The Influence of Inter-Project Strategy on Market Performance in the Auto Industry, 1980-1990

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Abstract

This paper examines differences in strategy for new product development at the firm level as well as the impact on market performance by analyzing 223 new car products introduced at 21 automobile manufacturers between 1980 and 1990. The results: Differences in market share growth correlate strongly with new product rates and average design ages of products. Japanese firms led in these areas and utilized a different inter-project strategy, with rapid design transfers among multiple projects. European firms had fewer new products but newer designs. U.S. firms did not develop many new products or designs, and performed worst in the market.

1. Introduction

Since the management of new product development has become a central issue in global competition, numerous academic researchers in recent years have undertaken studies of how effective and efficient projects have been in various industries. Most of the empirical research has focused on managerial or organizational approaches as well as performance measures for individual projects (Imai et al., 1985; Henderson, 1990; Clark and Fujimoto, 1991; Cusumano, 1991). At the same time, there are various reports that Japanese manufacturers tend to develop new products much more frequently than U.S. or European competitors and that this has been one of the major reasons, along with manufacturing skills, for their strong performance in global markets (Abegglen and Stalk, 1985; Dertouzos et al., 1988; Womack et al., 1990). But researchers have not yet studied in depth the management of multiple new-product development efforts over time at the firm level. This is important because, while high levels of engineering productivity in individual projects may contribute to making a firm overall more efficient in product development, to develop a successful stream of new products over many years, as well as to take advantage of designs and components in more than one product without compromising the final products unnecessarily, requires some degree of planning and coordination above the level of the individual project.

In industries where manufacturers offer multiple products to the market and undertake multiple projects in parallel, such as with automobiles, new product development strategies and organizations must take at least two elements into consideration. First, they need to plan for the frequency of new development projects, both to replace existing products and to expand the breadth of available product lines (Utterback and Abernathy, 1975; Miller, 1988; Kekre and Srinivasan, 1990; von Braun, 1991). This frequency becomes an important competitive dimension because some manufacturers appear to be much more prolific in their new product introductions than others. Secondly, firms need to plan how related they want products to be, such as in terms of components or design features, and manage the coordination process among multiple projects as necessary. For example, some manufacturers develop an extensive number of different products that share the same basic design, while others prefer to use unique designs more often in each of their different new products (Clark and Fujimoto, 1991; Womack et al. 1990). These differences may reflect decisions made above the project level, yet they affect not only the project organizations but also a firm's competitiveness. Nonetheless, there has been little empirical research that explores the interrelationship of these factors and their impact on either market or organizational performance.

This paper examines these differences in strategy for new product development at the firm level, as well as the impact on market performance, by analyzing 223 new car products introduced at 21 automobile manufacturers between 1980 and 1990. The next section presents a brief review of past studies of new product development in the auto industry to highlight what conclusions researchers have drawn as well as what areas have yet to be studied in depth. The third section then proposes a framework to analyze inter-project strategies. The last two sections describe the sample and measures used to explore the impact of inter-project strategy on market performance, and then discuss the results of the data analysis.

2. Recent Studies of New Auto Product Development

Numerous studies in recent years have examined differences in strategy, structure and performance for new product development among worldwide auto manufacturers (see Cusumano and Nobeoka 1991 for a detailed review of this literature). In particular, Clark and Fujimoto at Harvard University and the

International Motor Vehicle Program at MIT have found several important differences in management and performance among Japanese, U.S. and European manufacturers (Clark et al., 1987; Sheriff, 1988; Womack et al., 1990; Clark and Fujimoto, 1991). Clark and Fujimoto conducted the most thorough study, focusing on 29 projects from 22 producers. They concluded that the Japanese firms, in general, were better at new product development as measured by design quality, lead time, and productivity defined by engineering hours. Among volume producers, three factors also contributed to better project performance: heavier program manager responsibility, higher supplier involvement in engineering, and more overlapping between stages such as product planning, product engineering, and process engineering.

Clark elaborated on these data in a 1989 paper that focused on the result showing that Japanese projects used more unique parts than U.S. or European firms, which theoretically may increase design quality but also add time and cost in development, unless fitting old parts into new designs creates additional coordination that increases engineering time (Clark, 1989). He concluded that Japanese projects had more unique parts and higher engineering productivity than their U.S. and European counterparts primarily because they made more extensive use of suppliers.

