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PRODUCT DEVELOPMENT LEADERSHIP IN THE U.S. AND GERMAN AUTO INDUSTRIES

Ahmad Syamil
Business Management Program, Management Department,
BINUS Business School Master Program, Bina Nusantara University
Hang Lekir 1 No. 6, Senayan
Jakarta Pusat 10170, Indonesia
asyamil@binus.edu

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ABSTRACT

The purpose of this research is to look at leadership through heavyweight product development managers and its impact on supplier involvement, customer involvement, and concurrent engineering. Using responses from 406 product development managers and executives in the U.S. and German auto industries, this research validates a model of heavyweight product development managers and their consequences on both internal integration (concurrent engineering) and external integration with suppliers and customers. The results indicated that American heavyweight product development managers have significant positive relationships with both internal integration and external integration in order to develop marketable products well. In contrast, German managers have significant positive relationships only with internal integration efforts within a company and weak relationships with external integration efforts, such as those with suppliers and customers.

INTRODUCTION

Developing new products in the auto industry has never been an easy task. In today's dynamic environment with shorter product life cycles and demanding customers, developing winning products becomes an everyday challenge for all auto industry giants trying to build a sustainable competitive advantage. Large numbers of components (e.g. up to 20,000), enormous amounts of money, and hundreds of design engineers are involved in each new project (Monden, 1993). The most recent trends in integrated product development (IPD) research focus on the technological and managerial aspects of the phenomenon, but there is still a visible need for defining and understanding leadership issues in this area.

In the early years of the 20th century, when cars were designed and developed by a number of engineers working under the direction of legendary leaders, such as Henry Ford, Gottlieb Daimler, and Shoichiro Toyoda, the organization of product development was not such a burning issue. General skills and broad responsibility of the engineers, close communication, and guidance of the ‘master architect’ in implementation of product concept were the most important factors for product success (Clark & Fujimoto, 1991). As problems became too complex for a few people to solve and growing competition demanded greater depth of expertise, the number of people involved in product development increased significantly. The logical idea of organizing product development came straight from the most commonly used organization structure, i.e., the functional structure. In this structure, companies create cross-functional project teams consisting of the necessary number of design and manufacturing engineers supported by members of other functional departments, and working with a product development manager. The reality showed that the managers were perceived more as coordinators than leaders and product development programs, such as the GM-10 project, were simply unsuccessful (Womack, Jones, & Roos, 1991).

Clark and Fujimoto (1990) popularized the term “heavyweight product development managers” as product integrity champions – a phenomenon observed in Japanese product development practices. Japanese auto manufacturers realized early enough that successful firms employ organizational designs that enable them to deal effectively with their competitive environment and achieve product integrity through leadership. Heavyweight product development managers are powerful senior product development managers with substantial expertise and decision-making authority to champion and direct product development efforts (Wheelwright & Clark, 1992). They are empowered by top management to lead product development projects and reorganize this traditionally sequential process to a concurrent process where product engineering, process engineering, and manufacturing planning activities overlap (Koufteros, Vonderembse, & Doll, 2002; Hong & Schniederjans, 2000; Clark & Fujimoto, 1990).

The concept of heavyweight product development managers is more traditionally positioned in the context of organizational structure, i.e., the managers possess both position and seniority, along with specific skills and experience while working in an organizational environment that includes a structure and system to support a strong product focus, multifunctional teams of broadly skilled people, and extensive cross-functional communication and influence. The leadership theory recognizes three leadership behavior dimensions that can be applied to the heavyweight management context: (1) production-centered leadership (initiating structure), (2) employee-centered leadership (consideration), and (3) change-centered leadership (Ekvall & Arvonen; 1991, 1994; Caesar, 2016). Consideration is more important in one-to-one relationships, while initiating structure is more important in interdepartmental or interorganizational leadership, which is a basis of successfully creating cross-functional teams in product development. There are many benefits of initiating structure what will be further presented in the theory development section.

The purpose of this research is to look at leadership through heavyweight management in product development and its impact on supplier involvement, customer involvement, and concurrent engineering.

This research is a large-scale, international research conducted in the U.S and Germany in order to understand heavyweight product development managers in the auto industry. We are moving forward and leaving behind the stage in product development research where issues of the heavyweight management were mostly discussed in case studies and anecdotes. A notable exception must be given to Koufteros (1995) who used a large-scale study to collect his data. However, his data came from various industries and was limited to U.S. companies.

