Potential Problems of Advanced Product Development Strategies
in the World Automobile Industry

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Abstract
This paper exemplifies recent practices in product development in the world automobile industry and reveals potential predicaments in modern strategies. For these purposes, product development practices in the 1980s have been evaluated and modern approaches are illustrated. It becomes obvious that the recent practices are beneficial, but contain potential problems such as brand homogeneity, constraints on aftermarket and shift of industry power. These shortcomings may jeopardise the latest attainments in product development strategy of world automobile manufacturers in the long-term.

Key Word

1 Introduction
Back in the 1960s, U.S. carmakers such as Ford, GM and Chrysler were dominating their domestic market and building market share in Europe. Germany, on the other hand, demonstrated engineering expertise by building a reputation for making the best-engineered high-class cars available. Unquestionably, however, the Japanese companies dominated the car industry in the 1970s and 1980s. They not only acquired increased market share in North America and gained a foothold in Europe, Australia, and parts of Asia, but they also resolved how to design automobiles efficiently and with high quality. Product development became a key element for competitive advantage in the marketplace.

Research findings by Clark and Fujimoto [1] verify that unique strategies and capabilities such as the degree of supplier involvement and organisational tactics [2] in product development are responsible for regional performance differences. Womack, Jones, and Roos' broad study on the automobile industry [3] is in part based on Clark and Fujimoto's research and shows the superior performance of Japanese carmakers in the 1980s by applying lean production systems.

Various studies [4] in the automobile industry field, carried out for instance by the International Motor Vehicle Programme (IMVP) at the Massachusetts Institute of Technology (MIT), concentrated, among other things, on different aspects of advanced product development strategies such as common platforms and parts, global strategies, and modularisation. However, they did not point out the differences in the introduction of these strategies and their effects on product development performance. In addition, there are no considerations on the problems comprehended in those strategies.

Therefore, the intention of this paper is to investigate systematically the different product development strategies of Western and Japanese automakers in recent years and to make clear the influence of the different strategies on product
development. Based upon these findings, potential problems in modern product development strategies, confronting the world automobile industries conceivably in the future, will be exemplified.

2 Product Development during the 1980s

Since around 70 percent of a product's cost is determined during the design phase, product development plays a key part in the competitiveness of carmakers. Clark and Fujimoto identified in their studies three factors, having a direct influence on the effectiveness of product development: Quality, lead time, and productivity measured by engineering hours worked.

By using the data perceived by Clark and Fujimoto, we summarised the performance in product development in the 1980s, as shown in Figure 1. Japanese carmakers needed only 45 months to design and develop a car, compared with 60 and 57 months for the average American or European company. This is measured by using the factor “adjusted lead time”, which refers to the time from concept development to market introduction required by the average company for an average project. The factor “adjusted engineering hours” proved that Japanese companies developed cars with almost twice the development productivity, relative to their Western competitors (3.2 and 3.0 mil. hours vs. 1.7 mil. hours).

![Figure 1: Performance in Product Development in the 1980s](image)

Hence, Japanese automobile manufacturers could introduce more new models, enjoyed a shorter model life, and opened their product lines faster than their Western counterparts. Conversely, we discovered that European automakers showed a strong position in the quality of high-end automobile designs with a quality store index of 84 compared with an index of 53 for carmakers in Japan. The “average quality index” includes indicators of conformance and design quality, customer satisfaction and long-term changes in market share. We calculated this index by building the average of Clark and Fujimoto’s Total Quality Index, developed for individual companies and regions. For the high-end specialists like Porsche, time-to-market and range of product line are less critical, since their overall performance is anchored in the sophisticated design and superiority in product development.

