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CUSTOMER SATISFACTION RESULTING FROM THE AUTOMOTIVE DEVELOPMENT PROCESS

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1. INTRODUCTION

For automobile manufacturer range of the process of product development, automobile manufacturer covers the entire activities from the creation of the product concept to the start of mass production in the factory. At present, concurrent engineering in product development is dominant instead of a linear type of engineering. But various types of concurrent engineering are observed. The differences seem to come from many factors. Various way of decision making in product development among automobile manufacturers are also observed. This research investigates the influence of the decision-making style on the competitive position of automobile manufacturers under today's business environment where the need of customers fluctuates greatly. This paper will also propose the best way of decision making from the viewpoint of competitive advantage.

In this paper, I will focus on investigating (1)how Japanese and Western automobile manufacturers are advancing product development, (2)what are the differences in the process of product development among automobile manufacturers, and (3)what are the factors which influence these differences.

The rest of paper is divided into the following sections: theoretical

background; hypothesis tested; research methods; case study of product development of 3 automobile manufacturers(Toyota, Nissan, Renault); and conclusions.

2. THEORETICAL BACKGROUND

Many discussions have been done in various ways about the difficulties of making the optimal decision out of all alternatives within the short period when firms make strategic plans.

As the rationality of human beings is limited, we are accustomed to making a decision at the satisfactory point. But when an individual becomes a member of an organization, his or her rationality in decision-making can be raised. That is because one may make a decision only from the viewpoint of value conforming to each organization (H. A. Simon, 1957).

In this turbulent business environment with remarkable technological innovation, organizations also have a limitation against the realization of rational decision making. So, we cannot expect impeccable decision-making when planning a firm's strategy.

The other discussion also has been done from the different viewpoint of rigidity and minuteness of decision making when planning. The more in detail the plan is and the more organizational members are influenced by that plan, the less flexibility the firm has and the less free to use their own judgment the organizational members are (W.H.Newman, 1951). Especially in the case of advancing R&D which needs significant creativity, the minute plan seems to restrain the organizational flexibility. Because planning is to make the framework of activity for the organizational members, however, innovation and creativity serve to destroy the existent

framework and to redefine it anew. In short, creativity cannot easily emerge from strictly scheduled activity.

So, it is better not to choose only one alternative at the first stage of planning. Instead of that, the strategic plan should include various alternatives and a kind of ambiguity so that it can be changed along with the changes in the market. This means that the final decision-making should be put off as late as possible.

The above-mentioned way of strategic planning is similar to the emerging strategy, as Mintzberg calls it, when the original intended strategy is replaced by or mixed with more proper strategy on the way. As far as emerging strategy is more proper than the original intended strategy, decision-making biased toward the future or pulled from the future is more effective than decision-making done by analyzing present data.

3. HYPOTHESES TESTED

Within this theoretical framework, I advance the following hypothesis concerning the competitive advantage of the firm in the process of product development.

The hypothesis is that a firm with a competitive advantage in the process of product development takes the pattern of decision-making biased toward the future or pulled from the future. Decision-making biased toward the future seems to have characteristics of leaving ambiguity in the plan at the very first stage. So the firm enjoys abundant flexibility such as many alternatives and design tolerance, and can put off the final decisions.

However, some factors influence the achievement of decision-making

biased toward the future. Those factors are as follows.

job demarcation:

The loose division of labor which does not need sequential decision making seems more suitable for concurrent engineering, whereas strict job demarcation seems more suitable for linear engineering in product development.

role of prototype:

The prototype as a physical object should be considered as a means for solving problems rather than for confirming the solution when making decisions biased toward the future.

relationship between vehicle assemblers and suppliers:

There are two types of relationships between vehicle assemblers and suppliers. One type is cooperative in which vehicle assemblers and suppliers share the profit realized in a future by the cost reduction accompanied with some technical innovations. The other type is adversarial in which one's profit leads to the other's loss for the moment.

So, after examining these factors which influence the style of decision-making in the automobile industries, the competitive advantage of a firm based on its style of decision-making will be discussed later.

4. RESEARCH METHODS

To test the hypothesis, a qualitative method comprising data obtained from interviews of Toyota Motor Company and Nissan Motor Company and secondary data from the literature was employed.

