatives from various "knowledge creating" networks which can be brought to bear on a particular problem. As Brown and Duguid (1991) pointed out, day-to-day problems frequently prompt individuals to collaborate in informal groups and exchange ideas frequently through the exchange so-called "war stories" based on past experience. These war stories allow a problem to be viewed from different angles and achieve the "hypertext" facility, mentioned in the introduction, whereby comparison and re-contextualization of existing knowledge can lead to new understanding. The challenge for management is to use task forces in such a way that the collaboration that exists on an informal basis (in communities of practice) can be put on a more formal footing and directed towards organizational objectives. This requires building project teams which include relevant members who can be managed in such a way that they work effectively together in order to create the levels of socialization necessary to solve a target problem or, if necessary, redefine the target. Effective socialization depends on the existence of mutual trust between members and the rapid building of shared perspectives through continuous face-to-face dialogue.

Observations of Japanese companies have indicated that successful project teams generally comprise between 10 and 30 individuals, with the upper limit arising because of constraints on the level of interaction that can be achieved between members. The team typically includes 4 or 5 "core members" who have careers which include a range of job functions. The span of team activities need not be confined to organizational activities. This is especially true where project team activities include the seeking

out and exploitation of environmental knowledge. In Japanese firms, suppliers of parts and components are sometimes involved in the early stages of product development, while customers might be involved with product planning processes.

Once the team has been formed and mutual trust established, the immediate challenge is the articulation of project concepts through the externalization of relevant tacit knowledge. Here the use of metaphors and analogies can be made operational by recourse to dialogue and dialectical debate. This might seek to promote a multi-faceted interchange which allows scope for revision or negation. Participants should be able to express their ideas in a candid and open manner. Negation for its own sake, which is easy but not necessarily productive, should be is discouraged in favor of constructive criticism based on reasoned arguments. Dialectic debate tends to be most effective if there is temporal continuity to allow a spiralling of affirmation and negation in the pursuit of new knowledge. This process can often be stimulated by the volatile and dramatic nature of dialogue.

In a self organizing project team, redundant knowledge will typically play a major role promoting mutual understanding and building trust. Moreover, as the team progresses, apparently-redundant knowledge might suddenly find a niche for application and feed into the creation of new conceptual approaches. In consequence, more team members are exposed to the possibility of assuming a position at the forefront of the knowledge creating spiral. This notion is consistent with what McCulloch has described as the "principle of redundancy of potential command" (McCulloch: 1985). Under this principle, leadership varies according to prevailing circumstances and all parts of a system are assumed to embody the same potential for assuming a leading role.

1.8 Middle-up-Down Management

Notions of "top-down" and "bottom-up" management pervade the literature on management science. Both terms relate to the flow of information processing. Firms are often assumed to be located at some point on a continuum between the two extremes. This depends on the extent to which information is disseminated by top management or is allowed to rise from the lower levels of the organization and thereby inform the decision making processes. However, a central theme of the this report is the idea that organizations do not only have to process information -- they also have to create knowledge. This involves "communities of interaction" based on members from a diversity of locations in the organization and can also span organizational boundaries. The essence of "Middle-up-Down" (MUD) management is that no particular section of the organization has exclusive responsibility for creating organizational knowledge. Knowledge can originate from multiple sources within and outside the organization. It is then the job of management to decide how knowledge creation processes should be managed and exploited.

In the MUD model, top management provides images of future directions for corporate development and the time-scale by which these "visions" have to be realized. They are responsible for articulating the company's "conceptual umbrella" which defines a direction for unifying the companies different activities. Company leaders articulate these visions in terms of metaphors, symbols and concepts that give direction to knowledge creating process. Middle managers then translate these visions into practical projects. In other words, top management expresses the dream of the firm and middle managers look at the reality. The top management conceive of what ought to be while middle managers are more concerned with the harsh details of what actually exists. In such a model, middle managers emerge as the key link in the chain between current capabilities and future aspirations.

While future visions aim to provide a unifying theme, they might

also be ambiguous and open to a variety of alternative and even conflicting interpretations. This reflects the idea that a vision which is too sharply focussed becomes more akin to an order or instruction. If middle managers are given some opportunity to shape the concept, they are likely to become more committed to the process of putting it into practice. An equivocal vision gives employees and self organizing teams some degree of autonomy in setting their own goals. An important point here is that top management feels able to trust its middle managers.

At the lower levels of the organization, front line employees and junior managers are saturated by the details of technologies, products and markets. No one is more expert in the realities of the company's business than they are. Yet, while they are deluged with information, they frequently find it difficult to turn that information into useful knowledge. On some occasions, information can exhibit a bewildering quality which makes it difficult to interpret in a meaningful way. For example, signals from the market can be vague or ambiguous. Also, front-line employees can easily become so caught up in their own narrow perspectives on the job in hand that they loose sight of the broader context. Even if they do develop meaningful ideas, it can sill be difficult to communicate the value of that knowledge to others, since much of what they appreciate is likely to be tacit and context specific. The problem can be summarized succinctly by T S Eliot's speculation "Where is the knowledge we have lost in information?". Abstracting meaningful knowledge from the information that overwhelms day-to-day business activities therefore emerges as a challenge to middle managers. Thus, in MUD, middle managers have to provide their subordinates with some form of conceptual framework for making sense of their own experience.

