A product development process for linked management: application cases of electrical home appliance products

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Abstract: The effective linkage between necessary functions is critically important to implement a business strategy and achieve satisfactory performances. The linkage covers the essential activities from upstream actions (technology and product development) to downstream ones (procurement, manufacturing and selling). We propose that the construction of the effective linkage starts with the process of product development and requires the consistent effort to systematise the process based on the case study of the home appliance division of a Japanese electrical appliance manufacturing company. The case would be suggestive to many large Japanese companies not-least part of which business consists of the matured products facing severe competition.

Keywords: NPD; new product development; linkage of functions; front-end loading.

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1 Introduction: stagnation of matured products

Since the bubble economy's burst in Japan in 1990s, many Japanese manufacturing companies have suffered from the stagnation of their markets. They still cannot become optimistic about future even though they see some improvement of the situation now. In the electrical home appliance product markets, except for some products like digital cameras, liquid crystal display television receivers and DVDs that are all renovated by digital technologies, most matured products, such as refrigerators and washing machines, have been in sterile competitive situations characterised by price discounts and quick imitation, with declining demands. Table 1 shows the annual shipping volumes of some of the matured electrical home appliance products with negative growth, contrasted with a few of the growing products.

Table 1 Shipping quantity of three matured products contrasted with digitalised new products in Japan over the past seven years

Product / *Year*	*Refrigerators with freezer*	*Washing machines*	*Vacuum cleaners*	*Digital cameras*	*DVD videos*	*Liquid crystal display television receivers*
1996	5,309,024	5,351,265	7,081,632	n.a.	n.a.	1,240,492
1997	5,423,643	5,151,392	6,848,803	n.a.	n.a.	976,620
1998	5,167,899	4,814,378	6,192,652	n.a.	n.a.	1,201,347
1999	4,880,135	4,511,241	5,911,403	n.a.	3,694,848	1,073,077
2000	4,874,232	4,435,690	5,885,184	10,236,426	4,487,228	1,111,151
2001	4,793,166	4,520,115	5,729,346	13,771,314	5,744,452	1,292,353
2002	4,197,789	4,080,808	5,701,650	22,085,114	8,401,076	1,585,549
AGR	–4.0%	–4.0%	–4.0%	47.0%	31.0%	4.0%

The figures are annual sales shipping quantities. AGR is the average annual growth ratio.

Source: Year Book of Machinery Statistics 2002, Research and Statistics Department, Economic and Industrial Policy Bureau, Ministry of Economy, Trade and Industry (METI)

The low affordability of the market is not the only reason for the stagnation. The growing products in Table 1 suggest to us that if the company introduces new attractive values to the consumers, they respond to the values. The products are all traditional in their basic functions, but their new technological features give new value to the functions. The consumers take them as completely new products. The stagnation of the demand of electrical home appliance products indicates to us that they, even new, are eventually neither attractive nor differentiated enough for the consumers to replace the products they own.

The lack of product attractiveness results from poor insight into the needs of the markets and ineffective technological and manufacturing supports of new products on the side of the manufacturers. These problems mostly stem from the fuzziness at the front-end of product development pointed out by Khurana and Rosenthal (1998), though the boundary of the front-end stage is vague due to potential relationships between decision-makings in designing activities. The fuzziness invites the loss of centripetal forces by which all activities related to value creation are aligned in a synchronised way. Reducing the fuzziness is most important agendum.

According to our discussions with the development people of Company Z, a large Japanese electronics company to which we applied a new support system described later for New Product Development (NPD), two forces have nurtured the problems. The first force is the downsizing of the resources committed to matured products. They are sometimes associated with the concept of Dog business in the classical product portfolio matrix introduced by the Boston Consulting Group (1972). They are not worthy of further investment. Investment for them, if any, is kept minimal to squeeze the maximal profit.