5. CASE STUDY OF PRODUCT DEVELOPMENT IN THREE AUTOMOBILE MANUFACTURERS

5-1. PRODUCT DEVELOPMENT OF TOYOTA[1]

Toyota has been using a system of development centers since 1992. This development organization is divided into four sections; the first development center (Vehicles of Front engine & Rear drive), the second (Vehicles of Front engine & Front drive), the third (Recreational vehicle and Van), and the fourth (Development of Requisite technology). The essential reason why this organizational change was done existed in the complexity of matrix organizations and the enormous coordination among the project team and functional divisions done by the chief engineer. For example, in 1991 the functional divisions had about 15 projects for developing new cars at the same time. It was too much for them.

In the design and development process of Toyota, many opportunities of appraising several alternatives are systematized. In total, there are 5 meetings for scrutinizing alternatives by the persons concerned and 5 appraisal meetings by about 100 panelists inside Toyota, as Table 1 shows, from sketches, 1/5 scale clay models and 1/1 clay models until the approval of the final styling. As the panelists participate from the various divisions of Toyota, they would be able to evaluate 1/5 or full clay models from the viewpoint of the customers. So, the cognitive gap towards styling between automobile manufacturers and users can be filled up by 10 appraisal meetings composed of the persons concerned and panelists by turns. The diversity of the participants in decision-making at these appraisal meetings seems to increase the possibility of making optimal decisions. The appraisal standards of styling at the last three meetings by the persons

concerned is to qualify the following at each level; "this model will make it so-so", "this model will make it to some extent" and "this model will certainly make it." In this period, many alternatives of styling are filtered out so as to leave the best one, and the ambiguity in styling is also decreasing step by step.

When the top management could not choose the best clay model out of A and B models at the last meeting, engineers in the design division start to design without waiting for the final decision of styling.

This is because the design engineers only perceive the difference of models A and B as that of models A and A'. For example, the packaging of the engine compartment among the remaining two models is not especially different compared with the difference of the styling between models A and B.

Table 1 Toyota Appraisal Process of Design

Exterior Design Concept * Interior image sketch	Sketch 1/5 model Sketch rendering	# 1/1 clay models (several) * # mock up color plan	# 1/1 clay model (one) * 1/1 mock up color plan	# parts design * # parts design
Appraisal Member 1	2	3	4	5

1. chief engineer, design division's members and planning section
2. chief engineer, design division's members and planning section
3. officers, planning section and operating section

4. officers, planning section and operating section

5. officers, planning section, operating section and top management

* examining meeting

Appraisal by Inside Panelist

source: Toyota internal data

If the timing of decision-making for the final styling is put off until later, the preference of styling will change along with the changes in the market environment. So, the later the decision-making for choosing the best alternative becomes, the more possibility we can have for choosing the alternative which satisfies the customer needs at the time of introducing it into the market. One designer of Toyota said as follows; "Why do you have to decide the final style for a new model today, whereas you can decide it with clearer vision tomorrow?" This indicates the importance of timing in decision-making.

For instance, when Toyota decides body hardpoints, it leaves as much as 2 cm design tolerance at the first stage for making a full-sized clay model. It can be said that design tolerance is the amount of flexibility remaining in the design. The final decision of body hardpoints is made at the second stage. On the contrary, American automobile manufacturers fix body hardpoints before making a full-sized clay model and try to avoid changes in the design.[(2)]

However, when American automobile manufacturers find problems with conformity among parts in the end, they must repeat the same activity from the very beginning of the whole process. This is because they did not

leave several alternatives as design tolerance. In the case of Japanese automobile manufacturers, as they leave flexibility in design tolerance on the way, they need not go back to the very beginning of the process.

From the beginning to the approval of final styling, Toyota makes one thousand to several tens of thousands of sketches, 5~10 1/5 scale clay models and 2~3 1/1 clay models at an average.

As for some problems found in the design, Japanese automobile manufacturers try to send the problems to next process instead of repeating the same activities for the improvement. For example, when they find some points which are not in order in pre-design, they try to correct them in the specified design in the next process. And if they also find some mistakes in the specified design, they try to correct them in the main design in the next process. So they avoid fixing strict numerical values in each step of design in order to not make dramatic changes in the end.