The main reason for choosing the U.S. and Germany is because we expected to find some significant differences in understanding and utilizing the concept of heavyweight management in these two countries which are considered to be, together with Japan, the three largest auto producers in the world. We anticipated that the source of the observed differences was in the behavioral and cultural factors shaped by past and current industrial trends, in both the U.S. and Germany. Specifically, we addressed the links between heavyweight management and both external and internal integration practices in market-oriented new product development. We developed, from the literature, a non-culturally specific conceptual model, and then we tested the model in two distinct cultures. Clark (1990) pointed out that cross-cultural studies have no integrating theory; however, this exploratory study is a building block providing descriptive findings that should enhance our understanding of how new product development practices differ in countries with dissimilar cultures.

LITERATURE REVIEW

Automakers all over the world are well aware of the fact that product development has become the competitive battleground for long-term success. Product development has shifted from a narrow focus on the factory floor and internal product development activities without involving external parties to the broader integrated product development (IPD) (Ettlie, 1997; Paashuis, 1998; Moffat, 1998). IPD is a process that systematically employs cross-functional disciplines to integrate product development activities across the value chain from auto suppliers, auto companies, and customers. By bringing supplier and customer into product development, auto companies can expect to better meet the challenges of the global auto industry.

In spite of the fact that the auto industry is becoming global, the national environment (in which the firm is born and grows) still plays a significant role in determining the competitive advantage of the firm. Porter & Michael (1990) and other authors (Roure, 2001; Smeeds, Olivari & Corso, 2001; Simpson, Kollmannsberger, Schmalen & Berkovitz, 2002) offer a number of studies trying to determine a nation’s industry competitiveness factors and explaining existing differences among economically distinctive countries. For example, Porter and Michael (1990) argues that the presence of demanding customers who do not accept inferior or outmoded products, and the availability of supporting industries, such as world-class suppliers, are two important determinants of a nation’s industry competitiveness.

In our research, we concentrated on differences between German and U.S. product development practices, i.e., heavyweight product development managers, customer involvement, supplier involvement, and concurrent engineering. The four practices can be perceived as ‘common ground’ for these two countries. Both Germany and the U.S. automakers use all of them but in a dissimilar way. Our goal is to analyze and compare the impact of those differences.

Heavyweight Product Development Manager

The phenomenon of heavyweight product development managers has been discussed in product development literature. It is commonly known that successful firms employ organizational designs that enable them to deal effectively with their competitive environment. These firms appoint heavyweight product development managers who are charged with championing the project and reorganizing the product development process from a sequential ‘over-the-wall’ process to a concurrent process. A heavyweight product development manager provides expertise and organizational authority that facilitates this cross-functional process as well as the application of technology. These firms also include important constituents early on in the product development effort, i.e. suppliers and customers.

Clark and Fujimoto (1990) found that the key to product integrity is the leadership of heavyweight product development managers who focus on devising processes to create powerful product concepts, and making sure that the concepts are translated into design and manufacturing process details. Clark, Chew and Fujimoto (1987) indicated that the utilization of heavyweight product development managers led to fewer engineering hours and shorter development lead times. Moreover, Clark and Fujimoto (1991) found that the two auto manufacturers that possessed the highest design quality also have the heaviest product development managers.

Jurgens (2001) argues that the main difference between the U.S. and German automakers with regard to governance, one of the central dimensions of the formal organization of new product development processes, is clear. The U.S. companies use heavyweight project management and place a higher emphasis on rapid integrated processes; the German companies used light-to-middleweight project management with decisive roles made by the functional organization.

Supplier Involvement

Supplier involvement is the practice of developing ongoing interactions with suppliers to enhance their participation in product development activities. Imai, Nonaka and Takeuchi (1985) found that extensive supplier involvement is important for product development. The involvement allows suppliers to acquire specialized skills necessary to fulfill sudden and unexpected demands quickly and effectively.

Supplier involvement can benefit auto manufacturers by, among other things, shifting part of the development time to the suppliers. This leads to a reduction of the total product development time. Most supplier involvement activities also include intense communication and problem solving activities early on in the process (Liker, Kamath, Wasti, &

Namagachi, 1996). This early involvement leads to the early debugging of manufacturing problems, which in turn, increases product integrity and reduces manufacturing costs (Wowak, Craighead, Ketchen, & Hult, 2016). Cusumano and Takeishi (1991) find that the ability of the supplier to reduce product cost correlates with supplier involvement, which is especially true when suppliers are well-trained in value engineering.