The second force is the increased pressure on the process of NPD of these matured products, caused by their fragile market positions of all companies. They could never make the decision of divestment on them. Even though they expect no growth in these businesses, the market sizes of them are not small. Not only because every company feels it has the chance to be a market leader due to the situation of no champion, but also it's afraid that their customers might take the divestment decision as the retreat of the whole company. Moreover the large retailers that mainly sell electronics items with competitive discount and are influential in the markets aggressively ask all of the manufacturers for the customisation and modification of products in order for them to increase the competitiveness of their stores, as if they represent the Voice of Customers (VOC). They have been dissatisfied with the low attractiveness of past products delivered. Then the manufacturers have to respond to them as quickly as possible. It in turn shapes the forced annual cycle of NPD. The manufacturers' executives, on the other hand, put pressure to cut cost to improve the poor profitability of the businesses, and also tend to give arbitrary requirements to their development people based on the data of their market monitors as well as the specific large retailers' demands. The development people have to work subject to such pressure and requirements, in addition to tight constraints on the availability of people and time for NPD.

This situation invites the problems of cost and quality. The rushed development causes frequent design changes and the potential troubles related to quality. The staffs of manufacturing and procurement suffer from those problems. The problem is they cannot communicate well in advance with the people of NPD.

Furthermore the development of more advanced technology tends to remain out of gear with NPD. The volatility and vacillation of product concept makes it difficult to design a map for the development of technology. Then the development of technology hardly bears fruit that can be harvested by new products.

The poor performances of many new matured electrical home appliance products mostly stem from a failure to provide new and more attractive values to consumers. In other words, the business process from the development of technology to the service after-sales does not work to generate such values. The business process includes many functions, each of which contains various practices. The level of each practice tends to be positively correlated to each other. The linked set of practices' qualities determines the performance of the process, according to the work of Morita et al. (2001). The poor linkage of the practices results in a poor business process and then poor performance. We propose that this poor linkage is essentially caused by poor activities at the front-end that fail to invoke the commitment of employees as well as the consistency of their practices. The lack of the managerial excellence that is an important successful factor of NPD, pointed out by Zirger and Maidique (1990), results in due to it.

Porter (1985) advocates the concept of value chains. He points out that business strategy is deployed along the value chain. Based on his idea, we propose that poorly formed business strategy generates the inconsistency between the product to be provided and the process for the provision of the product. As in the case of Ford's model-T, if the fit between product and process is good and the value of the product's features is satisfactory to the market, the competitiveness of business is maximised. According to Chandler (1990), the next leader after Ford, General Motors, adopted the divisional management structure and made effective use of external suppliers and the concept of sharing parts among the different models to meet the diversified needs in the nearly saturated market. Then Toyota appeared as a tough competitor on the scene. Toyota, with cars of high quality, high variety and high fuel efficiency combined with the lean production system as shown by Womack et al. (1990), proposes another model of the fit between product and process.

In the present competition of electrical home appliance product markets, the Japanese companies, internationally, struggle with cost reduction pressure in order to compete with the products made in Asia. Domestically they compete with each other in differentiating their products, with the goal of expanding their market share. The problem is that they have to achieve both under the tight constraints of time and resource. Instead of meeting only the schedule requirement, which the annual cycle of development imposes, they need real value creation by means of a better fit of product and process in order to turn around their present situations.

2 Problems of New Product Development (NPD): cases of Japanese electrical home appliance products

The interview with the people of Company Z reveals one most significant problem with NPD in the Japanese matured electrical home appliance business is that many requests for the change of design come at the later stages of development. This is because fully designed mock-ups are not presented at the early stages, by which all the people involved including the manager in charge of all NPD projects, can understand well and confirm the

concepts of new products. They generally care about the product features of competitors in order to assess the validity of their own new products. Information on the product features of rivals is usually fed back at the later stages of development. However, because the on-time launch of new products is the most important goal of project managers, they try to arrive at the stage of production ramp-up anyhow. They have no time to assess adequately the final configurations of products in detail. Then often they have to schedule to complete the new product by adding the modifications potentially required, for example, within the three months after the launch. They change materials, parts, manufacturing processes, suppliers or terms of supply if necessary within this period. Also they have to cope with the market claims caused by the inadequate settlement of quality problems during their development. These changes spoil profitability significantly.

