Koty Lapid

Reflection on the Evolution of the Research Management Systems in Japan

The achievements of the Japanese economy have stimulated comprehensive attempts to explain Japanese economic figures. But out of all the publications generated by this upsurge of interest in Japan, relatively few have examined the substance of Japanese technological strength, their mode of organizing and coordinating research and development networks.

Governments, universities and industries all have their specific goals and these goals lately seem to be converging toward each others to tackle market challenges. This common goal seems to be the reason for the emergence of the "triple helix" phenomenon, where governments, universities and industries in the Western world try to find a way for their 'trialogi' to establish some kind of working relationship between them. Japan is a good example of organizing this 'triple helix'. The central feature of their organizational form is that it brings together firms, universities and government research laboratories.

The Transition to an Inventor Nation: The Emergence of Research Management Model

Generally in Japan, the government's own research and development effort is small, because large national applied research projects are led by government laboratories but are executed on contract by corporate work groups. The Ministry of International Trade and Industry (MITI) established a mode of working which depended upon a continuous dialogue on questions of technological development, both with industrial R&D personnel and with university scientists. In the 1950s, direct physical controls, allocations and priorities were still important. In the 1960s, indirect fiscal and other incentives were used to stimulate and channel the huge investment boom.

Having attained a technology level comparable to other nations in the mid-1970s, Japan began to make a concentrated effort to develop a technological lead. To

Science Studies, Vol. 9 (1996), No. 2, 27—33.

achieve this it was essential to move from traditional areas of development into new areas of product and process development and to promote those organizations that could create knowledge. In these programs there was a clear recognition of the strategic importance of information technology. In this context, the most ambitious program was the Fifth Generation Computer Program, based at the Institute for New Generation Computer Technology (ICOT) in the Tsukuba science city. The Tsukuba science city was established at the beginning of the 1970s when the Japanese government shifted its focus from heavy industry to knowledge-based industry (Lapid, 1994). The program was led by MITI and those participating in it came from the major Japanese companies and some universities.

Until that time, the Japanese had made little effort to carry out basic research, so they had not developed the necessary management skills for conducting research in this area. Thus, one of ICOT's goals was to train both researchers and managers to develop management skills for carrying out research in this area. They did this by attracting people both from Japanese and foreign companies.

Research groups in the participating companies' laboratories were assigned to track ICOT's progress and to exploit the research results for their proprietary use. The transfer of technology was based on two mechanisms:

1) Continuity. The researchers routinely reported back to their companies on the project's progress.
2) Periodicity. In this arrangement, ICOT researchers returned back to their companies after three or four years and by doing so secured personal interaction in transferring technology. All in all, over 200 technical people were directly involved in the ICOT project.

This program developed a research management system which could have managed a collective of richly linked, autonomous, localized research groups working in parallel. Moreover, in addition to the coordination of several sub-programs, there was a need to develop some managerial methods to coordinate cross disciplines within the framework of one sub-program. For instance, within one program there was the VLSI sub-program. In this sub-program, the coordinators had to learn how to coordinate the collaborative ventures of cross disciplinary research between economic institutions that had different, but complementary, accumulated know-how that had been acquired from various companies and different disciplines. This project involved more than five separate science fields, including biologists, biochemists, electrical engineers, biophysicists and special engineers who were working on proteins. Every field gave its expertise. For example, to develop the superconductor, researchers needed to separate one material into two parts in a way that the resulting materials would be of high purity. This task was solved by biochemists and electronic engineers working together.

The basic element of the information management in Japanese companies is the management of horizontal information flow. The development of this flow in companies started with the policy to assimilate imported technologies during the 1960's and 1970's, when the Japanese started to develop high-tech skills in designing the manufacturing process.

At that time, Japanese competitiveness was focused on cost leadership based on continuous massive investments in new plant, machinery and processes concentrated in Japan. The products were standardized, of high quality and reliability, and were manufactured through mass production methods. Within the framework of the Japanese type mass production management model, there were many management innovations. All these innovations assisted horizontal coordination. The 'kanban' system, introduced in 1953 (Cusumano, 1988) at the Toyota factory, was supposed to facilitate a smooth flow between different workshops along the production line, without the intervention of a supervisor.