In their study, Birou and Fawcett (1994) find that U.S. companies have a higher frequency and intensity of supplier involvement as well as earlier involvement in product development than do European companies. However, one must remember that their respondents are not only from the auto industry, but also from the electronic and machinery industries. In contrast, two studies in the auto industry described below clearly indicate that the degree of supplier involvement is higher in Europe than that in the United States. Unfortunately, the studies do not analyze European data by country.

Clark and Fujimoto (1991) found that on average, the auto suppliers' share of product engineering ratio for U.S. OEMs, Europe volume OEMs (e.g. VW), and European high-end specialists (e.g. BMW) are 14%, 36%, and 37% respectively. In black box engineering, auto manufacturers give rough product specifications for product function and performance, cost target, and development time to suppliers. The suppliers then create a detailed design and deliver the product to the auto manufacturers. In black-box engineering, European supplier involvement is also consistently higher than with U.S. suppliers.

In a more recent study, Sako, Lamming and Helper (1998) conducted a postal survey in Europe, Japan, and the U.S. They received detailed responses from over 1,400 auto suppliers. Among other things, they found that the proportions of suppliers involved in product development in Europe and in the U.S. are 84% and 67% respectively.

Most recent studies (Ragatz, Handfield & Petersen, 2001; Maffin & Braiden, 2001; Takeishi, 2001; Krause, Handfield, & Scannell, 1998) point out that supplier involvement is a positive factor in the product development process. However, Jurgens (2001) argues that early supplier involvement may result in product development problems, especially from an operational level perspective. In his study, the share of the total problems of U.S. suppliers is much greater than those of German suppliers. The U.S automakers, for instance, are particularly affected by spatial distance, poor quality, lack of competence and training, as well as technical incompatibilities with their suppliers. In addition, he found that the U.S. car companies forced new responsibilities too quickly on their suppliers. Substantial problems are due to the increase of direct data exchange with suppliers and the corresponding problems with technical incompatibility.

Customer Involvement

Customer involvement is the practice of developing ongoing interactions with customers to better understand their needs and wants. External communication with outsiders, such as customers, is important so that the product development team gains diverse opinions and inputs beyond those of the team (Katz & Tushman, 1981)

Rather than simply delivering products to the customer, the auto industry has brought the customer closer to the upstream process in product development (Chang & Taylor, 2016). Several methods for involving the customers by capturing their input are available (Cui & Wu, 2017). These include formal surveys, focus groups, visiting customers personally, field intelligence through repair technicians, and Quality Function Deployment (QFD).

Companies use QFD to translate customer needs into design requirements, part characteristics, manufacturing processes, and finally, quality plans (Evans & Lindsay, 1996). QFD improves product development in several ways. For example, QFD can lead to understanding customer requirements better and preventing design errors, which in return can avoid costly engineering changes (Aigner, Lovell, & Schmidt, 1997). The American Supplier Institute (1989), which is very active in promoting QFD, claims that QFD can reduce engineering changes up to 50%.

In his cross-industry study, Kleinschmidt (1994) finds no differences between the degree of customer involvement between North American and European companies. However, other researchers suggest that the degree of customer involvement is lower in the U.S. In an auto industry study, Clark and Fujimoto (1991) find that product development managers in the U.S. have less involvement in concept development with customers than their European counterparts. Other studies also indicate that U.S. product development managers have less intimacy with customers compared to product development managers from New Zealand (Souder, Buisson, & Garret, 1997) and Scandinavia (Souder & Jenssen, 1999).

Concurrent Engineering

Concurrent engineering is the practice of involving teams of functional specialists to simultaneously plan product and process activities (Ponticel, 1996; Izuchukwu, 1996). Concurrent engineering focuses on internal integration among product and process activities within a company. Koufteros (1995) argues that concurrent engineering consists of three sub constructs: cross-functional cooperation, early involvement of constituents, and overlapping development stages.

The cross-functional nature of concurrent engineering improves the effectiveness of the product development team when dealing with complex product development problems that require various perspectives (Susman & Dean, 1992; Moffat, 1998). For example, customer requirements are understood and assimilated better through the product development process because the requirements are not filtered through gatekeepers in the marketing department, something that happens in sequential engineering.

Early involvement of constituents such as manufacturing personnel means that manufacturing issues and complexities are brought up early. It also leads to higher product integrity because manufacturing problems are debugged earlier (Swink, Christopher, & Mabert, 1996).

Numerous studies (e.g. Swink, 1998; Moffat, 1998; Terwiesch & Loch, 1999; Abdalla, 1999; Hauptman & Hirji, 1999) indicated that the main benefit of the overlapping of development stages is to reduce product development time. Handfield (1994) in his study of 31 made-to-order firms also found that concurrently engineered products are developed 40% faster than sequentially engineered products. Clark and Fujimoto (1991) found that concurrent engineering increases product development productivity, reduces engineering time, and cuts product development time.