As a whole, Toyota regards the hard model as playing a role of solving problems, and decides the details of design after making real objects. So, Toyota does not try to solve all problem in each process but moves to the next process where Toyota tries to solve the remaining problems. The concept of ambiguity is very important for Toyota. Toyota remains ambiguous during the process and puts off the final decision-making until the last moment. That is how Toyota develops new models more effectively, speedily and cheaply than Western automobile manufacturers, whereas Western automobile manufacturers seem to be very efficient superficially by choosing only one alternative at the very beginning.

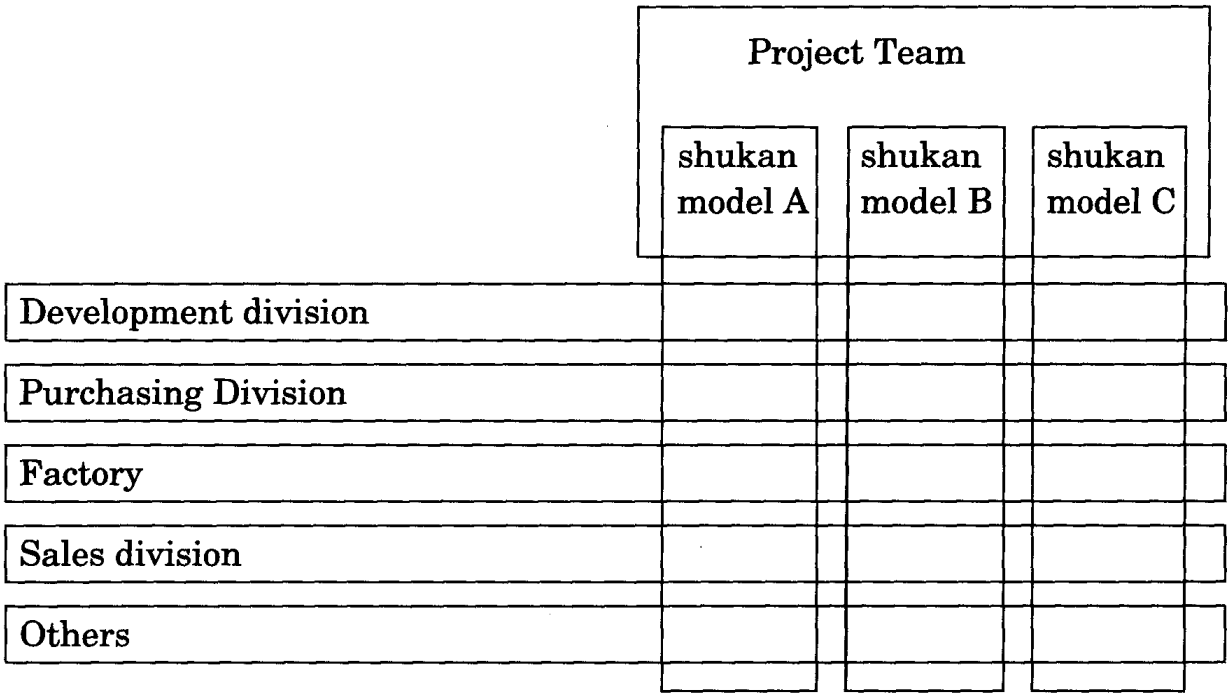
5-2. NISSAN'S PRODUCT DEVELOPMENT -from the viewpoint of target costing-

The organization of product development in Nissan is a matrix like figure 1, composed of project teams by each car model under the leadership of 'Shukan' (product manager) and functional divisions.

Therefore, Nissan does not have the system of 4 separate development centers like Toyota. To determine the price of a new model, Nissan has been taking the current target costing method shown in figure 2 since the mid-1980s. The examining meetings for the attainment of target costing are held 7 times in total between Nissan and parts suppliers. These meetings are called 'hearings' where Nissan hears the present situation of target costing activities from parts makers.