Knowledge creation does not simply rely on charismatic managers at the top of the organization or on the detailed knowledge of front-line employees. Instead it extends across and beyond the

Table 1 A Comparison of Three Management Models

	TOP-DOWN	MIDDLE-UP-DOWN	BOTTOM-UP
agent of knowledge creation	. top management	. group (with middle managers as intrapreneurs)	. entrepreneurial individual
resource allocation	. hierarchically	. from diverse viewpoints	. self-organizing principle
pursued synergy	. "synergy of money"	. "synergy of knowledge"	. "synergy of people"
organization	. big and powerful Hq. staff . use manuals	. team-oriented . affiliated firms by intrapreneurs	. small Hq. . self-organizing suborganizations
management processes	. leaders commanders . emphasis on info processing . chaos not allowed	. leaders as catalysts . create organizational knowledge . create/amplify chaos/noise	. leaders as sponsors . create personal information . chaos/noise premised
accumulated knowledge	. explicit . computerized/ documented	. explicit & tacit shared in diverse forms	. tacit . incarnated in individuals
weakness	. high dependency on top management	. human exhaustion . lack of overall control of the organization	. time consuming . difficult to coordinate individuals

Source: Updated from Nonaka (1988b).

company and, in this respect, middle managers occupy a position at the cross roads between vertical and horizontal information flows. They bridge the gap between visionary ideals at the top of the organization and the front-line of business activity conducted at lower levels in the hierarchy. Neither pure romanticism nor undiluted realism provide comprehensive recipes for running a company. Middle managers have to mediate between the child-like innocence of grand visions and the hardened cynicism of front-line employees whose dreams have long since passed. Their function is analogous to a knot that binds top-down and bottom-up models. They are the knowledge engineers of the knowledge creating organization. A comparison MUD, top-down and bottom-up management styles is shown in Table 1.

MUD management and more general principles of knowledge creation will now be illustrated by the three case-studies that comprise Part 2 of the report.

PART 2 CASE-STUDIES OF ORGANIZATIONAL KNOWLEDGE CREATION

2.1 CANON's MINI-COPIER

The main focus of this case-study is Canon's successful development of its Mini-Copier, which provides a graphic example of how a company can create a new market by re-conceptualizing an apparently mature product. At a time when the photocopier market was saturated, Canon used a remarkable ability to learn from past experiences (derived from unsuccessful diversification activities) to plot a an unerring course towards the development of a significantly cheaper product that would be within the reach of a much larger population of potential users. This involved a completely fresh approach to photocopier design in order to avoid the maintenance requirements that were associated with established products and, at the same time, produce copies of an acceptable quality. The study shows how a task-force can be marshalled to bring a diversity of expertise to overcoming technological bottlenecks in such a way that creativity is combined with an acceptable level of efficiency.

Canon's experience illustrates how a sense of "crisis" can be used constructively to concentrate attention on the realization of visions for future development. The task of top management is to translate these visions into reality by communicating attainable targets to employees. In the case of the Mini-copier, the crisis induced by saturation in the traditional photocopier market was used to focus the efforts of a large "task-force" to overcome the problems of producing a new type of copier. Under this umbrella, the "horizontal" diversity of thought, which is frequently a critical element in creative problem solving, was balanced with the need to concentrate on the "vertical" target of progress towards the product performance specifications that would have to be met if the product were to stand any chance of being commercially successful. In this respect, the study emphasizes the importance of "requisite variety", together with

the importance of an interdisciplinary but integrated technological knowledge base.

Background

Canon was founded in 1938 and, for more than twenty years, concentrated on being a specialist in camera and optical technologies. The first attempt to extend this well-established technological knowledge base came in 1959, when development started on the "Synchro-reader" or "voice mail", which was a machine for encoding spoken messages on magnetic cards which could be sent in the mail. The recipient could then use the card to reproduce the spoken message. However, the quality of reproduction represented a poor substitute for a telephone conversation and the product was a spectacular failure. Nevertheless, it did serve to challenge the established status quo within the company and focus attention on the possibility of doing things in a new and different way. This was reflected in a second attempt at diversification, which came in 1964 with the launch of the "Canola 130" -- a fast easy-to-use calculator, that enabled Canon to capture a growing share of the calculator market.

By 1970, calculators had become the second mainstay of Canon's business portfolio, accounting for 40 per cent of sales. However, the success story was interrupted in August 1972 when the calculator market was turned on its head by the launch of Casio's "Mini" pointed the way towards a growing demand for compact, personal calculators selling for less than 10,000 yen. Initially Canon equivocated about following this trend towards "popularizing" the technology -- believing that its expertise lay with higher quality products -- but , under pressure from the sales department -- who were desperate to a product that could compete with Casio, Canon developed the "Panther" personal calculator as an emergency measure. Canon entered the market more than a year-and-half after their competitors and immediately faced an uphill battle. In the first instance, Casio had a major

advantage in the form of an established distribution network via stationery store outlets -- whereas Canon had to start from scratch. The decisive blow for Canon came when it was discovered that the pioneering use of light emitting diodes (LEDs) had caused reliability problems. The LEDs, which were imported from a US company were sensitive to heat and frequently failed during Japan's hot summer months. These difficulties were compounded by difficult trading conditions arising from the effects of the 1973 oil price increases and, by June 1975, the company was unable to pay the shareholders a dividend.