Clark et al. (1987) find that U.S. companies have a higher degree of overlapping development stages than their European counterparts. However, information transfer between the stages is more intense in Europe. They made this conclusion after studying dye development for outer body panels in the auto industry.

Other researchers indicate that European companies appear to have better multi-functional cooperation than do North American companies (Gerpott & Domsch, 1985; Edgett, Shipley, & Forbes, 1992; Song & Parry, 1996). They indicate that product development teams in German companies have good cooperation across functions and top management. Interestingly, Jurgens (2001) finds that although the German companies have formally installed cross-functional engineering teams, conditions for concurrent engineering such as infrastructure and empowerment were much weaker in Germany when compared with the U.S. companies.

A Conceptual Model

A model of the relationships between product development practices is depicted in Figure 1. In this model, heavyweight new product development managers have a direct relationship with concurrent engineering, customer involvement, and supplier involvement. There is also an indirect (mediating) relationship to concurrent engineering through customer involvement and (separately) supplier involvement.

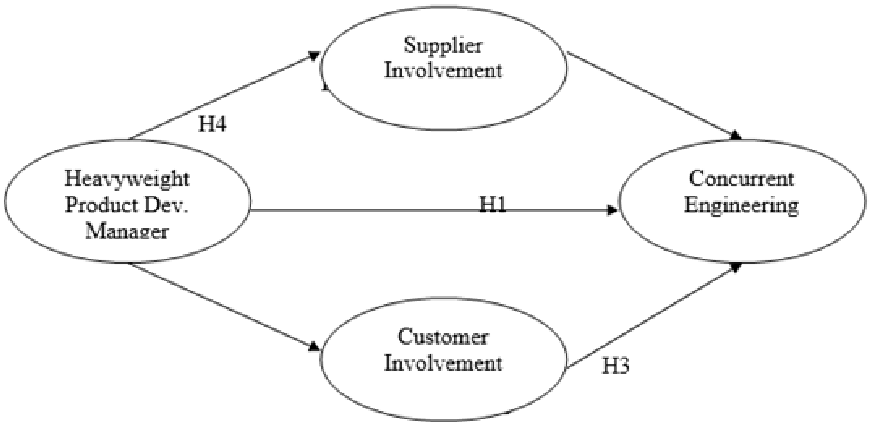

Figure 1. A Model of New Product Development Practices

As suggested by Koufteros et al. (2002), the selection of a heavyweight product development manager is an important structural decision from an organizational and development process design point of view. The key task of the heavyweight development manager is communicating with both external (i.e., customers and suppliers) and internal constituents (i.e., top management and product development team) in a language they understand. The manager’s role as an agent of integration is vital. The heavyweight product development manager’s access to top management also improves the understanding of the firm’s strategic situation. This enables early top management consideration, buy-in on the product concept, alignment of the project targets with strategic objectives, and shared vision. Heavyweight product managers have an overall direct and positive effect on the use of concurrent engineering as a tool in a firm's effort to achieve cross-functional integration. Hout, Gonzales, & Petitdemange (1996) found that the use of heavyweight product development managers facilitated coherent implementation of cross-functional concepts throughout the organization. This is accomplished through heavyweight product managers' expertise and positional authority to champion product development, including marshaling resources that are required to support concurrent engineering. Therefore, we suggest:

H1: The heavyweight product development manager has a direct positive relationship with concurrent engineering.

Heavyweight product development managers have a substantial knowledge of external constituents involved in product development processes, and with their power and influence, they should be able to initiate and enhance cooperation with both suppliers and customers, in order to involve them in product development activities (Karlsson & Ahlstrom, 1996; Staudenmayer, Tripsas, & Tucci, 2005). Both customers and suppliers require an integrated rather than a functional response to their queries and proposed design changes. Thus, one way heavyweight managers may encourage cross-functional development is to encourage the early and continuing involvement of suppliers and customers. Therefore, we suggest the following two hypotheses:

H2: The heavyweight product development manager has a direct positive relationship with supplier involvement.

H3: The heavyweight product development manager has a direct positive relationship with customer involvement.