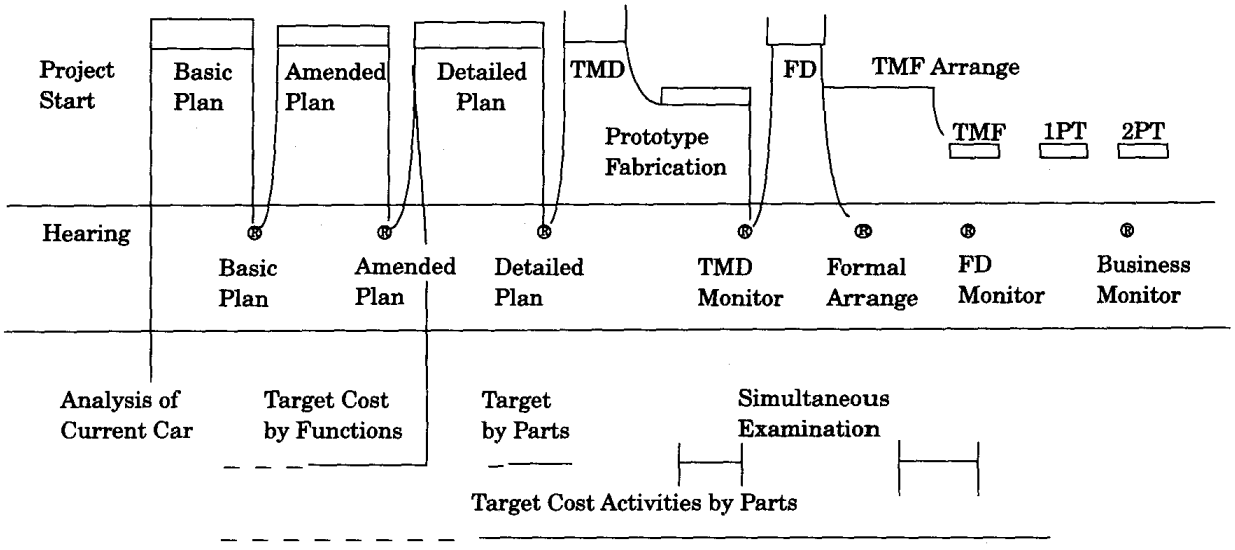
The summary of the target costing process is as follows. At first, the designer makes the basic plan for each part, based on the product concept of Shukan. The place to discuss the basic plan is at the 'hearing' in which the manufacturing engineer, the purchasing division, the target costing division, and Shukan participate. Then each participant brings back the issues discussed to its division. After some issues have been examined in each division, the results are fed back to the amended plan which the designer makes in the next process. In the amended plan, the target costs are allocated by each functional part. In the final detailed plan, the target costs by each part are calculated finally.

Figure 1. Nissan Matrix Organization for Product Development



source: Nissan internal data

Figure 2. Target Cost Activities in Nissan's Product Development



* FD = Formal Design
* TMD = Trial Manufacture Design
* TMF = Trial Manufacture in Factory
* 1PT = First Production Trials
* 2PT = Second Production Trials

source: M. Kajita 'Concurrent Engineering of Nissan and its group', Kigyo Kaikei, Vol. 47, No.6, 1995, p.53.

Therefore, Nissan takes steps of allocating target costs into the functions wholly at first, then into each part partially. What comes next is the process of prototype fabrication by which the persons concerned make efforts to realize the unaccomplished target costs by changing the design. The prototype is to be fabricated according to the trial manufacture design based on the detailed plan. Nissan calls that design made before making the prototype the 'trial manufacture design'. The final design will be decided after making the prototype. The final design is called the formal design. The change of design for target costing must be finished by the first production trials.

Since Japanese car makers regard the prototype as a means of solving problems as Nissan does, they fabricate the prototype under the uncompleted design with some design tolerance. If they find any problems facing the real prototype, they feed back its solution so as to complete the formal design in the next stage. In short, the trial manufacture design seems to be a kind of guideline for prototype fabrication. Therefore, Nissan ends up fabricating many prototypes as alternatives and chooses the best alternative which has passed various tests. Then Nissan makes the final

design from the chosen alternative.

On the contrary, in Western automobile manufacturers, the final design has already been decided before the fabrication of the prototype. They use the prototype in order to confirm the completeness of the final design.[3]

In the relationship between the design and prototype fabrication in terms of target costing at Nissan, the final decision to choose the best design is put off until the prototype fabrication. So, ambiguity in design can be allowed at the first phase. The remaining ambiguity in design will be clarified step by step, by VA(value analysis) and VE(value engineering) under the cooperative activities of the automobile manufacturers and the parts suppliers.