The reason why full mock-ups are not made at the early stages of NPD is because product designers cannot obtain from product engineers the information on the functional features to be appealed early enough to design the mock-ups of new products. The organisational structure many Japanese electrical home appliance manufacturers adopt, under which the product designers undertake the designs of many types of new products single-handed like a corporate function, amplifies the difficulty of communication between the product engineers and designers. Under the annual cycle of development, it's difficult to set up often enough the occasion where they can adequately discuss and share their understanding of the features of new products.

A mock-up gives a product its first facial image, synthesising appearance, newly mounted functions, colour, etc. Since they assume the price should be set at a similar level to that of their competitors due to the severe competition, the facial image becomes one of the most important factors to differentiate the product. However the delay of the development of the mock-up invites plenty of arbitrary interferences from various sides to blur the concept of the product.

As the information on competitors' products usually comes near the later stages of development, judgement about the reasonableness of implementing the requested modifications from the information becomes critical. They have to make the judgement without systematic method for it. If judging the modifications has to be done, they may have to change the moulds and parts already ordered or order new ones, and also put necessary corresponding modifications on manufacturing processes during the short period allowed to keep the schedule for its introduction. As a result, direct material cost goes up and quality goes down. Planned profitability deteriorates. Furthermore, regardless of their efforts, they need even more effort after the introduction, as mentioned before. The problems of NPD have turned chronic. The morale of the involved people has sunk, and their work has been inconsistent with each other.

Additional interviews with project managers and an analysis of the problems in the NPD cases of refrigerators with freezers and washing machines with dryers of Company Z have revealed one more basic problem underlying this poor development process. The problem is that they cannot generate the consensual and challenging themes of product development under which they can converge to create clear product concepts as foci for their efforts in the long run. It looks like the case for completely new products, which are still in a fluid state regarding technology and value.

They used to think that most of the significant improvements of the matured products are nearly over, and that all they have to do is add some modifications to harvest profits with minimal effort and resources. But consumers and retailers take these as gimmicks. Once in a while they develop successful models, but other competitors imitate easily. Then the models are profitable only for a short period, at most one season or half a year. It's difficult to create sustainable differences without their own committed theme and not imitable technologies. The absence of a theme makes the process of product development vulnerable to arbitrary ideas including the VOC.

Most of the Japanese electrical home appliance manufacturers used to think of the VOC as the primary information source to find a focus for development of matured products, even though they have been not successful so far. The VOC before product introduction is at most valid to define necessary features such as the qualifiers for competition discussed by Hill (2000). Competitors perhaps obtain similar information. It's difficult to find the themes of products developing the ideas for order-winning features from the VOC.