Another managerial innovation, that emerged during the development of 'the reverse engineering process', was how to manage this process. Reverse engineering was to ensure the assimilation of the imported technology by analyzing and improving it in an integrated way. The management of this process comprised of many concurrent engineering elements. (Concurrent engineering is a systematic approach to the integrated concurrent design of products and their related processes including manufacture and support.)

The success of the 'reverse engineering process', according to Freeman (1987), was owed mainly to the Japanese industrial structure, where relational subcontracting coordinated design and investment.

Supplier integration was based on the Japanese industrial organizational format where the formal vertical disintegration among companies was complemented by strong, but highly stratified, vertical organization facilitated by relational subcontracting. This type of subcontracting, coordinated design and investment (Ikeda, 1987).

Aoki (1990) argues that the horizontal coordination between operating units, based on knowledge sharing in contrast to the more familiar Western mechanism of hierarchical coordination, is characterized by the separation of planning and implementation and also by an emphasis on the economies of specialization. The horizontal information flows are also an important feature of inter-company cooperation within the 'Keiretsu' (an industrial organizational form that consist of major firms and their dependent supplier firms, organized into three or sometimes four 'tiers'. For example, Matsushita has over 600 firms in its keiretsu (Altschuler *et. al.* 1985; Bolton *et. al.* 1994). The members of an industrial group are coordinated through their equity links and management working groups and can share research facilities, support staff and production capacity.

What should be emphasized, is that when MITI coordinated the government-industry-university joint projects and developed the managerial skills for running basic research within the framework of the 'Fifth Generation of Computers', the Japanese companies already had very important skills in running 'programs' at the company level and at the inter-company level. These companies already had the basic skills of designing and managing manufacturing processes. Such management techniques could be transferred to designing network coordination between MITI's program members. Thus, management of the inter-company flow of information, and even within individual companies, preceded the development of the management of the flow of information within a large MITI program. The Japanese could then transfer this horizontal pattern of designing and managing the interaction of manufacturing processes within the companies so that they could manage their businesses under the umbrella of the MITI program.

Moreover, we argue that during MITI's program, the program managers improved and enriched the original managing pattern, and the new pattern later flowed back to the companies. This technology transfer secured a successful know-how transfer back to the companies. In this sense, the transfer was not a single point transfer of basic research results to a commercialization process. It covered the R&D management process too, now already enriched by the ability to coordinate increased numbers of different sub-programs in parallel, and by their ability to coordinate cross-discipline research for further product development.

Open-Ending Management Model

During the utilization of the basic research of the MITI program described above, companies developed the overlapping type of R&D management pattern in order to remain in the market. This pattern was based on the concurrent pursuit of sequential generations of a product line and its associated technology. Kodama (1995), Okimoto and Nishi (1991) described how one

Japanese semiconductor firm managed the diverging pattern of Dynamic Random Access Memory (DRAM) development. They note that the system was designed to organize engineers from development and manufacturing into a series of small research teams. These teams were used to sustain research simultaneously for consecutive DRAM generations.

Toshiba was the first firm to devise this widely emulated organizational approach to R&D (Takeuchi and Nonaka, 1986). Using a three-layered structure, Toshiba developed the system of 'three generations in parallel sequencing' of DRAM development. For Toshiba, the CRL research lab developed the fundamental technology, the DL (semiconductor device engineering lab) brought this technology into the orbit of mass manufacturing, and the FEL (engineering department in memory division) established a mass-manufacturing system. Toshiba's engineering center for semiconductor systems was responsible for marketing, application, and testing (Kokubo, 1992).

While the use of overlapped development may result in a shorter development time, we need something more to manage the high-tech pattern. We need the right amount of interaction. Wheelwright and Clark (1992) noted that rapid product innovation depends not only upon overlapping stages of development, but also upon "intensive" (as opposed to "batch") communication among team members.

At this point we can state that companies successfully assimilated not just the fruits of basic research from the MITI program, but also the management methods developed within the program. Moreover, Japanese companies started to focus on upstream processes rather than on downstream manufacturing activities, because to utilize basic research results required more preparatory processes or manufacturing. The companies shifted their concentrated business processes from the manufacturing phase to engineering phases such as product design, more sophisticated production system design, etc.