Since Clark and Fujimoto's sample consisted of one or two projects from each firm, they limited their study to a project-level analysis and comparisons, with statistical analysis, of regional averages for Japanese, European, and U.S. producers. Therefore, it is difficult from this sample to generalize about the linkage between project-level performance and firm-level performance in the marketplace. Nor were they able to explore the potential impact of different inter-project strategies and management approaches on organizational and market performance.

As part of the MIT study, Sheriff measured differences in the frequency of new product introductions and average project complexity for 25 major auto manufacturers between 1982 and 1987 (Sheriff, 1988; also reported in Womack et al., 1990). Project complexity was calculated through an index that assigned weights to changes made in major exterior, interior, and platform components, with adjustments upward for each additional body style or wheelbase variation. These data confirmed that Japanese firms introduced new products much more frequently than U.S. or European firms. As a result, the Japanese firms maintained much newer products in the market and increased the number of product offerings during this period. In addition, Sheriff's measurements showed that the European projects had the highest average complexity, followed by the Japanese and then the U.S. producers. Fujimoto and Sheriff then compared their data to explore interrelationships and found positive correlations between productivity measures such as lead time as well as engineering hours at the project level and the performance variables at the firm level (Fujimoto and Sheriff, 1989). They also found a positive correlation between the rate of new product introductions and market-share growth, although this paper did not explore the impact of project complexity on market performance.

The purpose of our study is build on this research and explore product-development strategy and performance at the firm level. The underlying hypothesis is that, apart from differences in productivity or lead time for individual projects, differences in inter-project strategy and management can significantly influence how efficient and effective an entire firm is in new product development.

3. Firm-Level New Product Strategy and Inter-Project Strategy

Large automobile manufacturers have several product lines and constantly develop new products to replace existing products or to add new product lines. There are two basic considerations that determine how product lines evolve within firms: the frequency of new product introductions, and the way different projects interact or relate to each other in design engineering. Our research framework consists of two approaches to examine these dimensions. First, we define variables critical to measure firm-wide new-product development outputs during a fixed period, which include the *new product rate*, *average design age*, and *average intra-project variation*. Second, we develop a typology of inter-project strategies, which categorize the alternatives for inter-project interactions into four types.

Variables on Firm-wide Measurement of New Product Development: The new product rate is the ratio of the number of new product introductions adjusted by the number of product offerings in a base year. A higher new product rate makes it possible for a firm to replace existing products or enter new market segments more frequently than competitors (Miller, 1988; Fujimoto and Sheriff, 1989; Kekre and Srinivasan, 1990). In order to increase the new product rate, however, firms need to invest more financial and engineering resources, or decrease the average project task requirements (complexity). Otherwise, frequent new-product introductions may reflect incomplete development efforts and result in products that suffer from problems in design quality and perform poorly in the market. If firms do not want to or cannot increase their resource investments, then increasing the new product rate requires a decrease in task requirements. As Clark (1989) illustrated, a project that develops more new components requires more lead time and engineering hours.

Firms also have at least two choices to decrease engineering tasks for new components: decrease the average intra-project variations or repeat the same design among different new projects. Decreasing intra-project variations may have a negative impact on market competitiveness because products appear similar to consumers and lead to a reduced coverage of market segments. The repeated use of the same design or components may also have a negative impact on market competitiveness, because the purpose of frequent new product introductions is to capture changes in customer needs with new technology. Reuse of an old design may conflict with this objective, although the rapid reuse among multiple projects of new technology may actually improve the overall newness of a firm's product offerings.

Therefore, we can hypothesize that the negative impact on a firm's market competitiveness should depend to some extent on the average design age of new products introduced into the marketplace. There should be a tradeoff between increasing the new product rate and incorporating new designs into each new product, rather than extensively reusing the same design. Successful Japanese automobile firms, however, appear to develop more new products without introducing older designs than their U.S. and European counterparts. One of Clark's findings, for example, implied that, in order to avoid this tradeoff, Japanese manufacturers depended more on outside suppliers for new component designs (Clark, 1989). Our study offers the hypothesis that the Japanese manufacturers may also have different inter-project coordination strategies from U.S. and European manufacturers in order to mitigate this tradeoff. Specifically, we are interested in exploring whether Japanese manufacturers transfer existing new designs from one project more quickly into other projects developing new products. The next section discusses the second part of our framework that deals with this research question.