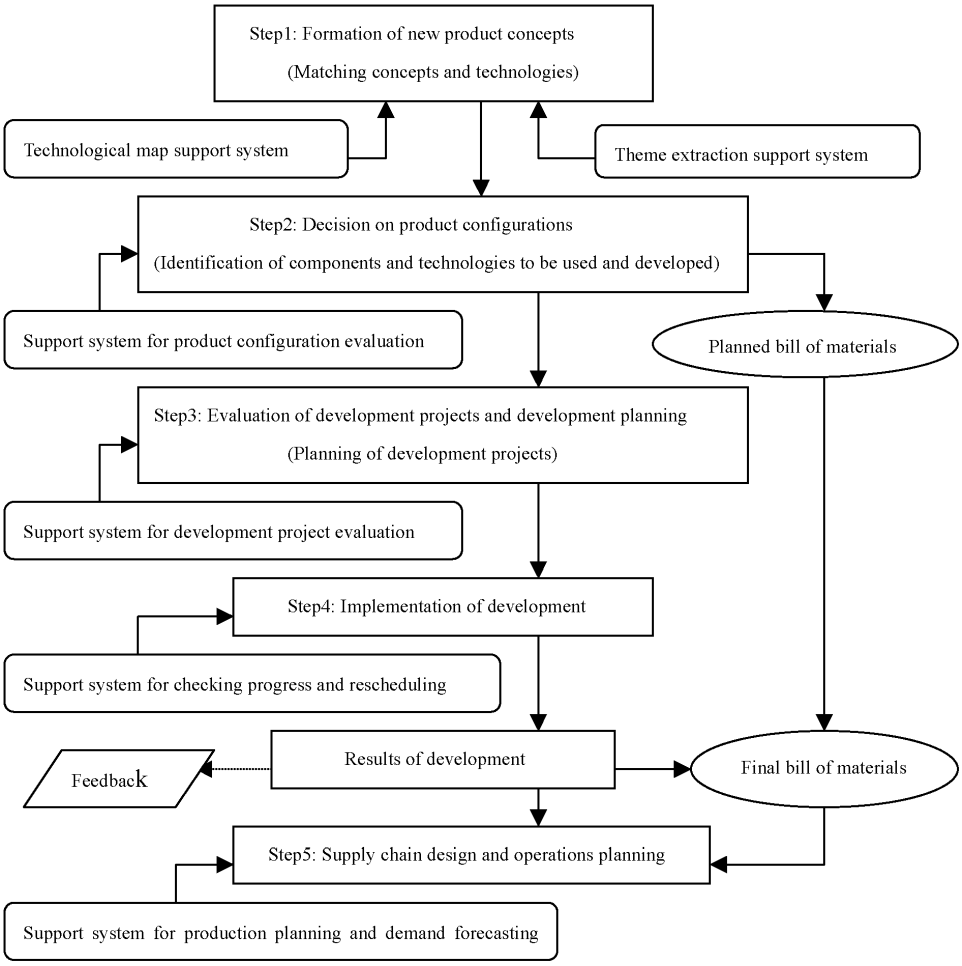
Furthermore, if depending only on the VOC, we may fall into the trap of making too great a commitment to existing customers and thereby lose the whole view of the market, as suggested by Danniels (2003). We may miss the opportunities to tap some more promising needs of the market. We may also suffer from the tyranny of the served market conceptualised by Hammel and Prahalad (1994). A market-oriented approach is basically important, but it's not the same as customer-led one as suggested by Slater and Narver (1998).

One of the most urgent items on the agenda is to set up a theme of product development composing the concept of platform, by which the development of technology, the development of products, manufacturing, procurement and selling could be combined together to form an effective linked process in order to create the distinguished values of products. This linked process creates a product that provides customers with distinguished and unique values, which is the most important characteristic of successful new products as pointed out by Cooper (1994). It also brings about high profitability. The real key for successful NPD, according to the work by Khurana and Rosenthal (1998), is to enhance the effectiveness of the front-end activities. The work by Im et al. (2003) found that good initiation including the formation of product concept led to high performance of NPD, especially in Japan.

3 A support system for New Product Development (NPD)

The whole view of the support system proposed for Company Z by us to improve the NPD of the matured electrical home appliance products is shown in Figure 1. It is designed to achieve effective front-end loading. We firstly focus on the formation of product concepts and then explain briefly the rest steps.

Figure 1 Proposed support system for product development process



3.1 Formation of product concepts

The advocated system starts with Step 1, the formation of new product concepts assisted by two supporting sub-systems. The first sub-system for technological mapping evaluates the existing technologies of Company Z from three dimensions. The dimensions are the type of technology, its organisational location, and its present technological level available. The last one is assessed together with the following second support sub-system.

The second sub-system is concerned with the formation of the themes of products. It defines the substance of the values the company wishes to create. It requires an insight into the potential needs of consumers that are influenced by their environments. They are hardly visible in available market data.

This sub-system calls for an anticipatory insight into desirable product features under the potential characteristics of markets influenced by general environmental trends. We assumed three types of values to be embedded in the concepts of products. The first is concerned with social values that give influences to customer's values.