Since the differences in product development performance among countries are remarkable, we broadly investigated the possible reasons for these differences. Table 1 shows the summary of our investigation. In general, carmakers employ different product development strategies. While Western carmakers tend to follow a great leap forward strategy with major model changes every 8.1 to 12.2 years, Japanese manufacturers prefer a continuous strategy with model changes every 4.6 years. The Japanese strategy is advantageous since Japanese companies avoid start-up confusion by undergoing small technological steps and by using existing plants and equipment. The high rate of design renewal enables Japanese firms to streamline their development process, orienting the entire organisation to continual learning and improvement.

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<td>1st-tier Supplier with limited engineering capability</td>
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Table 1: Differences in Product Development in the Automobile Industry during the 1980s

Secondly, in Japan a few first-tier suppliers provide sub-assembled units from parts, produced by lower-tier suppliers, resulting in a tall supplier hierarchy. The supplier's development team, with the help of resident design engineers from the assembler and the second-tier suppliers, conducts...
detailed development and engineering. The system of mutual information sharing among all parties involved works well, because prices, costs and profits are evenly allocated among participants, generating an atmosphere of trust. On the contrary, the Western supplier system is depicted by mistrust. Contracts are awarded to the lowest bid. This policy creates a very flat supplier system with numerous suppliers, dealing directly with manufacturers on the basis of short-term contracts. Overall, the Japanese system is advantageous because the know-how of suppliers is used in design and development, and suppliers are regarded as partners.

As a consequence, suppliers' engineering effort in Japan to total vehicle-engineering effort is around 30%, compared with merely 7% in the U.S. The ratio of black box parts is approx. 62% in Japan, compared with just 16% in the U.S. [5]. The high ratio of black box parts indicates a high supplier involvement since only basic design information is set by the carmaker, and the supplier does detailed engineering including drafting, prototyping, and testing. Close supplier relationships and continuous strategies with minor technology changes between the models allow Japanese automobile manufacturers to use more newly developed parts than their Western counterparts.

Moreover, the Japanese system is typified by short prototype lead time, short lead time for die production and efficient pilot runs on existing volume lines. Japanese carmakers regard prototypes as problem detectors at the early stages of product development and emphasize reasonably high quality and representativeness. Western companies see the prototype as a master model to prove product design. The highly integrated network of die suppliers allows Japanese firms to produce dies at half the cost and in half the time compared to U.S. and European systems. Faster problem-solving cycles and more realistic pilots also distinguish Japanese carmakers. The tendency of U.S. and European firms to place pilot production in a separate facility seems to extend the problem-solving cycle and complicates knowledge transfer from pilot to commercial production.

Additionally, Western companies apply product manager organizations, where functional engineering departments are very strong and the project managers are weak. In contrast, Japanese automakers prefer product manager organizations, where the project manager has authority over the entire product development process. As a result, the integration across functions increases.

Finally, Japanese carmakers employ integrated intensive problem solving cycles. Western companies rely on sequential, batch/unilateral problem solving cycles. The integrated Japanese approach allows parallel operation and simultaneous engineering, resulting in improved lead time. In addition, it reduces errors and waste that consume engineering hours and jeopardise product reliability. In Western companies, critical design trade-offs will not be solved until a very late project stage. In Japan, conflicts about resources and priorities in product development are solved at the very beginning of a project. Thus, the number of team members diminishes after the lifetime of a project, while in Western companies the number of people involved increases over time.

3 Advanced Product Development Strategies

As discussed in section 2, the product development performance of the Western car industry lagged behind Japan's car industry in the 1980s. Therefore, Western companies had to improve product development lead times and productivity. Our investigation of recent advancements in product development revealed that Japanese and Western carmakers followed different strategies since the 1980s, as shown in Figure 2.

![Figure 2: Recent Advancements in Product Development](image)

To close the performance gap with their Japanese competitors, Western carmakers introduced common platforms as early as in the beginning of the 1980s. This practice results in an increase in
production numbers per platform and a reduction in costs due to increased economies of scale. Furthermore, product platforms allow to increase speed in product development, to deliver increased variety and to reduce managerial complexity. This is feasible, since a product platform is a set of subsystems and interfaces that form a common structure, from which a stream of derivative products can be efficiently developed and produced. For automobiles, the product platform is generally defined as a combination of chassis, engine, drive train, and transmission.