Although the calculator group subsequently carried on to develop successful word-processors and type writers -- helped by the distribution channels to stationery stores -- in the mid-1970s, the company had to confront a level of crisis that threatened its very survival. To address this problem the president attempted to re-establish his employees self-confidence by offering the challenging vision of transforming Canon into a "Premier Company". The idea was to give people a worthwhile goal -- or rallying point -- that would provide a means to overcome the prevailing difficulties. This Premier Company Plan was scheduled to run over two successive three-year periods -- in the first instance focusing on Japan and subsequently on a more global markets. The realization of premier company status was to be achieved through rigorous attention to performance, quality and the building of sales networks. This included the reorganization of the company into product groups, directing attention towards the more effective use of personnel, increased automation and more general measures to build the corporate image.

The Canon Production System initiative was launched in 1976 as a drive towards greater efficiency in which employees were encouraged to reflect on their job functions and consider the potential for improved performance. This was done on a cooperative basis and efforts were made to the type of coercion that breeds resentment and the excessive pursuit of personal as opposed to corporate objectives. During 1978, the organizational

structure of the company was developed into a "matrix" style organization which reflected the evolution of "communities of practice" that had been taking place over several years. Horizontal structures responsible for research and development produce ideas and proposals that are appropriate to a cross-section of product groups which have the aim of making profits. The technological knowledge base represents related ares of expertise and is manages to promote synergic linkages between overlapping areas. A "dynamic harmony" between research and product-development functions is promoted by regular meetings between the chiefs of both dimensions of the matrix.

Canon's research base is supported by bodies conducting research according to different time horizons for exploitation ranging from near-market development to the work of the Advanced Technology center which engages in research directed towards applications between five and ten years in the future. Compared to other companies operating in similar fields of technology, Canon has significant numbers of employees from a relatively wide range of backgrounds -- mechanical and electrical engineers account for 30 per cent of the total; chemical engineers make up another 17 per cent; 10 per cent are trained in physics, while a similar proportion have backgrounds in computer technology.

Canon's quest to become a premier company led to it placing more emphasis on photocopiers and business machines than had previously been the case. By 1990, business machines accounted for three-quarters of Canon's sales. In 1991, total sales exceeded 1 trillion yen, reflecting the accumulated effects of an average growth rate of 14 per cent over the previous decade. Net profit in that year was 76 billion yen and followed five successive years of growth. It was against the background of the success of Canon's attempt to acquire "premier company" status that the company achieved its resounding success with its Mini-Copier.

Mini-copier

Canon's established knowledge base in camera and optical technology provided technological linkages that proved to be a key factor in enabling it to diversify into the photocopier market. Despite some internal opposition, the company initiated a project to develop a plain paper copier in 1962. Six years later, it was able to introduce a product that did not violate any of Xerox's 600 plus patents. This remarkable achievement was helped by strong linkages and commonalities with their established expertise in camera and optical technologies.

By the late-1970s, the demand for plain paper copiers levelled of as the market became saturated. Rather than admit defeat Canon set about re-conceptualizing the photocopier in terms of a cheaper and more reliable product that could be used by a larger population of users without incurring prohibitive maintenance costs. New users, such as small businesses and perhaps even households, would then extend the copier market. Naturally the new copier should be capable of producing clear copies. In addition, it was felt that it should be lightweight (less than 50 pounds) and compact, requiring only extremely simple maintenance or none at all. Moreover, the initial price should be equivalent to approximately $1,000 dollars. As a first step, a feasibility study team was formed to examine the problems that would be encountered in realizing the concept of a Mini-copier. A 14 member team was formed which had an average age of 28 and comprised 8 members from R&D, 3 from production, 2 from marketing and 1 from product design.

The central problem in producing a Mini-copier was resolving the conflict between low cost and high reliability. Reliability analysis of existing copiers revealed that 90 per cent of problems involved the drum. Brainstorming sessions were held on how to improve the reliability of the drum. Towards the end of one such session, the leader sent out for some cans of beer which were then consumed. At this point, discussion turned to the cost of disposable beer cans and, by analogy, the possibility of developing disposable photocopier drums. This stimulated a

lively discussion and prompted the conceptualization of a fresh approach to basic photocopier design based on packaging the drum and surrounding components in a disposable cartridge. By bringing everything together in the drum, the whole structure could be simplified allowing both cost savings and improvements to reliability.

It was clear from the outset that the commercial development of the Mini-copier would require talents from across the whole company. In consequence, a task-force was assembled comprising some 300 members selected by the president. With the exception of the enormously successful AE-1 camera development initiative -- this task force was the largest ever formed at Canon. Its slogan became the "development of the AE-1 copier", which was a powerful rallying call that evoked images of past success.

The projected use pattern for the copier was such that the reliability achieved by television sets was selected as an appropriate target. A Cost Group within the task-force sought to ensure that the product was engineered to meet the target selling price. New design technologies were developed to facilitate miniaturization, reduce weight and automate assembly procedures. The assembly line featured automated inspection machinery and process technology designed in collaboration with supply companies and the knowledge base so formed was subsequently exploited in other office automation products.

The Mini-copier was launched in 1982 and by 1987 had been instrumental in increasing Canon's share of the total copier market to 35 per cent, compared to 24 per cent in 1979. Between 1976 and 1983, the company's sales grew by a factor of 6.9 representing the highest rate among Japanese companies in the top 500 companies listed by Fortune magazine.