For example, the recognition of lack of energy and water resources prevails in society. They start to feel their savings are important since their costs will rise in general. Then the feature saving them will be evaluated highly by people.

The second is related to the employee's motivation. For example, engineers have their own values they respect. Even if the marketability of a feature looks promising, they may not be motivated to tackle with it since the related technology is not inspiring. Though people point this value orientation sometimes leads to failure of new products since it ignores market needs, this value is important to drive the people of the company and create not easily imitable features.

The third value is the value of market. Consumers decide the final success of products. It is invisible essentially, though the data of past products and customers' claims feed back many suggestions to the company. We need to check whether the value designed is valuable to market in some ways before the introduction to market. Our idea is the check should be done based on the actual responses of customers to the value designed.

We hypothesise that promising themes for product development should be extracted from the intersection of the three values. The process for the extraction consists of two stages. The first stage concerns with the extraction of the two values' intersection, the social and challenging values. The second stage is to check the consistency with the market value by the means of showing customers full mock-ups including those revised based on the customers' responses. In order to realise the process, the company should shorten the lead-time of NPD enough to complete the process or develop the theme of NPD early enough to complete the process. As a conclusion of actual experimentation, the company has learned the early formation of the theme made it possible to shorten the lead-time also.

They extract the trends to be considered to form the themes of NPD from the general environmental problems anticipated. The people involved in NPD search for them in many types of information sources such as academic journals, books, governmental reports, etc. For example, the trends related to refrigerators and washing machines, extracted from surveys, include our increasing awareness of the green house effect, the spreading of deserts, the shortage of water, the consciousness of health, the increase of double income families and the widespread usage of information technologies.

These trends are converted into implications for the four environmental facets of living, work, health and social infrastructure surrounding the consumers. We introduced these four environments for the convenience to make the people involved easily associate the trends with implications for extracting themes. They are not rigorously proved ones. In each facet they make the projections of themes related to the trends for every five years in the next 15 years. The themes are all attached by functional agenda and then broken down into functional components. Each functional component is an item with which they can relate specific elements of technologies.

Then themes such as the saving or conservation of water, the recycling of water, etc., emerge in living facet. The themes are translated into functional agenda for new products. For example, in the case of washing machines, the reuse of water and maximum cleaning effect with less water come up as functional agenda. They, however, are not enough to form the product concept. Other functional agenda also pointed out in the other facets, should be integrated with them mentioned above because users are living in an environment embracing all of the facets. For example, the themes picked up in the facet of work include the increased emphasis on time saving, doing the washing at night and

quick and easy handling since socially the double income of household is increasing as a trend. In the facet of health, allergies, including hay fever, and health consciousness are increasing. Thus the enhancement of the quality and effectiveness of washing become a theme. When it comes to the facet of social infrastructure, the increasing availability of communication and information networks is exploited. A theme making maximum use of the networks emerges. Combining those themes in the four facets develops synthesised functional agenda such as quick and easy handling, a design reducing the pain of physical posture required for operation, excellent cleaning power with less water, low consumption of electricity, low noise and the enhancement of convenience by the use of remote control using the digital networks.

They relate specific technologies to the synthesised functional agenda by breaking down the agenda into functional items. They translate the agenda into the concept of a product. They develop a product concept for each phase of five years over the next 15 years judging from the technological difficulty of the involved technologies. Not only development people including designers, but also sales, procurement, quality and manufacturing people are involved in this stage of the formation of the concept of a product. The functional mapping advocated by Wheelwright and Clark (1992) follows after the stage of generation of product concept, but here the functional mapping is integrated part of the stage. The people involved evaluate also the feasibility of generated concepts from functional viewpoints to make final decisions. The final agreed concepts over time imply agenda each function should commit to achieve.

Then all the people involved are expected to understand the concept and prepare to build it from each functional viewpoint and expertise. A common understanding among the people involved is one of the important prerequisites for the effective linkage of necessary functions.