Inter-Project Strategy: Firms have various alternatives for inter-project strategies used in new product-development. Figure 2, which presents a typology of these strategies, categorizes new product development projects into four types, depending on two dimensions: the extent of changes and sources of the base design. The extent of change differentiates a new project whether its core design is newly developed or transferred and modified from other projects within the firm. Projects that develop their own new core designs are categorized as a *new design*. In the latter case, variations of the modification can be broken down into three types, depending on the location of base design sources: either an on-going other project, an existing other product, or the new project's predecessor product. These three types are labelled here as *concurrent design transfer*, *sequential design transfer*, and *design modification*, respectively.

New design thus refers to the development of a new product with a core design produced primarily from scratch, without a preexisting base design. In this type of project, there is little relatedness or interaction with any other projects within the firm. Members of the project can concentrate on creating a new design and a new product. While the project's engineering task requirements should be high because the design is new (Clark, 1989), both coordination costs and design constraints are low because the project does not have to be coordinated with other projects or follow design constraints derived from an existing design base.

The next two types of projects transfer and share a core design from other projects within the firm. In the second type, concurrent design transfer, a new project begins to transfer a core design from a base project before the base project completes its design engineering. These two projects -- the new project and the base project -- require extensive and potentially costly coordination because (1) they must overlap chronologically, (2) the new project needs to incorporate a design from the base project while the design is still relatively new, and (3) mutual adjustments in design between the two projects are still possible and perhaps likely.

The third type, sequential design transfer, transfers a design from a base model after the base model's development is finished. Because this type of project basically reuses an existing design that is "off-the-shelf," inter-project coordination is not needed. When a new project uses the core design in this manner, however, the design being transferred is already relatively old, compared to designs transferred more concurrently. In addition, design constraints may be high because mutual adjustments between projects on the core design are no longer possible. (This discussion of hypothetical differences between concurrent and sequential design transfer are partially based on Thompson's distinction between "long-linked technology" and "intensive technology," where the latter also requires mutual adjustments and higher coordination costs. See Thompson, 1967).

The last type, design modification, refers to a new development project that modifies a direct predecessor product as in a relatively minor model change. This type of project does not need any inter-project coordination either, but has to consider constraints from the core design of the current model. The difference between the design modification and the sequential design transfer is thus the source of the base design. While the design age in this type is determined by the base product's life cycle and can even be older than with a sequential design transfer, modifications may be easier than with a sequential design transfer, which transfers a core design between different product lines. Another difference is that sequential design transfer can be used to add a new product line, while a design modification is only for replacement projects.

4. Sample Characteristics and Measurements

The sample in this study covers the 21 largest auto manufacturers in the world, including seven Japanese, three U.S., and eleven European producers, and the 223 new car products they introduced between 1980 and 1990. Data on new product development in the industry were collected from Auto Review, an annually published industry journal that covers design features and introduction dates for all new products worldwide. Unstructured interviews with engineers in these firms were also conducted when needed for clarification. As a market performance variable, following Clark and Fujimoto (1991), we used the cumulative worldwide market (unit-production) share growth of each manufacturer during this period. Other measures as described below were also used as classification and performance variables.

New Product Rate, Intra-Project Variation, and Design Age: We measured the *new product rate* for each manufacturer by the ratio of the number of new product introductions between 1980 and 1990 divided by the number of product offerings in 1979. Following Sheriff (1988), we also broke down the new product rate into the *replacement rate* and the *expansion rate*. The replacement rate measures the ratio of the number of new products that replaced existing products divided by the number of product offerings in 1979. The expansion rate is the same ratio for new products that were developed to add a product line. A sum of the replacement rate and the expansion rate, therefore, equals the new product rate for each firm. We also measured the *change in the number of product offerings* during this period as a control variable. This variable also determines the breadth of market coverage, which is affected not only by the expansion rate but also by withdrawal of product lines.

We defined a new product as a model designed within a single project and with completely new interior and exterior stylings. By this definition, a new product with minor cosmetic modifications is not counted as a new product. Product variations designed within a single project, such as the Ford Taurus and Mercury Sable, count as only one new product. On the other hand, we used another variable for *intra-project variation* to show the average number of different body types and stylings developed within individual projects. Whether two or more new variations were in fact developed together within one project or separate projects is critical to this study, because this affects the total number of new projects and the nature of their interrelationships. Most cases, such as the Taurus and Sable, are openly discussed in Auto Review or other industry journals. For unclear cases we have had to rely on interviews with company engineers.