Close cooperation with qualified suppliers and customers enables information to flow through the organization quickly and effectively, thereby, reducing uncertainty (Koufteros, Vonderembse, & Doll, 2001). At the same time, it enables debate, clarification, and enactment, which can have a significant effect on the concurrent engineering activities (Kotler & Keller, 2004; Gerwin & Barrowman, 2002). Both customers and suppliers require an integrative response to their suggestions and proposed design/manufacturing changes. Therefore, we propose:

H4: Supplier involvement has a direct positive relationship with concurrent engineering.

H5: Customer involvement has a direct positive relationship with concurrent engineering.

We tested each of the hypotheses above using U.S. and German data sets.

MATERIALS AND METHODS

The research design was guided by several objectives. First, we sought to test the above model of product development practices using a large sample of project managers who were responsible for specific projects in the automotive industry. The automotive industry was selected because it uses heavyweight product development management concepts, supplier and customer involvement, and concurrent engineering extensively. It also has comparatively long development times, and is directed by rigid, structured decision-making process. It is a setting where a model of product development practices, if validated, might have practical application by explaining potential, overall differences between the U.S. and German approaches to product development, and by guiding organizations to understand this phenomenon and to gain a competitive advantage. As mentioned earlier, it is also a large multinational industry, although never tested before in a large scale, single industry sample.

Secondly, we wanted to develop and test an explicit measurement model for product development practices to guide and inform other scholars or practitioners who may want information on its psychometric properties. Third, we wanted to use structural equation modeling (Jöreskog & Sörbom, 1986) to provide a rigorous test of the causal relationships depicted in Figure 1.

The Sample

The unit of analysis was the project team. A professional engineering association provided a mailing list consisting of engineers with the job title of Program Manager, Program Director, Project Manager, Director of Engineering, Engineering Team Leader, Manager of Product Development, Engineering Manager, Vice-President of Engineering, Director of Research and Development, Chief Project Engineer, or Director of Product Development. The respondents were asked to identify a recently completed project that they were responsible for and to answer the survey questions with respect to the project team working on that project.

The large scale survey was administered via mail to 2912 product development professionals in the U.S. auto industry and 975 product development professionals in the German auto industry. Each sample was made up of individuals from auto manufacturers and first-tier suppliers. The surveys were mailed twice in both the U.S. and Germany with three weeks separating each mailing.

The U.S. survey was in English, whereas the German survey was in German. A German native speaker with a Masters Degree in Business who works in the automotive industry translated the English survey into German. An American graduate student, who used to live in Germany, conducted the translation back to English. Revision was performed when necessary. Finally, a professor in German literature checked the translation.

Of the 2912 surveys that were mailed in the U.S., 296 responses were collected which accounts for a 10.2% response rate. Of the 975 surveys mailed in Germany, 145 responses were received (a 14.8% response rate). The total sample collected was 441, with 35 responses not used due to incomplete questionnaires or industries that were not a part of our desired sample, such as R&D firms or heavy-truck suppliers. Therefore, 406 responses were available for a combined response rate of 10.4%.

The sample of 406 consists of 267 responses from United States and 139 responses from Germany. Of the United States responses, 75 were from auto manufacturers and 192 were from first-tier auto suppliers. Forty of the German responses were from auto manufacturers and 99 were from first-tier auto suppliers.

Measures

The original survey items were borrowed from Koufteros (1995) and Koufteros et al., (2001). The measurement items for the survey were generated based on a comprehensive literature review using a five-point Likert scale ranging from 1 = ”not at all” to 5 = ”a great deal”. Personal interviews with product development managers, a pilot study, and a large-scale study in multiple industries in the U.S. were performed to validate and to test the reliability of the survey instruments.

The researchers of this study then conducted the large-scale survey in the U.S. and German auto industries described in the previous section. The researchers used structural equation modeling (LISREL) to purify the items using the combined 406 responses from the U.S. and Germany. For example, items with high modification indices and high-correlated error terms with other items were dropped. The final measurement items shown in Appendix A consisted of three items for each of the four constructs.

RESULTS AND DISCUSSIONS

The data set for each country were analyzed in two phases. Phase one's focus was on measurement assessment. It included assessing the measures of each dimension for reliability and validity and testing the hypothesized measurement model of product development practices. The second phase focused on assessing the structural model for model-data fit and testing each of the structural hypotheses.

