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NPD (New Product Development) Structural Features for Successful Product Proliferation

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제품 다양성의 활성화를 위한 신제품 개발 조직의 구조적 특성

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Abstract The aim of the current study is to look at the mediating effects of structural features (i.e. decentralization, formalization, and specialization) on the relationship between product variety and the performance of product family. This study investigates the impact of decentralization and formalization for platform and derivative projects separately and in the context of the performance of the product family as a whole, as opposed to individual projects. In addition to relationships between people and groups, the current study considers physical element of an organization such as geographical location in which business tasks are conducted. The current study focuses on spatial differentiation which refers to the number of different sites or locations operated by an organization. Based on a cross-industry sample of 103 Korean manufacturers, this study examines the role of organizational structure features in which firms successfully increase product variety. The study examines that formalization in platform projects and decentralization in derivative projects enhance high variety firms' product family performance. The study finds significant mediating effect of spatial proximity on the relationship between product variety and product family performance.

요 약 본 연구는 성공적으로 제품 다양성을 증가시키기 위한 신제품 개발 조직의 특성을 분석하는 데 있다. 본 연구는 플랫폼 및 파생제품 개발을 위한 조직의 구조적 특성을 개별적으로 고려하여, 제품군 (product family) 전체의 성과에 미치는 영향을 분석하고자 한다. 본 연구에서는, 조직 내 구성원 및 그룹간의 관계를 규정짓는 3가지 요인 (분권화, 공식화, 전문화)과 함께, 개발 관련 조직 간 공간적 근접성 (spatial proximity)을 조직의 구조적 특성을 파악하는 요인으로 사용하고자 한다. 본 연구는 국내 103개 제조업체로부터 수집한 설문응답 분석에 기초하였다. 조직 구조적 특성은 기업의 제품 다양성 정도와 신제품 개발 성과 간의 관계를 매개하는 것으로 나타났다. 특히 본 연구결과는 기존 신제품 개발 조직 연구와 상반되는 몇 가지 결과를 보고 주고 있다. 제품 다양성을 증가시키는 기업에게 있어, 플랫폼 제품 개발 과정의 공식화 및 파생 제품 개발과정의 분권화는 제품군 전체의 성과를 향상시켜 준다. 본 연구는 개발 조직의 공간적 근접성이 성공적으로 제품 다양성을 증가시키는 데 중요한 조직요소라는 것을 증명하였다.

Key Words : NPD (New Product Development) structural features, Platform / Derivative projects, Product variety

1. Introduction

Firms have continuously developed their structural features in order to adapt environmental changes and to implement their strategic orientation. Increasing product variety is one of the most distinctive characteristics of industrial competition today[12]. Pine[28] notes that the phenomenon of increasing product variety appears prevalent in the business world today and companies

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consider product variety as a critical dimension of their product strategy. Similarly, Drucker pointed out that "The main marketing issues facing organizations today is that the mass market is shrinking and highly specialized markets are emerging,"[8, *p.* 11]. In order to meet various and heterogeneous customer needs economically, firms adopt a "product family approach" (also known as platform-based product development) over the last decade [17]. For example, Sony created almost 250 models based on only four technical platforms in the U.S. market during the 1980s [33]. Previous studies investigate various topics in relation to product families, including definitions, product portfolio and product family positioning, platform-based product family design, manufacturing and production[17].

The NPD(New Product Development) literatures highlight the importance of structural mechanism in influencing new product outcomes[6, 20]. Researchers also suggest that NPD structural features that are well-aligned with the firms' strategic orientation and projects' characteristics may increase NPD operational (e.g., NPD cycle time) and financial performance[20,29].

If managers can understand the links between product variety expansion using a product family approach, NPD structural features and performance, they can efficiently allocate their scarce NPD resources to structural features that substantially improve product family performance. Our study adds to the existing body of knowledge by examining the relevance of using fit theory in product family development including different types of projects (platform and derivative).

The aim of the current study is to look at the mediating effects of structural features on the relationship between product variety and the performance of product family as a whole.

2. Theoretical Background

Organizational structure refers to "relationships between people or groups that are fairly stable and are recognizable to observers as well as participants"[23]. Based on initial studies of organizational structure [3,29], NPD studies utilize primary structural dimensions to explore the structural configuration of new product development. These studies examine association between NPD structural features and NPD performance. For example, Gupta, Raj and Wilemon [14] suggest that formalization hampers the integration between functions and cause non-involvement of specialist. On the other hand, recent studies suggest that formalized NPD processes enhance NPD performance[4,33]. For example, Schmidt, Sarangee, and Montoya[33] highlight the importance of formal review practices for controlling risk, prioritizing projects and allocating resources.