The *design age*, which is the age of the core design a new project uses, measures the difference in time between the introduction of the new product and when the base product was first developed. For example, the design age of a new project that develops a core design from scratch is zero. The core design used in the present data analysis is the platform design, which determines the basic characteristics of other major component designs, including the body and engine size, drive-train type, and the general level of design sophistication. Designing a new platform from scratch requires both financial and engineering resources as well as new technology. In order to determine whether the platform of a certain new project was newly developed or transferred from preceding products, we assigned points to the extent of changes in platform design between the new product and preceding products similar to the new product, based on changes in the wheelbase and tread as well as the suspension design (see Appendix 1 for more details).

Inter-Project Strategy: As a firm-level analysis of inter-project strategies, we classified projects done within individual firms during 1980-1990 into four inter-project strategy types. New projects that developed new platform designs are automatically categorized as the first type, new design, while those developing new products based on platforms from other projects fall into one of the other three categories. Projects that developed a new product based on the platform design of the predecessor model are categorized as design modifications, while those which shared platform designs with any preceding projects are either concurrent design transfers or sequential design transfers. As indicated earlier, the distinction between concurrent and sequential transfers is determined by the transfer time lag, which is the same as the design age defined above.

First, we compared the average transfer time lags for the Japanese, U.S., and European projects that were not new designs or modifications. We then defined concurrent design transfers as a transfer between two projects occurring within 2.0 years of the introduction of the core design. Visual analysis of a frequency distribution for new projects indicated that one group of projects transferred designs within 1.25 years, while another group transferred most designs after 2.25 years (Appendix 2). The figure 2.0 years was also the median transfer lag time for the entire sample and is close to the midway point (2.25 years) for the average lead time (4.52 years) for new car development as calculated by Clark and Fujimoto (1991: 73). We also tested the sensitivity of this division by using 1.5 years and 2.5 years as cutoff points, with no significant change in the results. In addition, we believe that if the time lag is longer than two years, then there does not need to be much overlapping or coordination between projects.

5. Results and Discussion

New Product Development and Market Share Growth: Table 1 shows a regression analysis with cumulative worldwide market share growth as a dependent variable and firm-wide measurements of new product development as independent variables. The first model shows that new product rate and average design age significantly influence market share growth, while either change in the number of product offerings or average intra-project variation do not. In other words, firms that developed more new products and, at the same time, incorporated newer core designs into their new product development efforts tended to increase their market share. On the other hand, merely increasing the number of product offerings by, for example, keeping old products available for many years, did not increase market share. It is also significant that increasing the complexity of projects by adding variations in styling and body types did not have a significant impact on market share either. In addition, when adding the replacement and expansion rates instead of the new product rate in the second model, only the replacement rate has a statistically significant impact on market share, though both variables are associated with increases in market share.

The last two models examine regional differences. The third model, which includes independent dummy variables for U.S. and European manufacturers, supports earlier findings by Sheriff (1988) and Clark and Fujimoto (1991) that show strong regional differences. Japanese manufacturers on average increased their market share by 62%, while European firms gained only 9% and the U.S. firms declined by 27%. Because these regional dummy variables are strongly correlated with the two key predictor variables, no variable in the last model is statistically significant.

The regional differences are evident in Figure 2, which plots the regional identifications along with two key determinants: the new product rate and average design age. Japanese firms tend to be in the high new product rate/small average design age region and gained more market share than competitors. European firms tended to develop fewer products with newer designs. All three U.S. firms and two European firms developed fewer products with older designs than most of the Japanese firms and lost in market share. Figure 2 also suggests that European and U.S. firms, but not Japanese firms, experienced a tradeoff between the new product rate and average design age. This may well be because Japanese firms, which achieve both high new product rates and new average design ages, may have different inter-project strategies and management approaches.

Inter-Project Strategy and Regional Differences: Table 2 summarizes regional differences in usage of different inter-project strategy types. Three different patterns are evident in each region. Most importantly, the average transfer lag times for the Japanese, U.S., and European samples were 1.47, 3.46, and 2.78 years, respectively. This reflects, we believe, that Japanese manufacturers utilized more concurrent design transfers than European and U.S. firms, which resulted in both higher new product rates and relatively new average design ages. In other words, instead of developing many completely new core designs to achieve these two key objectives, Japanese firms created a few new core designs and quickly transferred these to other product lines, while the designs were still relatively new. Since 23% of new projects at Japanese firms used concurrent design transfer, at least 46% of Japanese projects may have required extensive inter-project coordination because each concurrent transfer involves some overlapping with at least one other project from which the core design is transferred.