Conclusion

Canon's Mini-copier involved a move into a new area where there

were no teachers and, in consequence, limited scope to use authority as a legitimate mechanism for suppressing free discussion. Recognizing this fact and using a task force to coordinate a company-wide diversity of perspectives on the technical bottlenecks associated with Mini-copier's development. In addition to bringing together perspectives from a diversity of backgrounds, there is also a need to incorporate variety in the "mental approach" of different members to solving problems. For example, some individuals are biased towards active experimentation, while others are more inclined to draw insights from observations and passive reflection on the results of the enquiry. Naturally both sets of skills are needed -- experimentation generates new experience, which is complemented by the reflection that paves a way towards the formation of new concepts.

Canon's Mini-copier task force brought threw people together who then had to work as a self organizing team. A important point here is that the self organizing team was not a self-selecting team. Left to their own devices, senior development engineers would tempted to select team members that reflected their own research profiles -- whether "experimentation oriented" or whatever -- thereby undermining the principle of diversity and reducing the potential for creativity.

The diversity of the self organizing team creates an environment for asking basic questions that "experts" in a particular field might not consider. In addition to tacit understanding, there is also what might be called "tacit misunderstanding" where individuals believe they are sharing a common body of knowledge but in fact have inconsistent impressions of the problems being addressed. The involvement of individuals from different backgrounds can lead to a simpler dialogue in which understanding that might normally be shared on a tacit basis has to be externalized.

2.2 NISSAN's REVITALIZATION

Introduction

The present case-study of Nissan, which is Japan's second largest automobile maker after Toyota, illustrates how the use of "future visions" were used by the president to tackle what might be called the "big company disease" associated with the consequences of a bureaucracy characterized by rigid departmental barriers and a lack of creativity on the part of the employees. Initiatives were introduced to promote the constructive exchange of opinions and the opportunity to create new knowledge by reflecting on a diversity of viewpoints. Positive feedback arising from a new-found confidence in the ability of employees to propose different ways of doing things accelerated the momentum of change within the company. The prevailing organizational culture captured this change as employees became more customer-oriented in their attempts to promote the companies image.

However, creativity is no guarantee of competitiveness. Sustained increases in market share rely on products that embody a combination of price and performance characteristics which is appropriate to prevailing user requirements. Sustained increases in market share rely on products that embody a combination of price and performance characteristics that are appropriate to prevailing user requirements. In Nissan's case, signs of an improved competitive edge in its domestic market, which followed from articulating creativity in terms of new product designs, was undermined when the Japanese "bubble economy" of the late-1980s finally burst in 1991. Prior to this collapse, buoyant trading conditions had encouraged Japanese auto-makers to place some considerable emphasis on product differentiation as a means to capture a larger market share. Yet, when trading conditions became difficult, price competition became more significant and the industry leader, Toyota, whose motto is "good automobiles at a reasonable price" had a much larger sales infrastructure and economies of scale to switch back to this form of competition

with relative ease. By contrast, Nissan was not so well placed to adapt and in March 1993 went into the red for the first time since a period of extreme turbulence just after the Second World War.

Changing the Culture at Nissan

Many of the seeds of Nissan's creativity crisis can be traced to the period between 1975 and 1985. At that time, the company was concentrating on the rapid expansion of overseas operations and was less attentive to problems back in Japan where its organizational structure had developed into a rigid bureaucracy that stifled flexibility and creativity. It was an era when sheer sales volume was believed to be the key to profitability. Product designs reflected a great deal of compromise between different sectional interests within the company. When the design teams offered alternative proposals for new models to the President for approval, there was a general belief in "safety in silence". Designers worried about what middle managers would say and middle managers were anxious about the thoughts of senior management. No judgement was made until options had been assessed by the President. Designs for cars originally targeted at young drivers were modified to take account of the opinions of senior executives who might be over 60 years old. The overall image of the company's products tended became dull and out of touch with the evolution of customer requirements.

Discord and confrontation between top management and the union made matters worse. Management could not transfer employees or bring in new production equipment without the union's consent. Pressure to conform with the union's position discouraged employees from expressing their own opinions. Without the transfer of individuals between departments, employees tended to become inward looking with a loyalty to the group rather than the company as a whole. Change was resisted because it seen as a source of new problems for the department: preserving established

procedures was easier.

Labor relations dominated the President's time and management was restructured to try and promote collaboration between middle managers and shop floor supervisors. A new Labor Management department was established in 1984 but it was not until the powerful head of the automobile workers union resigned in 1986 that things started to settle down. In the meantime, Yutaka Kume was promoted to President in June 1985. On the basis of his past experience he had diagnosed that the design process was at the heart of Nissan's problems and sought to continue his fight against stagnation and inflexibility. His was approach was to articulate a new corporate vision with the phrase "let's change the flow" meaning "let's stir up the status quo and get things moving in a different direction".

Creating an Atmosphere for Free Dialogue

President Kume felt that senior management at Nissan were overly conscious of status attached to different positions within the company. He wanted to promote dialogue and whenever he had the chance walked around the company proclaiming "let's not respect harmony too much", "having controversy at every level of the organization is proof of its health" and "there's too much Keigo [ie the very polite form of Japanese used to show respect] at Nissan". He felt that if the employees were to have a sense of unity and become oriented towards customer needs, there was a need to dispense with "meaningless formalities".