All this required management patterns. The companies took the management MITI pattern, and broke it down into many smaller elements. In this way, the companies' R&D processes were broken down into many autonomous disciplines, aiming at maximizing 'economies of competence' through in-house transfers of technology and rapidly diffusing research findings to discourage the emergence of any rival alternative technology. This improved management model allowed companies to conduct some type of basic research themselves, and at the same time to utilize the fruits of their own basic research.

The next large scale government-university-industry project in the context of this paper, was the Sigma Program. The Sigma Program was established by MITI in 1985 as a system for industrializing and standardizing the production of software. I would like to note that in Japan, the procedures of industrializing and standardizing the production of products have already been known and widely used.

Instilled Change: Overlapping Management Model

With the software and network research knowledge derived from the Sigma Program flowing back to individual companies, Japanese companies focused much more on upstream processes than they had done so previously. Many Japanese factories had started to refine this function in terms of Business Process Re-engineering (Hammer and Champy, 1993) through concurrent engineering technologies, enhancement of information infrastructure, organizational restructuring, as well as through traditional improvement activities. By exploiting the various efforts that had been made to elevate productivity through the use of shop floor workers they found a significant way of obtaining the relevant results. Moreover, the companies devised many frameworks for design process improvement (Katayama, 1994). Combining the above mentioned tools, the outcome was the establishment of a new development process where one company can develop several product platforms simultaneously.

The Future evolution of the Overlapping Basic Research Model

Over the past ten years, the government has been working at full steam for the enhancement of the information infrastructure in Japan. One of the prominent programs within this context is the ongoing 'New Media Community Plan' which was promoted by MITI in 1984. The program aimed at developing various types of information and communications systems in response to the diverse needs of local industries and residents (InfoCom, 1994). The Japanese government in 1987, introduced the fourth Industrial Policy Program, which was based on R&D, and the further development of the software service industry. Tagged on to this industrial program, another program was introduced, the Regional Program, with which the Japanese government intended to boost Japan's regional development.

The 'brain program' was introduced in 1987, and focused on a new industrial need. It was based on new concepts of competitiveness around information and innovation. The challenge was to harness the tremendous flow of information instead of being engulfed by it. The ability to mobilize information and the ability to create new structures for sharing information and increasing its velocity within organizations, are the best measures of competitiveness. With networked PCs on virtually every office desk, they tried to redefine how people work with computers and with communications software.

In one of the major government laboratories, the Advanced Telecommunication Research Laboratory, (ATR) located in Kansai, there were many project running whose staff came from abroad as well as from Japanese universities, and also from public and private laboratories. In this laboratory, the research management pattern was more than just the overlapping of a particular sequence in the same product – it was the management of the concurrent development of several infrastructure projects. This center has obtained 500 patents for its work over the last five years. Its focus is the building of Japan's information superhighway while currently developing local and wide area networks (LANs and WANs) where the tools using it are spread over a wide area (Lapid, 1996).

Recently, major industrial corporations in Tsukuba have established consortia to promote industrial R&D at the precompetitive level in selected strategic areas in cooperation with the government agencies and universities (Swinbanks, 1994). The new organization, called the Tsukuba Advanced Research Alliance (TARA) could well stimulate change throughout Japan's conservative university research system.

Conclusion

I have shown in this paper that Japanese companies, by participating in their national programs, retained not just product know-how, but management know-how as well (by managing their own basic research, as well as managing product development) that has led to extremely quick lead times.

Throughout the twentieth century, management practices were developed around Taylorist theories that has led to increasing resource specialization and to the creation of strongly skill-based functional management practices. This type of sequential approach was employed by a number of US companies in their product development practices. The Japanese companies at the end of the 1960's, to assimilate the technology that was being imported, developed several management methods for designing the manufacturing process. This led to the development of process management models which allowed cross-boundary management. This was the first step toward the development of overlapping management model in Japan.

Later, at the end of the 1970's, the Japanese, within their national program, developed a research management system both for the concurrent coordination of the many basic research sub-programs and as models for interdisciplinary research. The research management systems, which I call the "first generation of overlapping basic research models", developed within the framework of the national program, improved many elements of overlapping management model tools used by Japanese companies in their process management.