5-3. PRODUCT DEVELOPMENT IN RENAULT

Here, product development in Renault is mainly analyzed from the relationship between Renault and its parts suppliers. Renault was forced to take a policy of vertical integration in terms of fabrication of parts until 1984. As the Socialist Party in France had enhanced the creation of employment at that time, Renault could not fire superfluous employees. So, Renault used them as workers for parts fabrication.

As the global competition in the automobile industry became more intense, Renault decided to introduce Japanese-style efficiency into the relationship between the vehicle assembler and the parts suppliers. This meant that Renault changed its strategy from vertical integration to outsourcing in terms of parts fabrication. The ratio of outsourcing has raised step by step since that time. In 1994, Renault purchased parts from suppliers as much as about 70% of the production costs of a vehicle. In contrast, the number of parts suppliers with which Renault deals has been

decreasing (for example, from 720 in 1990 to 543 in 1994, see p.27 Renault Economic Atlas, 1995). This is because Renault, like other automobile manufacturers, took measures to deal with system suppliers which could subassemble several parts into a component part, and Renault developed new cars in partnership with them. So although the ratio of the outsourcing of parts has increased, Renault has been able to decrease the number of parts suppliers.

Along with the shift to the outsourcing strategy of Renault, desirable suppliers became the ones who could maintain excellent function and quality, competitive prices, and precise delivery time of parts through the whole development process, whereas traditional suppliers were only required to have the lowest price at the competitive bids. As a result, the choice of parts suppliers by the vehicle assembler does not depend on the suppliers' ability to make the best proposal by having the lowest price at the beginning, but instead they are chosen for their ability to coordinate the design of parts through the whole process of development. Especially since the design and development of the compact car 'Twingo', Renault has changed its traditional style, adopting the new style termed 'design to cost' and 'plateau du projet'.[(4)] 'Design to cost' means that designer designs considering the cost of parts, and 'plateau du projet' means the place of the project where all participants get together and develop a new model. By these measures, Renault has been able to introduce target costing and concurrent engineering into design and development. But if these measures were examined in detail, there are differences in some points between the Japanese method and the French method as the following table 2 shows.

Table 2. Comparison of relationship between automobile manufacturers and suppliers in Japan and France

Japan <----------France shifting	
cooperative	adversarial
After the cost table of suppliers is disclosed to a car maker,	
their margin is guaranteed to some extent.	their margin is reduced.
Suppliers can make proposals of cost reduction by innovations without any anxiety.	Suppliers are not willing to propose cost reduction which leads to reducing margins.
Car makers guarantee the period of transaction.	Car makers are not willing to guarantee the period of transaction.
Car makers and suppliers have mutual responsibility as partners.	Car makers tend to lay emphasis on the responsibility of only suppliers and put the responsibility of designs on suppliers even if suppliers do not have ability to design by themselves at once.
Car makers trust fabrication of parts to suppliers who participated in design and development.	If there were suppliers who can fabricate parts cheaper, car makers happen to switch over to them from the suppliers who participated in design and development.
Car makers and suppliers make efforts to reduce costs until the level of target costs.	Although suppliers undertake the fabrication of parts at the target costs, they have much incentive to raise costs by some chance.

The relationship between vehicle assemblers and suppliers in France has become more cooperative step by step by introducing 'Japanization' that suppliers design parts from the car maker's rough specification at the target costs. French vehicle assemblers also expect suppliers to reduce the costs of parts by scale merit. So, they are encouraging suppliers to diversify their customers. This means that cost reduction can be realized by both methods of target costing and scale merit. On one hand, target costing needs many changes in design by VA & VE during the design and development process. On the other hand, scale merit needs standardization in the design of parts. So, these two methods are incompatible if their realization were considered strictly. If French automobile industries aim at real 'Japanization', all systems should be reconstructed into Japanese systems such as 'long term transaction with suppliers', 'reorganization of suppliers in tiers', 'heavy weight product manager' who has big power and responsibility and so on. This is because even if French automobile industries adopt only one Japanese system such as target costing, it does not work well as a whole. But is is not impossible to change all their systems. So, French automobile manufacturers will adopt a slightly-changed Japanese system so as to suit their system.

As for the capabilities of suppliers, they must be able to coordinate the design of parts according to the change of the adjacent parts' design through the whole process of design and development, and also need to realize the target costs. So, they are required to commit themselves until the end of design and development, instead of only proposing the best design and the lowest costs to their customer at the beginning of design and development. That is, the design and costs of parts at the last moment of design and development teach us how much capability the suppliers

have.