Kume believed that new ways of thinking are driven by diversity and targeted the role played by middle management as a key instrument for rejuvenating the organization. A weekly newsletter was established as a forum for middle managers to express positive proposals for change. Other newsletters followed to provide a means for employees in general to express their opinions. At the organizational level, a completely fresh

approach was taken to product development, while Personnel Management was restructured.

Implementing a new culture: the "Be-1" project

The case of Nissan's Be-1 car is a striking example of how the principles of Kume's vision of creative product development and was launched in 1984 when he Head of R&D. Whereas past practice had limited the role of the design department to providing images of concepts already developed by the product development section, the Be-1 was to be a design-driven project. The intention was to provide scope for free thinking and a fresh approach. A design team was formed and divided into three groups. While team A worked in accordance with Nissan's traditional procedures, the B team worked in collaboration with independent apparel designers and team C commissioned a design from an Italian company.

The B team teams approach was most radical in that the company had no tradition of collaborating with outsiders from the very conception of a project. Working with fashion designers who tended to put a relatively low priority on functionality was something of a culture shock for Nissan's designers. The team toured fashionable areas of Tokyo to look at the imagery associated with leading retailers and attended lectures on fashion trends. Gradually their new way of thinking led them to seek a product that embodied "warmth" and "an ability to recover human values from high technology".

Subsequently all three teams submitted clay model of their prototypes to evaluation by a panel of 160 employees chosen at random except for an age bias towards younger members of staff. The B teams model emerged as a clear favorite and developed as a "concept car" intended only to show the latest design trends at Nissan. Nevertheless, the company subsequently changed its mind following an extremely favorably reaction to a prototype exhibited at the 1985 Tokyo Motor Show and persistent enquiries

about the market introduction date from potential customers. Notwithstanding the four year development time normally associated with a new model it was decided to set a target of small scale production within one year. A niche market was identified based on a product with a fair degree of customization (covering details such as the roof and transmission) with a sales target of 10,000 units in two years.

Although the development actually took one-and-half years, this was still spectacularly fast. While part of this achievement could be explained by the extensive use of components from another model, a further factor in the equation was a break with past development procedures. For the first time, Nissan made use of cross functional teams to bring together members from all over the company and even affiliated companies to work on design, test, production, purchase, sales, advertising and distribution. Production was based at an affiliated company and was mainly by hand reflecting the need for flexibility in the customization process. Thus it appeared that Kume's vision of "changing the flow" had been effective in establishing a new way of doing things at Nissan. A further example of this vision was provided by the case managers involved in engine research and development at the company's plant in Tsurumi.

"The Lively Tsurumi Company"

In March 1976, action was taken to "stir up" the 1,500 employees at the companies research facility in the town of Tsurumi. This initiative, known as the "The Lively Tsurumi Company" (which was a reference to a company depicted in a popular television program) aimed to challenge old values and give young employees a chance to feel confident about expressing their opinions. All the activities were voluntary and conducted outside official working hours. At heart young people are dying to express themselves and can often provide valuable opinions if the an atmosphere is created where they feel free to express themselves and offer alternative opinions about company organization and

procedures.

Putting the Customers First

In December 1986, on the occasion of nissan's 53rd anniversary, President Kume proposed that meaningful steps should be taken towards becoming customer-oriented. Customers should be conceptualized in a broad sense as people all over the world that could be served by Nissan's products. Providing these customers and potential customers with good service required that Nissan should pull together as an integrated team characterized by synergic interaction between members.

A Product Headquarters scheme was initiated to integrate product development, manufacturing and sales. Previously, different departments had acted with less than appropriate regard to realizing the original vision behind new product developments. for example, the designer of the "Skyline" model had a vivid image of a flash of lightening striking a Japanese cedar tree standing alone on a plain. Yet the marketing copy did not come up with anything more inspiring than "the Skyline is urban engineering".

Restructuring Personnel Management

An important dimension of the promotion of fluid communications took the form of careful attention to the implementation of policies for rotation between job functions, changing the criteria for employee evaluation and introducing new policies for recruitment. To introduce rotation between departments, Kume challenged the validity of traditional attitudes that prized "thoroughbred functions" and instead placed emphasis on job rotation between functions. This policy led to a product manager being chosen from sales as opposed to R&D which had always been the case in the past. Significant numbers of people were

transferred to other departments, while it became a rule that no one could be promoted to the position of director unless they had served in at least two functional areas.

In order to encourage younger employees, changes were made the system for evaluating personnel. Instead of personnel evaluation being undertaken by the individual's immediate supervisor, assessments from colleagues and subordinates were also taken into account. The opinion of superior managers in other departments could also be taken into account, if the candidate requests that this take place.

A new payment system was introduced which stressed performance-based pay and greatly reduced the importance of seniority. This new system attempted to encourage more competition between employees and thereby increase the chance that more able individuals will rise to the point where their abilities are realized.

Conclusions

Initiatives such as "changing the flow", promoting young talent as a source of creative thinking and becoming more customer-oriented show how a stagnant company can be regenerated. While Nissan's subsequent down-turn in fortunes suggests that organizational creativity is not sufficient to protect the company from a shift in trading conditions, it is likely that the company would be more vulnerable to these challenging market conditions if it had retained a fragmented internal structure. Communication is a key element in building flexibility and the overlap of understanding, based on common experience gained through job rotation and so on, is an important factor in building a route towards more efficient production.