At the beginning of the 1980's when the companies reaped the fruits of the first national program and the fierce competition continued, Japanese companies improved the "first generation of overlapping basic research model" after learning how to develop several generations of products concurrently. In the mid 1980's within the framework of the Sigma Program that dealt mainly with the uniformization of the development of computer software, a great emphasis was made on software development management practices. There appears to be no empirical or theoretical basis to argue that this program led to the development of more sophisticated management styles or to the second generation of overlapping basic research model (which could have led to more disciplined engineering, production and quality management practices in software development). But the rapid development of in-house information infrastructure in those companies following this program indicate that this is in fact what happened.

To answer the diverse consumer needs in many industrial sectors, companies improved the 'second generation of overlapping basic research model' based on the many management practices gleaned from the Sigma Program. The outcome of this improvement was the establishment of a development process where one company develops platform of several products concurrently.

At the end of the 1980's when the Japanese decided to enhance the Japanese information infrastructure, they developed the 'third generation of overlapping basic research model'. By employing this model, the Japanese were able to manage the concurrent development of several infrastructure projects at the same time. Once again, the government program helped to enlarge the existing development management model used by the companies. (From the company scale, it was enhanced to the national scale.)

In this paper I have tried to describe a spiral mode of development of "overlapping development models for basic research project management" in Japan. I found that Japanese basic research project management models co-evolved (Etzkowitz and Leydesdorff, 1995) through the joint learning of companies, government laboratories and universities. This process started with a continuous development model that was applied at the company level - a small scale development model. Then with government assistance, it was applied to large scale basic research project management. The models then went back to the companies where they were further improved to fit their needs. The process can be repeated ad infinitum. The Japanese government continues to search for a successful technology policy suitable for the 21st century, which includes not just critical technologies, but also the management of the research process.

REFERENCES

Altschuler, A., Anderson, M., Jones, D. and Womack J.
1985 The future of the Automobile: The Report of MIT's International Automobile Program. Cambridge, Mass: MIT Press.

Aoki, M.
1990 "Toward an Economic Model of the Japanese Firm."Journal of Economic Literature 28: 1–27.

Bolton, M., Malmrose, R. and Ouchi W.
1994 "The Organization of innovation in the United States and Japan: Neoclassical and Relational

Contracting." Journal of Management Studies 31: 653–679.

Cusumano M., .A.
1988 "Manufacturing Innovation: Lessons from the Japanese Auto Industry", Sloan Management Review Fall 1988: 29–39,

Etzkowitz, H. and Leydesdorff, L.
1995 "The Triple Helix–University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development." EASST Review 14: 4–19.

Freeman C.
1987 Technology policy and economic performance: lessons from Japan. London: Pinter Publishers.

Hammer, M. and Champy, J.
1993 "Reingineering the Corporation." Harper Business: 1–30.

Ikeda M.
1987 "The subcontracting system in the Japanese electronic industry." Engineering Industries of Japan 19: 43–71.

InfoCom Research Inc.
1994 Information and Communications in Japan 1993–1994. Tokyo: InfoCom Research Inc.

Katayama, H.
1994 "Framework for Design Process Improvement-To Build a Strategic Tool of Reengineering." Operations Strategy and Performance (The Proc. 1st International Conference of the European Operations Management Association), Cambridge: Cambridge University Press: 157–162.

Kodama, F.
1995 Emerging Patterns of Innovation. Boston: Harvard Business School Press.

Kokubo, A.
1992 "Japanese competitive intelligence for R&D." Research Technology Management, January-February: 10–33.

Lapid, Koty
1994 "Report on Science Cities in Japan: Kansai and Tsukuba." the grant for the improvement of social conditions of the technical development: P-2203/94, Budapest.

Lapid K.
1996 "Science Cities in Japan" (Az alkotok varosai). Elet es Tudomany: 300–303.

Okimoto, D. and Nishi, Y.
1991 "R&D Organization in Japanese and American Semiconductor Firms." paper presented at the Stockholm Schollo of Economics Conference, Stockholm, Sweden.

Swinbanks, D.
1994 "Unique research body to energize Japan's R&D." Research-Technology Management [RMG] 37 (5 Sep/Oct): 3–4.

Takeuchi, H. and Nonaka, I.
1986 "The New Product Development Game." HBR, 69, no 1.

Wheelwright, S. and Clark, K.
1992 "Creating project plans to focus product Development." HBR March-Apr: 70–82.

Koty Lapid
Scientific Society for Organization and Management
1026 Budapest
Orso .I. 3.
Hungary