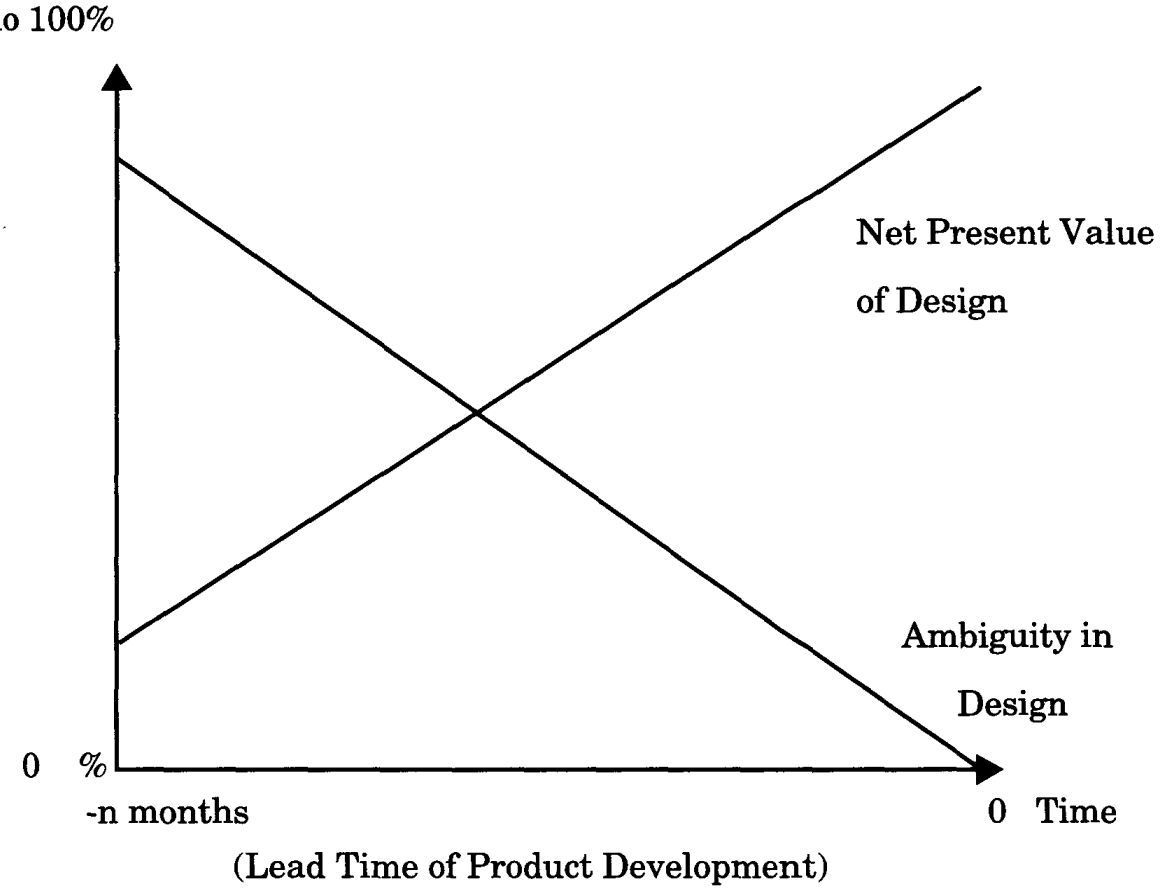
6. AMBIGUITY IN DECISION-MAKING

The process of design and development can be seen as the repetition of solving problems. The cycle of solving problems consists of the followings; bringing forward a problem, making several alternatives, making appraisals, and decision-making for choosing the best alternative. The problems to be solved in the first half of the design and development stage are concept creation, product planning and advanced engineering. The problems to be solved in the latter half of the design and development stage are product engineering, process engineering and pilot run. The optimal pattern of decision-making in design and development is to put off the final decision for design as much as possible and to finish the development as soon as possible. So, the design should be ambiguous to some extent by allowing design tolerance until the final decision. If so, the designers can take changes in the market into consideration in their designs to the utmost.