Measurement Assessment

For each of the four constructs in the model, Table 1 and Table 2 provide descriptive statistics, the correlation matrix, reliability (Cronbach's alpha on the diagonal), and the chi-square value and p-value of a test of discriminant validity (df=1) for each pair of variables using the U.S. and German data respectively (Bagozzi & Phillips, 1982). Reliability is frequently characterized as the 'repeatability' of a measure over time or subjects (Bollen, 1989; Nunnally, 1978) and is often described in terms of the amount of random error in the measure (Lord & Novick, 1968; Bollen, 1989; Nunnally, 1978). While there have been many proposals for assessing reliability (see Hattie, 1985; Nunally, 1978), coefficient alpha (Cronbach, 1951) is generally preferred (Peter, 1979) because it does not depend on the assumptions of other indices of reliability.

For the U.S. data, the four variables have satisfactory values of reliabilities, ranging from 0.78 for supplier involvement to 0.87 for customer involvement. All pairs demonstrated discriminant validity at $p<0.001$. All average variance extracted (AVEs) are excellent, i.e., 0.75 and above.

Table 1. Correlation (R) Matrix, Reliability, Discriminant Validity, and Average Variance Extracted (AVE) for US data (267 responses**)**

	Heavyweight Product Development Manager	Customer Involvement	Supplier Involvement	Concurrent Engineering
Heavyweight Product Development Manager	[0.7841][a]			
Customer Involvement	R=0.162 χ^2 = 241.31[b]	[0.8680][a]		

	$p < 0.001$			
Supplier Involvement	R=0.174 $\chi^2 = 258.91$[b] $p < 0.001$	R=-0.023 $\chi^2 = 248.85$[b] $p < 0.001$	[0.7852][a]	
Concurrent Engineering	R=0.320 $\chi^2 = 249.74$[b] $p < 0.001$	R=0.318 $\chi^2 = 237.07$[b] $p < 0.001$	R=0.283 $\chi^2 = 206.59$[b] $p < 0.001$	[0.8058][a]
Mean	3.3345	3.7516	3.1830	3.5101
Standard Deviation	0.79473	0.99972	0.93074	0.85722
Average Variance Extracted (AVE)	0.7611	0.8301	0.7526	0.7619

Note:

- All correlations are significant at p-value <0.01 except the correlation between supplier involvement and customer involvement that has a p-value = 0.703
- a = Reliabilities (Cronbach's alpha) are on the diagonal
- b = Difference in chi-square (fixed and free correlation) along with p-value

For the German data, the four variables show satisfactory reliabilities, ranging from 0.68 for concurrent engineering to 0.88 for supplier customer involvement. All correlations among the constructs are significant at p-value 0.01 except the correlation between heavyweight product development managers and supplier involvement (p-value=0.082), heavyweight product development managers and customer involvement (p-value=0.260), and supplier involvement and customer involvement (p-value=0.023). All average variance extracted (AVEs) are satisfactory, i.e., 0.66 and above.

Table 2. Correlation (R) Matrix, Reliability, Discriminant Validity, and Average Variance Extracted (AVE) for German data (139 responses)

	Heavyweight Product Development Manager	Customer Involvement	Supplier Involvement	Concurrent Engineering
Heavyweight Product Development Manager	[0.7499][a]			
Customer Involvement	R=0.148 $\chi^2 = 56.91$[b] $p < 0.001$	[0.8840][a]		

Supplier Involvement	R=0.096 $\chi^2 = 109.41^b$ $p < 0.001$	R=-0.192 $\chi^2 = 63.33^b$ $p < 0.001$	[0.8256][a]	
Concurrent Engineering	R=0.267 $\chi^2 = 105.73^b$ $p < 0.001$	R=0.263 $\chi^2 = 63.64^b$ $p < 0.001$	R=0.230 $\chi^2 = 147.21^b$ $p < 0.001$	[0.6790][a]
Mean	3.2041	3.9093	3.3270	3.8399
Standard Deviation	0.75987	0.99617	0.95560	0.64531
Average Variance Extracted (AVE)	0.7240	0.8536	0.7818	0.6607

Note:

- All correlations are significant at p-value <0.01 except the correlation between:

-heavyweight product development managers and supplier involvement that has p-value = 0.082

-heavyweight product development managers and customer involvement that has p-value = 0.260

-supplier involvement and customer involvement that has p-value = 0.023

- a = Reliabilities (Cronbach's alpha) are on the diagonal
- b = Difference in chi-square (fixed and free correlation) along with p-value

Assessing the Structural Model and Testing Hypotheses

Figure 2 and Figure 3 below present the standardized solution and structural model of product development practices for the U.S. data (n = 267) and the German data (n = 139) respectively.