3.2 The rest of the supporting system

At Step 2, they identify the product configuration of the concept for each phase of five-years. They design the configuration by considering the urgency of the agenda and the assessment of the availability of the technologies and resources of product and process by all functional people involved from R&D to sales. The functional agenda of the last phase include high technologies that inspire the people involved in NPD and give new product features beyond customers' expectation at present stage.

At Step 3, they make a list of development projects, including technological development throughout the phases. They make decisions on the resources to be committed. If a specific agendum is urgent, the involved technologies become the targets for aggressive investment or for technological alliance with the external companies possessing them. They may modify the list over time, depending on the progress of technological development, competitive dynamics and the feedback from actual performances.

At Step 4 they start implementation. Here it is important to keep to the development progress as planned, though work-break-down structuring and scheduling by using project networking tools are interactively achieved to make a satisfactory development plan, that is proposed by Eppinger (2001). They may not be able to avoid unexpected incidents like failures and delays of technological developments. They have to grasp the progress as early as possible to cope with these incidents. During this step they put modifications to the planned bill of materials made at Step 2.

They make supply chain designs and production planning at Step 5. At present the system does not extend to Step 5 yet. But if the development goes well as planned, they find that they can secure a relatively smooth linkage with the process of the supply management including manufacturing.

4 Performance of the support system

In the case of washing machines, the final product concept was named "The finish of angels' touch" for the first phase (2003–2005). The naming represents the set of themes associated with the product concept such as quiet and smooth motion, nature-orientation, that is the low consumption of electricity and water as in hand washing, and the clean and soft finish when drying clothes. If the people involved share these associations with each other, the total integrity of the product concept becomes possible.

One of the most important new technological developments to realise this concept was concerned with the methods of washing and drying. They have developed new types of washing and drying methods controlled by digital signal processors. Yet if the system support and product concept resulting from it were absent, they might have stopped developing these new technologies and used other existing trivial technologies to develop the same type as the average product before. Instead the company-wide technological map they developed has suggested another more effective combination of technologies that requires only affordable developmental efforts.

With respect to refrigerators, they developed the product concept expressed by "The conservation of whole nature" for the first time phase. This implies keeping foods tasty as well as fresh. The saving of electricity is not the order-winner but the qualifier now. They have put the new technologies and ideas to cool and freeze foods appropriately depending on their characteristics and prepared spaces for them to achieve more electricity saving than ever.

Not only the conservation, but also the concept of the timely provision of conserved foods will come into the product concept during the next phase. The word of 'provision' connotes the service of providing information on the timing to eat the foods being conserved. They think this service reduces the chance of the wastage of conserved foods, increases the utility to users in terms of nutrition and taste, and helps them purchase foods anew. The service is designed from the themes responding to the environmental trends extracted. By interpreting 'provision' technologically they can plan on the development of new information technologies. The theme of provision augments other values to those of the conservation of the first phase.

They applied this support system proposed by us to the new models of refrigerators and washing machines from 2002. They recognised the two types of performance improvements. The first type concerns the process of development itself. One improvement is the reduction of the total man-hours committed to the developments. In both of the products, it was reduced by about 30–40%. The second improvement is the reduced frequency of design changes. It went down by 55% for the new models of the refrigerators and by 58% for those of washing machines. The third is the reduction of direct materials cost. This decreased by 22% on an average from the level budgeted. They could avoid the costs of remaking of moulds, new sourcing, switching of suppliers, and the urgent shipping by air that used to be frequent. The final improvement is the decline of market claims and quality problems, since they could devote more time to

prepare appropriate manufacturing processes to eliminate the potential causes of the problems than before.