In the mid-1980s, Western carmakers like Ford began to unify basic parts such as engines and transmissions. According to Ford’s Project 2000, Ford intend to reduce its 30 basic engine structures used in 1999 to a total of just 14 by the year 2004 [6]. Some Japanese automakers followed the Western path by introducing common platform and parts strategies as late as in 1992/1993, after the collapse of the bubble economy.

To support their improvements in product development, Western companies switched from product manager organisations to project team organisations in the 1990s, with minimal barriers between engineering functions and focused on individual projects. Around the same time, Japanese automakers moved to multi-project organisations, focusing on coordinating multiple projects. With multi-project organisations, the coordination among projects and cross-functional coordination is very strong, while project team organisations experience a lack in inter-project coordination.

The latest evolution in product development, however, is the intensified application of modularisation strategies in the design process, especially among European automobile carmakers. Modularity is a particular design structure, in which parameters and tasks are interdependent within units (modules) and independent across modules. Modular task structures can be created through a process of modularisation. Components of a modular product structure are interchangeable and interfaces are standardised.

Japanese carmakers have not yet embarked on this trend, since their just-in-time production systems, simultaneous engineering and their close supplier relationships still combine to make the most efficient production system in the world. Nevertheless, in view of the significant success of the European modular strategies, Japanese automakers have started to use modules in their production plants; however, the design responsibility still mainly remains at the automakers themselves [7].

In connection with modularisation, we also studied the relationship between modular and integral product structure and vertical and horizontal industry structure. In the 20th century the automobile was characterised by a highly integral product architecture, consisting of parts with long design timeframes and significant capital investments to produce in an efficient scale. In an integral architecture, parts and functions bear a complex relationship, and each of the parts has to be optimally designed to achieve overall performance. Integral automobiles are the result of a vertical industry structure relying on automakers, which retain control of the entire design and production process. This control mechanism can be achieved by either owning and operating all the suppliers themselves or by operating component divisions in-house such as General Motors and Toyota. By preferring an integral product structure, carmakers maintained technological leadership, and supervised quality and complexity of their vehicles.

Yet, new cars of the 21st century such as the Smart Car of DaimlerChrysler feature a modular product structure, and are mainly built to customers’ orders. Since the basic platform is built for stock, the final assembly of the car takes just four and a half hours and the overall lead time is two to three weeks [8]. To make this feasible, the car industry has to move to a horizontal structure, where whole modules of the car are subcontracted and the product development and design of the relevant module lies at the supplier.

In view of the increasing use of modularisation strategies in the design process, we studied the degree of modularisation and outsourcing in the Western and Japanese car industries. As illustrated in Figure 3, the design responsibility in Japan still remains mostly in-house because of their traditional supplier relationships. Western carmakers, in contrast, prefer modular product
designs, carried out by their suppliers. This modular/horizontal structure allows carmakers to shift technical and design variety, which is difficult to manage economically in an integral product structure, to suppliers. Moreover, carmakers pass on responsibility for capital expenditures on plant, tooling, R&D, or engineering to suppliers.

Figure 3: Modularisation and the Role of Suppliers in the Automobile Industry

As a result, Western automakers are able to improve their operating profit margins as well as return on capital employed significantly, closing the gap to their Japanese competitors.

Information technologies further strengthen the performance of the product development strategies, described above. By introducing computer-aided styling (CAS), computer-aided design (CAD) and computer-aided manufacturing (CAM) systems, engineering processes and associated changes can be done rapidly and economically, leading to improved product quality. For example, until the mid-1990s BMW had a product development cycle of seven to eight years with three prototype cycles, each exceeding one million dollars and requiring months of craftsmanship. Through the use of information technologies, BMW cut its lead time in half and the number of prototypes to two [9]. In general, information technologies lower fixed costs of new product developments, shorten development cycles and increase their frequency.