The European makers are characterized by an extensive use of completely new designs, which explains the low average design age of their new products. Even though they developed fewer new products, by concentrating on these products, they developed newer designs than other producers. The results of this strategy may reflect the ratio of change in unit sales growth per product offering, which only European manufacturers increased on average during this period. The U.S. makers tended to have more sequential design transfers than other firms, which resulted in older designs in their new products. Accordingly, they did not develop either as many products as the Japanese or as many new designs as the Europeans.

6. Conclusions and Further Research

This paper proposed a framework to analyze strategies for multiple new-product development projects measured at the firm level, focusing on a theoretical inter-project strategy typology and empirical results that support the importance of firm-level measurements of new product development and strategic alternatives. The results indicate that differences in a firm's market share growth during the 1980's correlate strongly with the firm's new product rate and the average design age of its products. The Japanese firms led in both these areas and utilized a different inter-project strategy from U.S. and European competitors, with much faster transfers of designs among multiple projects. European firms had fewer new products but newer designs, and increased unit sales per product ratio. U.S. firms did not develop many new products or use new designs, and performed worst in the market.

Further work remains to be done in several areas regarding organizational structure and process as well as new product development strategy. First, we intend to explore what are appropriate organizational structures and processes needed to implement different inter-project strategies. While concurrent design transfer appears to be critical for superior rates of market-share growth among the Japanese manufacturers, researchers have not yet examined coordination mechanisms between different intra-firm projects. Second, although the concurrent design transfer strategy of Japanese manufacturers was appropriate to increase market share, its impact on economic factors such as sales generated per product or returns on R&D investments remained to be examined. Other performance constructs that we intend to explore include the impact of inter-project strategy on design quality as well as manufacturing performance. Although these variables may affect market share growth, it is important to establish theoretical linkages and test these with empirical data. Finally, we intend to expand our data sample to include advanced engineering components, primarily engines and transmissions, rather than focus only on platforms and body styling to determine how "new" designs are as well how newness of major components affect market performance and economic returns.