In addition to organizational structure defined as "relationship between people or groups", other researchers[26] define the organizational structure as the relationship between "physical elements of organization such as geographical location in which business tasks are conducted". Based on geographical locations, previous studies define spatial differentiation / proximity which refers to the number of different sites or locations operated by an organization[26].

Although previous studies examine the direct impact of structural features on NPD performance, NPD researchers suggest that the fit between project characteristics and NPD structure and process is a critical factor in ensuring NPD outcomes [26]. There is no single best NPD structure for every NPD environment [20, 27, 37]. For example, Olson, Walker and Ruekert[27] found that high decentralization and low formalization are more effective at shortening NPD cycle times when projects develop truly new and innovative products which are new-to-the-company or new-to-the world, rather than for incremental projects which represent line extension and minor changes. However, high centralization and high formalization produce better NPD outcomes when firms develop incremental products. Their research findings are consistent with results reported by Kessler and Chakrabarti[20] who find that decentralizing decision-making down to NPD teams has a greater effect on shortening NPD cycle times for radical projects than for incremental ones.

2.1 Decentralization and Formalization

When firms adopt a product family approach, they are expected to develop different levels of formalization and decentralization in platform and derivative projects due to different level of NPD task's uncertainty. The task

environments of platform projects are more uncertain because platform projects are introduced to target markets that are newer to a firm and the industry than derivative projects[37]. In particular, high variety firms should strive to incorporate forthcoming product technology into a platform and maximize the number of components in a platform in order to economically generate numerous variants.

On the other hand, the task environments of derivative projects are stable because firms are familiar with both markets and core-product technologies, including the basic platform technology[37]. High variety firms are likely to greatly reuse components which have been developed in platform projects. This makes task environments of derivative projects more stable in high variety firms than in low variety firms.

Olson, et al[27] suggest that firms need different types of organizational structure during new product development depending on the characteristics of NPD projects (e.g., the degree of project innovativeness and task uncertainty). When NPD task environments are highly uncertain (i.e. developing platform), an organic structure, which is characterized by low levels of formalization and centralization, is more likely to increase NPD performance in terms of operational performance (e.g., NPD cycle time and product quality) and market share/sales than a mechanistic structure[27]. In comparison with an organic structure, a mechanistic structure is more likely to achieve favorable NPD performance when NPD task environments are certain (i.e. derivative products)[27]. Based on the preceding discussions, the following hypotheses are proposed:

H1a: The degree of product variety pursued by the firm varies positively with the level of decentralization in platform projects.

H1b: The level of decentralization in platform projects varies positively with the technical / operational performance.

H1c: The level of decentralization in platform projects varies positively with the profitability.

H2a: The degree of product variety pursued by the firm varies negatively with the level of decentralization in derivative projects.

H2b: The level of decentralization in derivative projects varies negatively with the technical / operational performance.

H2c: The level of decentralization in derivative projects varies negatively with the profitability.

H3a: The degree of product variety pursued by the firm varies negatively with the level of formalization in platform projects.

H3b: The level of formalization in platform projects varies negatively with the technical / operational performance.

H3c: The level of formalization in platform projects varies negatively with the profitability.

H4a: The degree of product variety pursued by the firm varies positively with the level of formalization in derivative projects.

H4b: The level of formalization in derivative projects varies positively with the technical / operational performance.

H4c: The level of formalization in derivative projects varies positively with the profitability.

2.2 Specialization

Specialization examines the degree to which tasks are divided into unique elements and the distribution of official duties among a number of positions[31]. When firms divide a certain activity into several sub-activities and thus a distinct sub-unit carries out each sub-activity, the sub-unit can accumulate specialized knowledge[6]. Specialization provides firms with adaptiveness in markets because highly specialized personnel involved in product development are more likely to clearly understand changing markets and develop suitable products[31]. A high product variety strategy requires firms to develop enhanced adaptiveness in numerous markets in order to fulfill the distinctive needs of market segments/niches. Accordingly, firms seeking to increase variants are expected to strongly emphasize specialization of NPD functions which enables them to increase adaptiveness in numerous market segments or niches.

H5a: The degree of product variety pursued by the firm varies positively with the level of

specialization.

H5b: The level of specialization varies positively with the technical / operational performance.

H5c: The level of specialization varies positively with the profitability.

2.3 Spatial Proximity

Although specialization enhances specialized knowledge across NPD activities, specialization can impede the integration between different NPD activities due to the boundaries that are set up between NPD functions[21, 31]. Sundgren[36] emphasizes that success of an overall product family also depends on the integration between different NPD activities across NPD projects. In particular, the success of a product family approach hinges on sharing common components across subsequent derivative projects and integration between platform and non-platform components. If firms fail to generate subsequent derivative products with consistent product quality, they may not achieve higher commercial performance of product families[36].