By introducing advanced product development strategies, Western automakers have considerably increased their product development performance in the mid 1990s, as shown in Figure 4. The indices, introduced in Figure 1, are employed to increase comparability. Overall, U.S. automakers have improved performance in terms of quality, lead time, and productivity by implementing different strategies. European carmakers have also increased their performance, however, at a much lower rate than their U.S. counterparts.

Figure 4: Performance in Product Development in the mid 1990s

Conversely, Japanese companies increased their product quality even further but at the expense of lead time and development productivity. This could be an indicator that Japanese carmakers are overestimating the quality aspect.

4 Potential Problems in Advanced Strategies

Although the advanced product development strategies are usually beneficial for companies, as demonstrated in section 3, they also contain several potential problems.

First of all, the wide use of common platforms and parts potentially leads to homogenous models and brands. Volkswagen is increasingly suffering from a lack in product differentiation between its Volkswagen and Audi brands, both competing for the same customer segment. This lack of brand identity can also be observed for Volkswagen's Skoda and Seat brands. Since their original markets are saturated, both brands are nowadays directly competing with each other in Volkswagen's home markets in Europe. Moreover, Volkswagen is sharing basic chassis and entire component systems among Seat, Skoda and even Audi, leading to accusations of product duplication and lack of brand identity [10].

Product differentiation among Japanese automakers, in particular the small car segment, is not considerably strong either. Due to limited space and high cost of car ownership, small cars are especially popular in Japan and thus competi-
tion within this market segment is very intense. To cut lead times and to reduce development costs, Japanese carmakers tend to use common platforms and parts as much as possible, even with their foreign partners. Nissan is increasingly sharing production facilities; jointly procuring parts and sharing platforms and engines with their French partner Renault to reduce costs and improve marketing and distribution till. Brand convergence may be the result of this strategy.

Furthermore, carmakers such as GM, Ford, and Fiat have tried to develop a "world car", fully standardised all over the world. However, these projects have proved a failure, because local conditions and preferences of customers, living in countries with distinct structural conditions, are too diversified. For instance, in Asian countries such as Thailand or Malaysia driving and climatic conditions are very different to Western or Japanese settings. Heating systems are not necessary, while air-conditioning and component durability have to be enhanced. As a consequence, carmakers dispensed with the "world car" concept and again focused on the development of country-specific vehicles, fitting to the local environment. By so doing, product costs are increasing due to lower production volumes, and higher capital expenditure for production equipment as well as local design adaptations.

Secondly, since product development times have considerably decreased, and the number of launched models increased over time, the number of parts necessary for aftermarket purposes has risen notably. This constraint is especially true for Japanese automobile manufacturers, changing their models every four years. For Western carmakers this deficiency is not as severe since they still tend to change models every eight years.

Figure 5 expresses these relationships in a diagram. Usually a vehicle is comprised of around 30,000 parts, which have to be available for the aftermarket right after product launch until its production stop and even beyond this point. Since the typical life expectancy of a complex product like an automobile ranges from 10 to 15 years [12], parts have to be available after production stops for another 12.5 years on average. As shown in the upper part of Figure 5, in case of Western carmakers with a life cycle of 8 years and a life expectancy of about 12.5 years, the aftermarket has to provide these 30,000 parts over a period of approx. 20.5 years.

For Japanese carmakers the situation is even worse, since they launch twice as many new models as their Western counterparts, leading to approx. 60,000 parts, having to be stocked during the same period of time. This increased number of parts notably burdens warehouse and logistics management, leading to increased product overhead costs to be incorporated in price calculations.

Even if some parts are shared among models, a considerable number of parts still have to be uniquely designed and produced. Moreover, common parts have to be available for an extended period of time, making the aftermarket management even more complex. By using an example, shown in Figure 6, we want to visualise this increased complexity.