While a return to price-based competition in a depressed trading conditions has reduced the extent to which creative designs can

secure an increased share of the market, the improved ability of Nissan to act as an integrated organization remains as an important achievement. In a recent interview, the new president was asked to explain Nissan's reduced market share and responded by drawing attention to Nissan's relative lack of sales power compared to that of Toyota. He went on to note that the cycle associated with model changes took approximately four years and that, in common with other companies, Nissan capitalized in increased sales during the first year after the introduction of a new model but failed to match the competition when it came to sustaining that interest in subsequent years. Nissan lacks the sales infrastructure that is needed to push its products forward in the face of the competition.

The case of Nissan serves to underline the idea that creativity can be generated but at a cost. In changing market circumstances, new problems can emerge that might have significant implications for the agenda of knowledge creation. It is therefore important that the organization devotes sufficient attention to these "windows" (or interfaces) with emerging difficulties.

2.3 THE FIFTH GENERATION COMPUTER SYSTEMS PROJECT: RESEARCH MANAGEMENT AT THE CENTRAL RESEARCH FACILITY

Introduction

This case study is concerned with research management at the Fifth Generation Computer Project's central research facility -- known as ICOT. The project began in 1982 and was initially scheduled to run for 10 years, but was subsequently extended for a further two years. Whereas earlier generations of computer had been characterized by their component technologies (valves, transistors, integrated circuits and very-large-scale-integration or "VLSI"), fifth generation computing was conceptualized in terms of what the computer would be able to do. It was expected that fifth generation computers would be able exhibit "intelligent qualities" that would make it possible to understand spoken instructions, emulate human reasoning and explain how conclusions are reached (Anchordoguy 1989; Feigenbaum and McCorduck 1985 and; Unger 1987).

The project involved a total of eight firms that allowed young researchers to work at the central research facility. Given the tradition of lifetime employment with the same organization the idea of sending employees off to collaborate with members of rival firms is somewhat against the grain of business practice in Japan and was only tolerated by the companies because of the basic nature of the research. In consequence, building ICOT as "an organization between organizations" was something of a challenge in that it involved all the problems of orchestrating a task force but did not have the advantage of being able to appeal to notions of loyalty to "the company".

Background

Government-sponsored cooperative research initiatives organized by the Ministry of International Trade and Industry (MITI) have

often been cited as an important factor in supporting the rapid development of Japan's competitive position in computer and semiconductor component technologies. These may be traced from the early 1960s and, over a 20-year period, were instrumental in Japanese firms to close the gap with best-practice Western technology. The apparent success of these schemes prompted MITI to contemplate a rather different type of collaborative research venture that, far from aiming to catch up with existing technology, would lead the world into a new era of so called "fifth generation" computing. The announcement of the project in, 1981, sent shock waves reverberating around the world information industry and prompted many competitor countries to adopt counter measures.

Much of the West's concern relating to the Fifth Generation Computer project stemmed from the apparent success of MITI's 1976-80 VLSI project, which was widely acclaimed as being a major factor in enabling Japanese integrated circuit makers to match best-practice US technology. The VLSI project was a near-market catch-up initiative, which involved a sufficiently large amount of money to ensure that non-participation would place the firm concerned at a serious disadvantage relative to participating firms. Although there was a central research facility for the shared creation of knowledge this was mainly concerned with more basic research, the project's more commercially-oriented work was organized on a "modular basis" -- enabling the firms to absorb the results of the government-funded research without compromising their competitive position. It could be argued that rather than being collaborative research, the project was more of a "balanced subsidy" to assist applied, commercially oriented development.

The Fifth Generation Computer Systems project was in complete contrast to the preceding VLSI project and, as is well known, reaction to the results announced at an international conference held in Tokyo in 1992 (ten years after the project was launched) was mixed. During the life of the project, progress in

alternative technologies as well as rapid advances in conventional computer technology overshadowed the achievements. While the ultimate value of the results of a technology that is still in the basic stages of its development are difficult to predict, it has contributed to the personal knowledge base held by a number of young researchers.

Articulating a Research "Vision" and Building an Environment for Knowledge Creation

The articulation of a common "vision" at ICOT was strengthened by the fact that its leader, Dr Fuchi, was able to bring three of his colleagues from MITI's Electrochemical Laboratory (ETL) to the project. Initially there were three labs within ICOT, two of which were led by Fuchi's colleagues from ETL. Fuchi's third colleague, who was more junior, became an assistant laboratory chief and was subsequently promoted to laboratory chief towards the middle of the project when the number of labs was increased to five. Individuals that shared a common vision of ICOT's objectives therefore emerged in key positions within the project. The core of ICOT's knowledge creation process centered on a common research environment in the form of one single room. In 1985, this room contained some 50 researchers and by the end of 1989 there were about 100 researchers. While the common room went some considerable way towards promoting daily interaction between the researchers, the process was further stimulated by regular changes in layout to bring particular groups that were working on related areas into closer physical proximity with each other. Conscious efforts were made to develop arrangements that would support evolving knowledge networks and information flows. The common room promoted the transfer of tacit knowledge through socialization and this effect was further strengthened by the fact that the researchers also shared the same living accommodation. ICOT trips featuring shared sporting and recreation time represent a further dimension of the notion of a shared environment and enhance the scope to share tacit

knowledge and understanding. By promoting socialization it was felt that, even if a researcher was only average, they would have a chance to contribute their full potential to the overall effort.