The second type of improvement relates to market performances. Just after the introduction of the support system, in the case of the refrigerators' new models, Company Z's market share went up by 15% and by 18% in the washing machines' case. The washing machine, following the planned concept for 2005 developed based on the support system, now became the market leader in spring, 2005. The new models did not suffer from the price discount, which used to be the case for past models. Furthermore, the new models of washing machines were highly evaluated by the Japan Electrical Manufacturers' Association for their low noise, usable even at night, and the high efficiency of water usage. The new models of refrigerators were also highly evaluated for their remarkable efficiency of electricity consumption. It was reduced to one sixth if compared with that of ten years ago. The new models of refrigerators were rewarded by the Agency for Natural Resources and Energy in 2003.

The system helped them develop the mock-ups of the new models at the early stages of NPD process. They could explain early the products' features and concepts to the executives of the company and the big retailers by showing the mock-ups. The retailers gave reserved orders before their introductions since they liked the concepts and well-designed packages of technological features of the products. The executives understood them by means of the mock-ups and did not interfere with their developments. The people of the manufacturing department prepared for the models well in advance and could achieve a more efficient production ramp-up than before. They could reduce the extra number of workers who used to be committed to solve the problems of manufacturing of new models.

Behavioural changes emerge after the introduction of the support system. The first change is concerned with risk evaluation. They used to make documentation only about the specifications of involved technologies, but the risks involved are mostly related to the interface of technologies. In the past the risk evaluation has been implicit and memorised only in the mind of the involved engineers. The support system now provides the engineers with the format of explicit risk evaluation in which the themes are shown together with related technologies and the relevant interfaces of other activities. They have started to evaluate the involved risk quantitatively following the format. Consequently the evaluation of the risk has been improved among them.

The second change is that the technological development of the company has become more anticipatory. Based on the explicit risk evaluation, for example, the engineers can have clear targets and put the appropriate priority of their commitments in their technological developments.

The third change is the commitment level of the involved people. As their product concepts are highly evaluated by the retailers and the executives at the early stage of development, they are encouraged at the start of the implementation of project. For example, those who used to come late now come early to meetings. Also they are aware of the involved risks initially and dare to challenge them. They become inquisitive about various things even external to their activities since they now understand the possible relationships involved.

The support system is not yet complete, but the initial application has turned out to be successful. The most important reason for the success is that the support system became a catalyst for the effective linkage.

5 Implications of the support system for the construction of an effective linkage

The support system has injected important effects into the process of value creation. The first effect works to generate a sustainable focus for the activities of the company, under which the involved people can continue to concentrate their energies and expertise consistently. The focus may not be theoretically valid, but reduces the fuzziness at the front-end pointed out by Zhang and Doll (2001). The accumulation of their efforts becomes meaningful. The variability of target used to be the source of their confusion and feeling of futility.

The second enhances the motivation of the people involved. The creation of sustainable product themes invokes their proactive thinking, not a reactive one based on only the VOC or shortsighted observations of competitors' behaviour. Imitation does not drive their challenging spirit.

The third effect promotes the organisation and grasp of the existing technologies of the company. Knowledge of the present level of the technologies not only identifies the present feasible region of the company but also suggests the future directions of the development of new technologies in reference to the themes of development. They can organise technological knowledge and have the possibility to generate their synergistic effects. The potentiality of technologies increases as the managerial ability of technologies enhances itself.

The fourth one increases the capability of implementing development. The function of the integrated planning and re-planning of activities is effective to secure consistent implementation in terms of timing and quality of activities. For example, during the development of one type of new model of refrigerators, a specific technological development was found to be far behind schedule. Then they changed the project leader instantly and strengthened the team by adding several people to make up the delay. At the same time, they rechecked their own technological map and also the patents of external companies. Both of the checks revealed alternative ideas of technological developments. Consequently the development could be done as scheduled. Even if the people involved understand the product concept, they never eliminate unexpected incidents. We need a system to cope with them.

These catalytic effects contributed to the construction of an effective linkage of activities. The effective linkage is characterised not only by the consistency of activities, but also by the commitment of the people involved to think and act proactively. They should be motivated to learn not only to do their jobs better, but also to make anticipatory preparations such as acquiring new knowledge, skills and technologies for what they think they should do in future. These behavioural features characterise the learning capability of the company.