We base our example on the research of Clark and Fujimoto, verifying that about 30% of parts are shared among models [13]. When in our example model 2 is launched two years after the
introduction of model 1, the 30% common parts between model 1 and 2 have a prolonged aftermarket cycle of 22.5 years, while the newly designed 21,000 parts have to be stocked for only 20.5 years. When introducing the successor of model 2, i.e. model 4 in year 8, the aftermarket becomes even more complex. As, based on our example, 10% of the parts of model 1 are shared with model 4, these 3,000 parts have to be stored for even 28.5 years. Thus, common parts increase aftermarket cycles and also increase the complexity of the stock management.

Comparing the maximum number of parts groups to be managed simultaneously between models with and without common parts can prove the latter argument. Without common parts, the maximum number of parts groups to be managed equals the number of models. However, when considering models with common parts, the maximum number of parts groups to be managed equals the number of models plus the number of common parts groups.

For our example in Figure 6, this would imply that the maximum number of parts groups to be managed simultaneously over time would be ten, as shown in Figure 7.

When assuming, however, that the models would not share parts, only four parts groups would have to be managed at the same time. As a result, for models with common parts the maximum number of parts groups to be handled is considerably higher than for models without common parts. Then, aftermarket costs rise because of higher coordination and handling costs and higher costs for warehousing and logistics.

Finally, due to the subcontracted design of models through suppliers, which is common among Western carmakers, the automobile parts industry will move from a horizontal structure to a more vertical industry structure. For the time being, Western automobile manufacturers regard modularisation as beneficial since complex and costly production as well as the design of these modules itself can be shifted to suppliers. This practice releases automakers from substantial financial investments in assets and R&D. However, as a result, automakers will increasingly rely on the technical and design expertise of suppliers, passing market power as well as negotiating power to suppliers, as suggested in Figure 8.

This modularisation trend, visible among Western carmakers, will alter the existing industry structure in the automobile industry. By taking full advantage of suppliers, the car architecture will be transformed from an integral structure to a modular type.

Automobile parts suppliers are pursuing the trend towards modularisation by an intensive rise in mergers and acquisitions to meet the design expectations of carmakers. Companies, producing car seating systems, illustrate this development apparently. In general, seats are the biggest single purchased item for automakers, provided by only a few single companies. These seat companies have begun to acquire related businesses for interior panels, carpets, etc. in order to offer a complete automobile interior [14]. These companies now exploit their market power by demanding carmakers to buy their whole product range.

As a consequence, the automobile parts industry is transforming into a vertically integrated structure. In contrast, carmakers are moving from
a vertical to a horizontal formation, resulting in a loss of expertise. However, module suppliers in the automobile industry will only have an effect on the industry, if they manage to own the intellectual property rights in order to have greater leverage over automobile manufacturers. For the time being, only Delphi Automotive Systems or Denso seem to have this kind of market power.

Japanese carmakers have largely opposed the trend towards modularisation so far. They keep their design responsibility in-house and rely on their close but hierarchical supplier relationships, built over a long period of time. Consequently, Japanese carmakers minimise the risk of losing technical expertise and industrial leadership to their suppliers. The horizontal industry structure of Western carmakers, on the other hand, results in increased information exchange and improved learning effects, since parts suppliers are shared among carmakers. Because of this inherent competitive advantage of Western carmakers, they could soon surpass Japanese carmakers.

5 Conclusion

In order to catch up with the Japanese superiority in product development during the 1980s, Western companies have introduced new development strategies such as common platforms and parts along with modularisation strategies, enhanced by the intensified use of information technologies.

Although the introduction of advanced product development strategies has improved the development performance in Western countries considerably, these practices also bring about several problems. These problems can be identified as homogeneity of brands, constraints on aftermarket, and potential shift in industry power from the automobile manufacturers to their suppliers. These problems have the ability to damage the recent performance achievements of the world automobile manufacturers in years to come.

Reference