There were various patterns by which researchers came to ICOT from the participating companies. One route followed from a feeling amongst ICOT's leader's that the research would benefit from the participation of a particular individual, in which case the company was approached with a request to allocate that researcher to the project. The normal period with the project was about three years, although there were instances where ICOT indicated to the company that they would like the researcher to stay a little longer.

Another pattern for joining the project occurred in cases where individuals who had just completed their doctorates approached ICOT because of the interesting nature of its work. While ICOT was a fixed-term project that was not in a position to recruit staff -- in about ten cases -- it was possible to introduce promising individuals to a participating company. These researchers were then hired by the company and allocated to ICOT. They worked continually with the project and eventually qualified as sub-leaders and during the latter part of the project, when the number of laboratories was increased, were promoted to the position of laboratory leader.

The basic nature of ICOT's work lent itself to the possibility of participating fully in various research networks without compromising the competitive positions of the participating companies. ICOT established a variety of committees and working groups covering universities and other research organizations in Japan. It also formed international links and a system was established for forming links with overseas organizations by inviting visiting researchers from these institutions to spend time at ICOT. Typically these researchers might come for an initial period of about three weeks and, if members of the lab

in question agree, promising individuals might be invited to stay for a longer period.

Implications for Organizational Knowledge Creation

In Japan, ICOT provides a rare example of an "organization built between organizations". Its temporary existence and the diversity of background and organizational affiliations of its members meant that the need to build an environment for effective socialization at the earliest possible opportunity was of crucial importance. Arguably, the promotion of effective socialization hinged on the ability of Fuchi to articulate a vision for the work and shared working and living environment that was constructed for the young researchers.

ICOT's emphasis on basic research placed a very high premium on the need to externalize conceptual thought processes that were located at the forefront of intellectual activity in the discipline. In consequence, socialization can be seen as an especially critical mode of conversion in the knowledge creating process. Once the formidable barrier of effective socialization has been overcome, other modes of knowledge conversion can follow with relative ease.

PART 3 CONCLUDING COMMENTS

This report has outlined the principles of a dynamic model of organizational knowledge creation. The model attempts to combine notions of developments inside the organization with parallel developments in the external operating environment. It stresses that organizations are organic entities that have a wide range and diversity of interfaces with the outside world. Intra-organizational knowledge creation involves "epistemological" and "ontological" dimensions that span organizational boundaries.

Differences between Japanese and Western Organizations

Japanese companies remain an enigma to many Western observers. They are not in any obvious way especially efficient, nor are they outstandingly entrepreneurial. Management strategies are generally grounded in accumulated experience rather than fashionable business school theories and yet, slowly but surely, the Japanese corporation has become an increasingly more strong force in the international market place.

For half a century, Japanese companies have operated in an environment where the only certainty was uncertainty. The effects of the Second World War left the economy in ruins and the reconstruction has been shaped by two wars in Korea and Vietnam, two "Oil Shocks", fluctuating exchange rates and the collapse of the "bubble economy" of the late-1980s. As a late-comer to international competition, Japan was continually faced with the problem of chasing a moving target as the frontier of best-practice technology moved forward. This induced patterns of continuous innovation which, in a cumulative sense, stand out as major achievements.

Japan's tradition of life-time employment engenders considerable loyalty to the company and a relatively high degree of

willingness to support measures that will promote the organization as a whole. This includes a considerable commitment to the company in terms of hours spent at work, with overtime being a way of life for many salaried workers. Socialization over a long working day is one of the factors that promotes the development of "redundant knowledge" which contributes to the effectiveness of the knowledge creation process. However, it costly, in terms of the input of human resources, and serves to underline the considerable size of the premium that is required to implement "Japanese style" knowledge creation.

Life-long commitments to a particular organization means that new technology is not seen so much as threat to employment but rather an opportunity to improve the corporate position. Robots and automation generally enjoy a positive image in Japan which contrasts sharply with Western concerns about their employment implications. For male employees, employment with a major Japanese corporation is a life-long investment. As such, participation in voluntary activities (such as Nissan's Lively Tsurumi Company") are simply one way of supporting that investment. Long hours, followed by after-work leisure time spent with colleagues, further builds an environment where apparently-redundant knowledge can be shared -- thereby building a knowledge infra-structure that can be deployed on some future occasion. Company trips and holidays spent with colleagues represent a further dimension to this process of "extended socialization".

The social network that overlays Japanese company culture provides considerable opportunities for building tacit knowledge and internalizing viewpoints expressed by colleagues. For example, in Japan face-to-face meetings are generally considered to be preferable to the popular Wester approach of "communication by memo". Western firms usually place a high value on the externalization of knowledge which can then be combined with other explicit knowledge. Thus, as was noted earlier, the Western system can be analogous to a relay race in which a "baton

of information" is passed amongst members of the community of interaction. Face to face dialogue -- the essence of "collaborating with the present" -- is then subordinated to the sequential accessing of "packets of information" that have been passed on from some point in the past. This places greater emphasis on the use of language and images to record the past -- which indeed might be invaluable when it comes to avoiding "tacit misunderstandings" but it is achieved at a cost removing the quality of "instant feedback" which is associated with real-time dialogue. Thus, the high performance associated with high-specification western style documentation is countered the greater flexibility that can be displayed by the Japanese system when it comes to responding to current needs and engineering incremental improvements to quality. Both systems also have distinctive shortcomings. Western concerns with explicit information can lead to "paralysis" arising from too much unintelligible detail, while Japanese-style socialization can end in "group think".