The U.S model

For the model with the U.S. data, the fit indices reflect a good model-data fit: $X^2 = 77.98$, df = 49, p-value = 0.004, RMSEA = 0.048, NNFI = 0.94, and CFI = 0.98. For the four latent factors, all item-factor loadings are above 0.55 (t-values >8.90), suggesting reasonably good convergent validity. The structural model has no suggested modifications, indicating that there is no evidence of any other direct paths between the four variables.

The standardized structural coefficient for the path between heavyweight product development managers and concurrent engineering is 0.30 (t-value = 4.03). This provides support for hypothesis H1, i.e., the greater the involvement of heavyweight managers in the product development process, the more successful and efficient use of concurrent engineering. This confirms previous studies that demonstrated the importance of heavyweight product development managers in product development (Womack, 1990; Clark & Fujimoto, 1990).

The standardized structural coefficients for the paths between heavyweight process development managers and supplier involvement (0.18, t-value = 2.36) and customer involvement (0.25, t-value = 3.38) are also significant. Thus, the hypotheses that heavyweight product development managers have a direct positive relationship with supplier involvement (H2) and customer involvement (H3) in product development activities are supported.

Hypothesis H4, suggesting that there is a direct relationship between supplier involvement and concurrent engineering was also supported (standardized structural coefficient = 0.30, t-value = 4.27), as well as hypothesis H5, assuming a direct relationship of customer involvement to concurrent engineering (standardized structural coefficient = 0.30, t-value = 4.44).

Chi-square = 79.25, df = 49, p-value = 0.00401, RMSEA = 0.048, NNFI = 0.97, CFI = 0.98

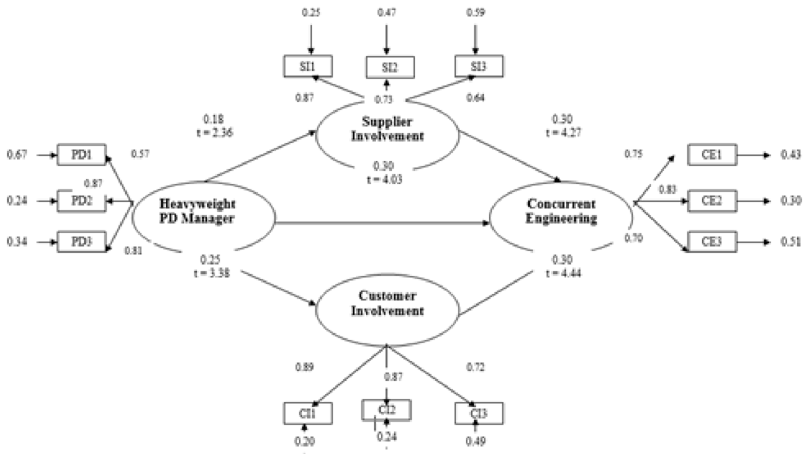

Figure 2. Structural Model for Product Development Practices – The U.S. Data

The German model

For the model with German data, the fit indices also reflect a good model-data fit: X^2 = 69.90, df = 49, p-value = 0.026, RMSEA = 0.056, NNFI = 0.94 and CFI = 0.96. For the four latent factors, all item-factor loadings are above 0.60 (t-values >5.0), suggesting reasonably good convergent validity. The structural model has no suggested modifications, indicating that there is no evidence of any other direct paths between the four variables.

The standardized structural coefficient for the path between heavyweight product development managers and concurrent engineering is 0.32 (t-value = 2.92). This provides support for hypothesis H1 stating that the greater involvement of heavyweight managers in product development process, the more successful and efficient use of concurrent engineering.

The standardized structural coefficients for the paths between heavyweight process development managers and supplier involvement (0.06, t -value = 0.60) and customer involvement (0.13, t-value = 1.35) are not significant. Thus, the hypotheses that heavyweight product development managers have a direct positive relationship with supplier involvement (H2) and customer involvement (H3) in product development activities are rejected in the case of German product development practices.

Hypothesis H4, suggesting that there is a direct relationship between supplier involvement and concurrent engineering is supported (standardized structural coefficient = 0.33, t-value = 3.07), as well as hypothesis H5, assuming a direct relationship of customer involvement with concurrent engineering (standardized structural coefficient = 0.34, t-value = 3.36).