The company equipped with such capability is the kind of learning company defined by Pedler et al. (1991). They argue that, "A learning company is an organisation that facilitates the learning of all its members and consciously transforms itself and its context". They continue that

> "This is the dream – that we can create organisations that are capable of changing, developing and transforming themselves in response to the needs and aspirations of people inside and outside the company and that enrich and sustain the wider world of which they are a part. The learning company maintains its viability by adapting to its context, and in doing so maintains

> meaningful work and development for its members, but also develops that context to achieve a sustainable relationship with it. This means that the people in such companies can, through their work, make contributions not to their organisations but through them to the wider society. In return they receive an enhanced sense of personal contribution and meaning."

The company sometimes fails to sustain its growth due to the constraint of managerial capability as the size of the company increases, as insisted by Penrose (1959). However the learning capability strengthened by appropriate system supports can break this constraint.

The support system has been recognised as effective in moving the company toward a learning company. The most important factor in this system is that it starts with the formation of a product concept or theme the company should seek. The formation used to belong to product planning. One significant problem with conventional product planning is that it stands aloof from the rest of company's activities in substance. Many companies adopt the system of a project manager responsible for the whole development process and also the concurrent engineering system. Company Z had adopted both of these. But many project managers failed to achieve satisfactory performances. They used to manage their activities from the formation of product concept to the ramp-up of production without any support system. They were not assisted by the systematic evaluation and checking systems of their themes, existing technologies and the feasibility of cooperation with relevant processes. Sometimes excellent project managers achieved successful performances, but their know-how used to remain implicit. The supporting system has promoted the knowledge sharing among the people involved throughout the process of NPD as advocated by Hong et al. (2004).

In NPD, a lot of researchers have mentioned many factors for successful development by emphasising specific aspects of the development such as rational plan, communication web, disciplined problem solving classified by Brown and Eisenhardt (1995). We propose the need of setting up a formal and systematic process to generate product ideas, consolidate all expertise and resources and coordinate the development effectively. The process is a catalyst for the effective linked management. It is very difficult to sustain the process without any systematic support. The systematisation effort sometimes invokes the resistance of involved people since they tend to think the process is not structured and they should be given adequate discretion to achieve. But the success of NPD in many cases depends on the effective planning and coordination of involved activities in terms of feasibility and time. The proposed systematisation helps them plan and coordinate under the constraints of time and resources.

6 Concluding remarks: strategic focus for the Japanese manufacturers

The performance of Toyota that is now considered to be one of the best-managed companies has been stable and satisfactory regardless of the different business conditions of the past 40 years. The most important key success factor for the performance is the Toyota Production System (TPS), based on the JIT system. The underlying concept of TPS, however, is the effective linkage of necessary activities, from the development of product concept to the sale of products now. The implementation of the JIT concept, still ongoing, is an effort to construct an effective linkage under the concept

of the maximisation of values to consumers by aligning all necessary functions as 'Just-in-time'.

In the electronics industry, one of the largest differences from the automobile industry is that technologies drastically change product configurations. The life cycle of a model is very short. They have put their focuses on the competition by new products. It has been difficult for them to have a stabilised supply network, and stable manufacturing processes on which they can put continuous improvements. They have increased the reliance on outsourcing. Now they become aware that it's too challenging to develop the effective and competitive linkage beyond organisational boundaries due to the problems of quality erosion and poor NPD performance that are frequently attached to easy outsourcing. They think they need to challenge to develop the effective linkage.

No systematic assessment of technologies, no systematic conceptualisation of product themes and concepts, no systematic evaluation of product configurations and no systematic monitoring and rescheduling of development progresses, – all these together end up with poor NPD. Without systematic supports of the process it's difficult for the company to achieve an effective linked process because the complexity of the process increases as the size and the product variety of the company increase. A real challenge towards the total integration of the processes and people is urgent to survive severe global competition.

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