Successful Japanese companies have used the principles of project task-forces and the development of structures to facilitate the development of inter-organizational knowledge networks that are sensitive to, and involved with, wider "communities of interaction" that go beyond the corporation to include competitors, customers and other stake-holders in the knowledge creating process.

Knowledge Creating Networks

A main theme of this report has been on intra-organizational knowledge creation but with the important caveat that organizational members are part of wider "communities of interaction" that span organizational boundaries. The individuals that make up an organization are members of various "knowledge networks" that link them to information sources both within and outside the organization. For example, members of a

sales team might have both formal and informal links with customers links with customers that enable them to share tacit expectations about product performance characteristics. This might enable the sales team to gain an appreciation of what the customer wants even before it is fully formed in the customer's mind. These "windows" -- or interfaces -- with the outside world can take a variety of forms and operate at every organizational level.

While it is important to note that knowledge-creating networks span organizational boundaries, the distinction between inside and outside the organization is of some considerable importance when it comes to implementing strategies for creating new knowledge. It is the organization that provides the resources for its members to interact and collectively create new ways of doing things. Organizational structures, rules, procedures and culture all combine to define a framework for creating knowledge. moreover, the organizational framework is relatively familiar to members -- especially in Japan, with its tradition of life-long employment. The case of Canon's Mini-copier showed how, within such a framework, a cross-functional team could be deployed to overcome the technological bottlenecks associated with producing a new type of copier. In comparison, the study of Nissan's revitalization showed how a more integrated forum for knowledge creation could be fostered within a company that had "sectional" and stagnant.

From an organizational point of view knowledge creation that involves outsiders is an intrinsically uncertain business. While informal personal contacts can be conducted according to the instincts of the individuals involved, elevating links with outsiders to the level of formal "organizational policy" represents a voyage into unknown waters. The core of the problem is bound up with issues of trust and the "costs of collaboration". Without mutual trust, the sharing experiences that are vital to knowledge creation will be stifled at birth. The case of the Fifth Generation Computer Project therefore

provides an interesting insight into mechanisms for building legitimacy in the space that exists between organizations.

Implementing Organizational Knowledge Creation

Knowledge creation involves a continual interchange between the advance and diffusion of new ways of doing things. Knowledge that is believed to have a potential for exploitation is likely to attract attention from an wider circle of interested parties leading to an amplification of the "ontological dimension" of knowledge creation.

The ability to generate and assimilate knowledge that can then be translated into some form of competitive advantage is at the very heart of business strategy. However, as the study of Nissan showed, the question of appropriate variety is by no means easy to determine.

A key requirement for the competitive organization is an ability to switch quickly between different "contexts" of knowledge creation to accommodate the changing requirements that occur within and outside the organization. In concluding this report, we therefore propose the idea of a "hypertext organization" which highlights some of the challenge for middle managers in implementing effective knowledge creation.

The "hypertext organization" draws on an analogy with the use of hypertext in computing, which refers to an ability to view a large amount of information from many different angles. By telling the same story in different ways it is often possible to make new connections and insights that trigger the creation of knowledge. Organizational knowledge creation embraces several contexts associated with the acquisition, generation, exploitation, and accumulation of knowledge. Different contexts tend to exhibit their own characteristics which makes them more or less appropriate to different organizational mechanisms. In

this connection, it is possible to distinguish two loosely defined and overlapping dimensions to the context of knowledge creation. On the one hand, there is novelty and uncertainty. Non-hierarchical self organizing teams are especially appropriate to the generation of fundamentally new knowledge through an active search procedures. This is likely to draw heavily on socialization and externalization. On the other hand, a hierarchical division of labor can be more relevant to the organization and development of relatively routine knowledge creating actives where incremental development is located within relatively stable technical or organizational parameters. This might be associated with the application and exploitation of knowledge which has progressed towards the development end of the R&D spectrum. In terms of knowledge creation combination and internalization are likely to be particularly prominent.

The key point to note is that the hypertext organization should recognize the respective roles that can be played by hierarchy and heterarchy and switch between the mode according to the requirements of prevailing circumstances. This should enable the efficiency and stability of hierarchical organizations to be combined with the creative potential of cross-functional task-forces.

The hypertext organization represents a potent mixture of: (1) hierarchical structure -- which acts as a skeleton for efficient and stable organizational processes, and; (2) "horizontal" task-forces that cut across organizational boundaries promoting "free thinking" and the re-conceptualization of established ways of doing things. These contrasting features of an organization relate to two very different "organizational rhythms" which can not easily be harmonized and, in consequence, require their own "organizational space". The challenge for the hypertext organization is to switch between the rhythms in a manner which is appropriate to any given stage in a given problem solving process. Thus, some aspects of a problem will strike a chord with the need for harmony with the hierarchical mode, while

others will be less clearly defined and require the more lateral approach that can be achieved by a cross-functional project team. A hypertext organization therefore has to be aware of mechanisms for integrating the disparate parts of its knowledge creating processes and ensuring that they are available for future use. This integration function is achieved in a third dimension of organizational activity which relates to "knowledge base management" -- ie the summation of hierarchy and heterarchy in a knowledge-base layer.

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