Chi-square = 69.90, df = 49, p-value = 0.02653, RMSEA = 0.056, NNFI = 0.94, CFI = 0.96

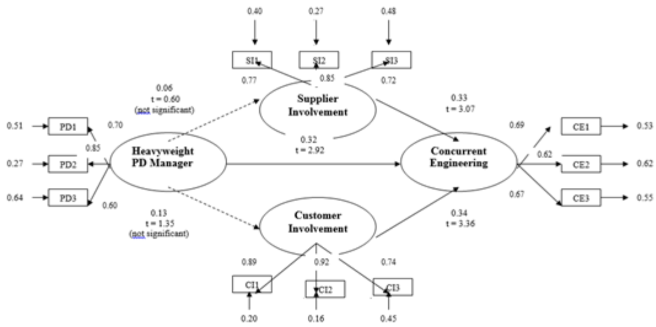

Figure 3. Structural Model for Product Development Practices – German Data

Discussion

The term heavyweight product development managers has been promoted first by Clark and Fujimoto (1990) and associated specifically with the auto industry. A heavyweight product development manager possesses both position and seniority, along with specific skills and experience developed while working in an organizational context that includes a structure and systems to support a strong product focus, multifunctional teams of broadly skilled people, and extensive cross-functional communication and influence. The practice of using the heavyweight product development managers has received some attention in management literature. In spite of that, there is still a need for more comprehensive study to relate heavyweight product development managers with other product development practices and how companies in different countries use heavyweight product development managers differently.

This study addresses the fundamental question of whether the heavyweight product development management, as one of key product development practices, impacts other product development practices. We concentrated on its impact on external integration with customers and suppliers, and internal integration with cross-functional product development that is manifested in concurrent engineering. The model developed and tested for the purpose of this research provides another interesting perspective. We applied the same model in two culturally distinctive settings, i.e., Germany and the United States.

In the case of the U.S. companies, this research found that U.S. heavyweight product development managers have a strong positive relationship with external constituents, such as suppliers and customers, to gather information about market needs and requirements as well as with internal design and manufacturing engineering units. The concept of the heavyweight product development managers is very well nested in the United States. Literature also provides sufficient practical support for early involvement of external and internal constituents in the product development process (Koufteros et al., 2002; Karlsson & Ahlstrom, 1996).

Our research indicates that heavyweight product development managers enhance cooperation with suppliers and customers that bring a substantial value of expertise in the form of ideas and possible solutions in product design and execution.

The results of our German study are quite different, i.e., product development managers do not enhance external integration processes with customers and suppliers. This situation is most likely caused by strict functional relationships in organizations. German product development managers are not as ‘heavy-weight’ as their American counterparts. The top managers and functional managers with the decisive roles are taking much of the ‘weight’ off.

Separate analysis of the U.S. and German data indicates that the relationship between heavyweight product development managers and concurrent engineering is significant in both countries. This finding clearly indicates that project managers, either defined as heavyweight or middleweight, play an important role in simultaneous engineering practices. The strength of this relationship is greater for the U.S. automotive industry. Although the German companies have formally installed cross-functional engineering teams, conditions for concurrent engineering work in terms of infrastructure (co-location facilities) and empowerment are much weaker.

This study has some limitations. The research model has been developed and tested for the automotive industry, which is characterized by very specific product development practices, complex products, relatively long development times, frequent and costly engineering changes, and great emphasis on cost reduction. The model validated for the automobile industry may be less appropriate or provide less value in other industries with shorter development times, less complex products, infrequent engineering changes, or simply employing product development practices different from those used by automakers.

CONCLUSIONS

This paper has presented and validated a model of new product development practices in the automotive industry to capture the important role of heavyweight product development managers in two major industrial countries, i.e., the United States and Germany. As it was presented, the German companies compromised between the tradition of function-oriented work and project-oriented cross-functional cooperation, while the U.S. firms engaged their heavyweight managers into coordinating practices involving close support from their suppliers and customers.

Further research is needed to evaluate the overall impact of heavyweight management not only on other product development practices but also on product development performance and overall project performance. This kind of research would allow translating intangible values related to heavyweight product managers, such as process integration, into tangible values such as product market success.

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Appendix A
Measurement Items

Variable	Item #	
Heavyweight Product	PD1	Product development managers are given real authority over personnel

Development Manager	PD2	Product development managers have broad influence across the organization
	PD3	Product development managers have enough influence to make things happen
Customer involvement	CI1	Our product development people meet with customers
	CI2	We visit our customers to discuss product development issues
	CI3	We involve our customers in the early stages of product development
Supplier involvement	SI1	Our suppliers develop component parts for us
	SI2	Our suppliers do the product engineering of component parts for us
	SI3	We ask our suppliers for their input on the design of component parts
Concurrent engineering	CE1	Product development group members represent a variety of disciplines
	CE2	Manufacturing engineers are involved from the early stages of product development
	CE3	Product and process designs are developed concurrently by a group of employees from various disciplines