Figure 3 shows the relationship between ambiguity in design and net present value of design based on the time of introduction of a new car into the market. The X axis shows the lead time for the introduction of a new car into the market. The Y axis shows the ratio. If the lead time is n months, net present value of design decided at the beginning of product development (-n months) is discounted. The discounted value can be filled up with ambiguity or flexibility left in the design. Even if the optimal design is decided at a certain time within the lead time, the value of the design will decrease according to changes in customers' needs. So, the

design should not be decided with 100 percent certainty until the last moment of deciding the final design. Therefore, as the lead time becomes shorter and shorter, the net present value of design will increase and the ambiguity in design will decrease as figure 3 shows.

Figure 3. Relationship between Ambiguity in Design and Net Present Value of Design based on the Time of Introduction of a New Car into the Market



7. CONCLUSION

The Toyota production method represented by 'Kanban' is called a 'pull

system' which pulls the way of working from the last process or the market. This means that Toyota rapidly manufactures vehicles ordered from customers with no defects. On the contrary, the traditional production system is called a 'push system' which pushes materials from the first process according to the production planning.

Here I propose that the design and development method of Japanese automobile manufacturers should also be called a pull system. The Japanese method of design and development is a 'pull system' in which the time of introduction of a new car into the market pulls the time of decision of the final design towards itself. So the ambiguity of design will remain as design tolerance until the last moment as much as possible. Once the final design is decided, the following product engineering and process engineering should be done rapidly before the design trends in the market change. In a pull system, the pattern of decision-making is pulled towards the future.

Compared with the Japanese pull system in design and development, the Western pattern of decision-making can be called a push system in which automobile manufacturers try to push the jobs theoretically and rationally from the beginning according to strategic plans. As there is not so much ambiguity in design, repetition of activities often occurs when malfunctions in design are found late in the process.

At present, the pattern of design and development of Western automobile manufacturers is approaching that of Japanese automobile manufacturers. That is because the design and development methods of Japanese automobile manufacturers has a more competitive advantage than that of Western automobile manufacturers, as has been proved in much of the literature (e.g. Clark & Fujimoto, 1991). Japanization in terms of

concurrent engineering, organization of project teams, heavy-weight product managers, target costing and the Japanese style of relationships with suppliers was also seen in the case study of Renault. Moreover, Japanization is also found in American automobile manufacturers although it is not mentioned here in case studies. American automobile manufacturers have introduced Japanese design and development methods such as concurrent engineering, heavy-weight product managers and 'design-in' of joint development with component parts makers since the end of the 1980's. By Japanization, they can shorten the lead time of design and development. However, they would have to reorganize their traditional development organizations divided by functions into organizations by car types so as to change their systems drastically.

Thus, Western automobile manufacturers are now on the way to the Japanese method, or "pull system", of design and development.

Table 3 presents a summary of design and development by automobile manufacturers.

Table 3. Design and Development Patterns of Car Makers

pull system (Japanese way)	←	push system (traditional Western way)
*target costing	← *cost minus method ←	*cost plus method
product manager has big power focusing on customers' needs	←	functional managers have big power focusing on technology
concurrent engineering by project team	← concurrent engineering divided by functions ←	linear engineering
long term relationship with suppliers (focusing on capability of design)	←	competitive bidding (focusing on price)
several alternatives with design tolerance		a few alternatives
prototype=a means of problem solving		prototype=master model
ambiguous job demarcation		strict job demarcation
decision-making biased to future		decision-making under rational analyses

*target costing　Price(fixed)-Profit(fixed)=Cost(fixed)

*cost minus method　Price(fixed)-Cost(variable)=Profit(variable)

*cost plus method　Cost(variable)+Profit(fixed)=Price(variable)

ANNOTATIONS

(1) From the data obtained by interviewing Chief Creative Designer of Toyota, Mr. Shigeaki Sugawara.

(2) Ward, A., Liker, J.K., Cristiano, J.J. and Sobek II, D.K., The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster, Sloan Management Review, Spring 1995, p.46.

(3) Clark, R. B. & Fujimoto, T. (1991), Product Development Performance; Strategy, Organization and Management in the Auto Industry, Cambridge, MA. Harvard Business Press. p.181.

(4) Midler, C. (1995), L'auto qui n'existait pas, Nouveau tirage, InterEditions. p.26.

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