Figure 1. Typology of the Inter-project Strategy

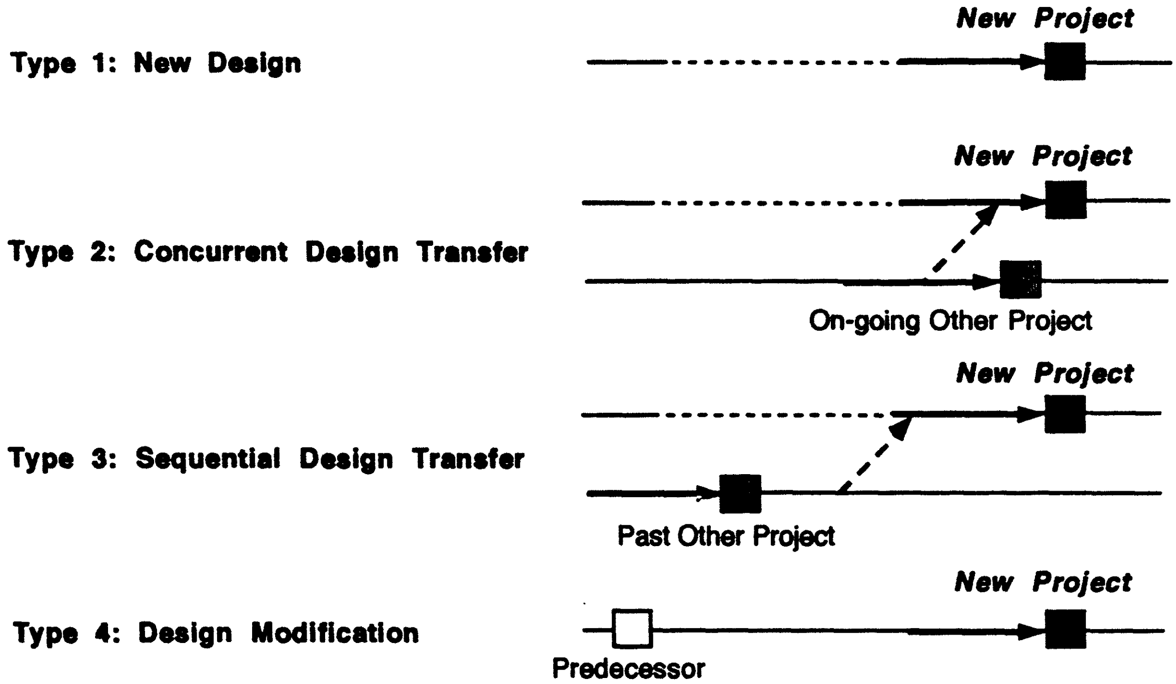


Figure 2. New Product Rate and Average Design Age

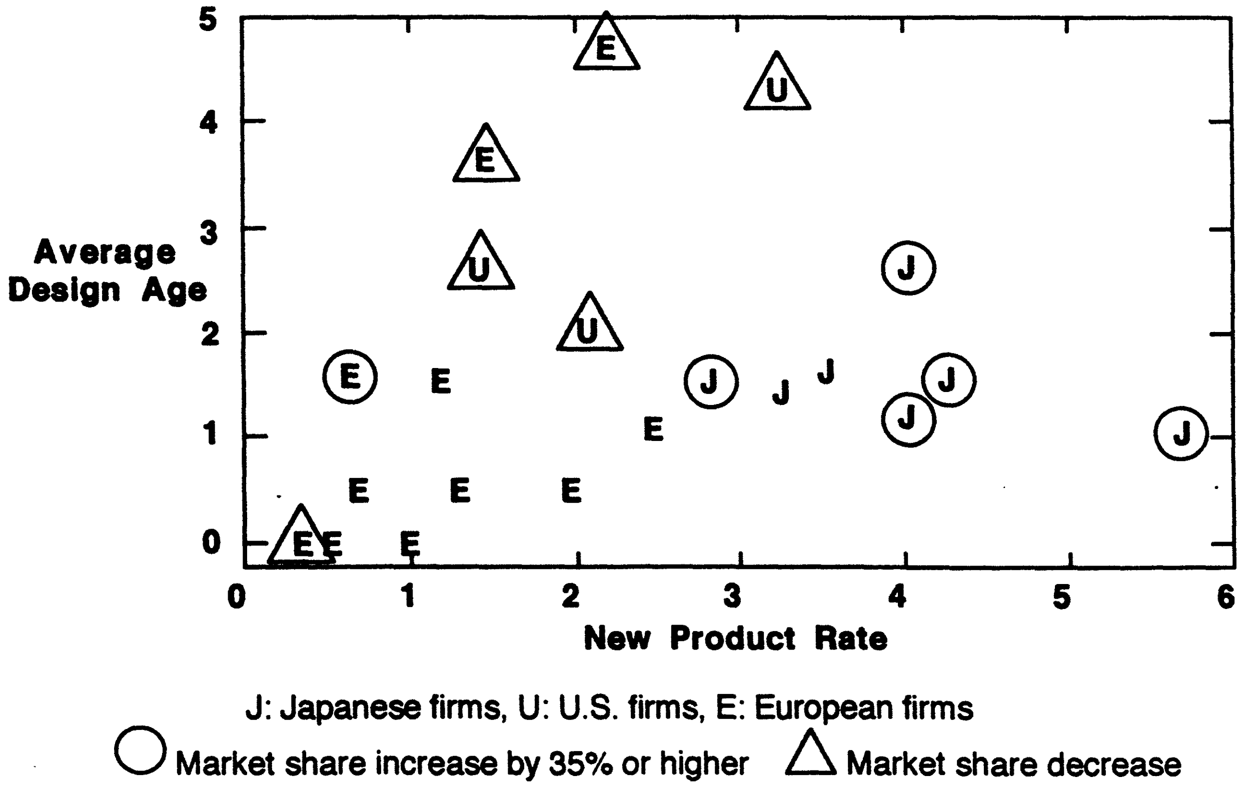


Table 1. Regression Results for Cumulative Worldwide Market Share Growth

	Dependent Variable=Market Share Growth (Number of Sample=21)			
Independent Variables	1	2	3	4
Constant	.48	.47	.62***	.17
New Product Rate	.29***			
Replacement Rate		.20**		.18
Expansion Rate		.23		.65
Change in # of Product Offerings	-.21			-.31
Average Design Age	-.15**	-.16**		-.10
Average Intra-project Variations	-.26	-.24		-.12
U.S. Manufacturers			-.89***	-.44
European Manufacturers			-.53***	-.06
Japanese Manufacturers				
Adjusted R-squared	.38	.35	.40	.37
F	4.10**	3.65**	7.72***	2.67*

Statistically Significant at: *** 1% Level, ** 5% Level, * 10% Level

Table 2. Comparison between U.S., European, and Japanese Manufacturers

	Japanese	U.S.	European
Number of Manufacturers	7	3	11
Number of New Projects	122	40	61
New Product Rate***	3.94 (.92)	2.27 (.92)	1.26 (.72)
Average Design Age[(a)]**	1.61 (.51)	2.97 (1.22)	1.29 (1.57)
Average Intra-project Variations	2.07 (.28)	2.22 (.81)	1.93 (.47)
Inter Project Relatedness Strategy			
New Design***	.42 (.12)	.36 (.19)	.71 (.24)
Concurrent Design Transfer***	.23 (.13)	.09 (.10)	.05 (.07)
Sequential Design Transfer**	.14 (.09)	.45 (.35)	.15 (.14)
Design Modification	.21 (.13)	.11 (.10)	.09 (.16)
Average Transfer Lag (Years)**	1.47 (.70)	3.46 (1.47)	2.78 (1.11)
Market Performance			
Market Share Growth***	.62(.52)	-.27(.16)	.10(.27)
Change in Unit Sales/Product*	-.16(.18)	-.56(.23)	.08(.51)

(Standard deviations are in parentheses)
Statistically Significant at: *** 1% Level, ** 5% Level, * 10% Level (one-way ANOVA)
(a): Only Japanese and U.S. difference significant (t-tests)

Appendix 1. Change Index of Platform Design

Change in Wheelbase and Treads

Points

0: Both wheelbase and tread are the same

1: Only either wheelbase or tread are new

2: Both wheelbase and tread are new

Change in Suspension Design

Points

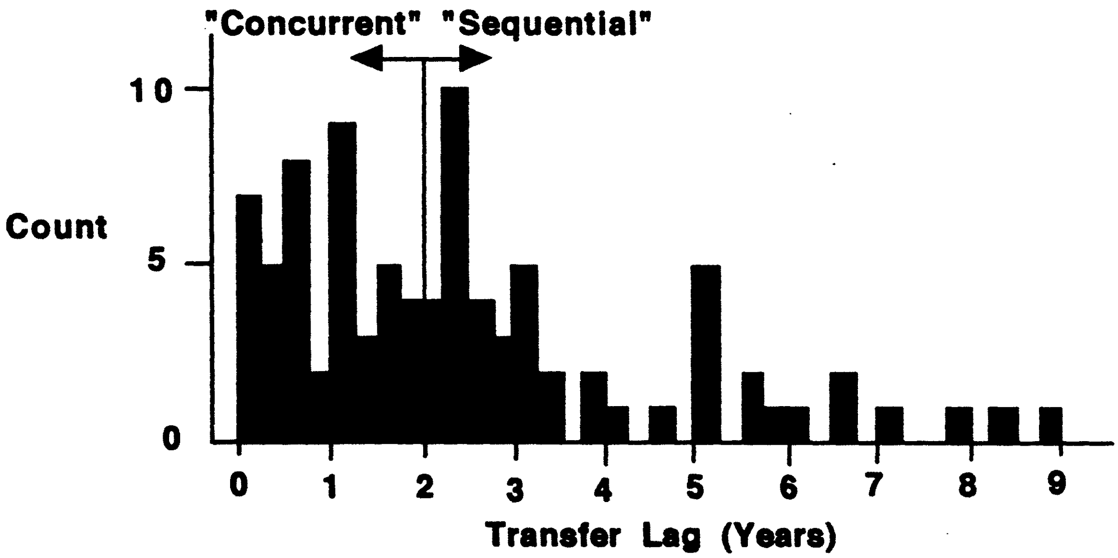
0: Suspension system and design are the same; modification in geometry

1: Suspension system is the same, but design is new

2: Suspension system is new

If a sum of the points in both areas is three or more, platform design is defined as new.

Appendix 2. Distribution of Transfer Lag



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