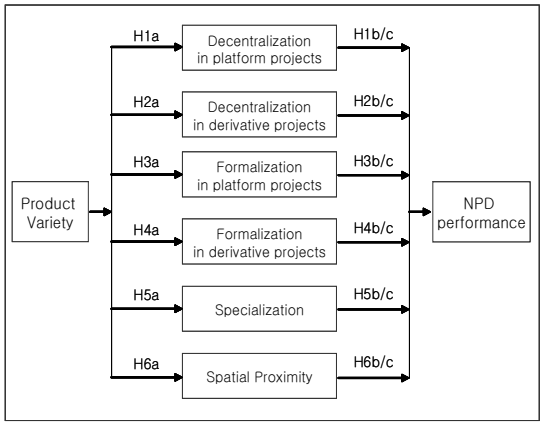
One of structural mechanisms to integrate NPD activities, particularly between platform and derivative projects, is a concentrated NPD structure, whereby NPD units are located in close proximity to facilitate information sharing and to foster better communication between NPD functions or units[9, 35]. Spatial proximity enhances the ability of management to develop new products concurrently and leads to a reduction in the number of disruptive engineering changes[28]. Previous studies have consistently showed that integration between NPD functions is positively associated with NPD performance in terms of operational performance such as NPD cycle times and NPD costs[21] and market share/sales and profitability[36].

H6a: The degree of product variety pursued by the firm varies positively with the level of spatial proximity.

H6b: The level of spatial proximity varies positively with the technical / operational performance.

H6c: The level of spatial proximity varies positively with the profitability.

Figure 1 visually depicts the hypothesized mediating roles in the translation of a firm's product variety into product family performance. NPD performance is measured by both technical/operational performance and profitability.



[Fig. 1] Research Model

3. Research Methodology

Although previous studies have measured product variety using objective measures (e.g. the number of product models or brands), this is inappropriate for this study which entails a cross industry sample. Ten models may equate to a high level of product variety in the automobile industry, but not in the personal computer industry - there are over 2000 different models in the PC market[2]. Therefore, this study used a subject scale to tap the level of product variety within a product family relative to competition. Informants were asked to rate their firm's product variety along a 7-point Likert-type scale (1 implies 'compared to competitors, we offer a lower number of variants that share the platform,' and 7 implies 'compared to competitors, we offer a higher number of variants that share the platform').

NPD structural features identified in this study are measured by using a 7-point Likert-type scale. The informants were requested to rate to what extent they agreed with the statements about formalizeed wi(3 items)[37], deceney lizeed wi(2 items)[16, 39], specializeed wi(3 items) [18, 30], and spatial proximity (2 items)[18], ranging from 1 = strongly disagree with the statement, to 7 = strongly agree with the statement

(Appendix A for summary measure of NPD structural features).

This study has measured decentralization by using two items: (1) One functional group dominated NPD related decision making, (2) NPD related decision-making authority was extended to lower level managers who were in charge of certain NPD activities. However, The reliability of the decentralization scale produces an alpha value of 0.15, which is much less than the suggested minimum[10]. In addition, the value of inter-item correlation is only 0.08. The scale reliability of decentralization cannot be acceptable. Therefore, the current study does not use a sum value of the two items for subsequent data analyses. Instead the study measures decentralization by using one of them – "NPD related decision-making authority was extended to lower level managers who were in charge of certain NPD activities".

Consistent with previous studies[13], this study measured overall product family performance in terms of profitability (three items)[7, 19] and product technical and NPD operational performance (four items)[7 15]. The measure of operational performance includes platform efficiency (the degree to which a platform allows economical generation of variants within the focal product family)[25]. Factor analysis confirmed the nidimensionality of each of the dimensions of product family performance (see Appendix B).

The current study also introduces two control variables which may affect firms' NPD performance – firms size or number of employees (implying more resourceful firms) and the number of product platforms or platform variety (reflecting firms with more platform development experience and a higher level of NPD proficiencies)[11,22].

Data were collected from companies, or strategic business units (SBUs) of selected companies drawn from the Korean Chamber of Commerce and Industry directory. The sample frame comprised 569 manufacturers in the following sectors: automobile and transportation, communication equipment, semiconductors, electrical and electronics, and medical and precision instruments. A total of 250 firms were randomly selected from the 569 firms in the sample frame. Following telephone contracts to identify key informants in firms, knowledgeable of over NPD activities, 124 firms agreed to participate (which represented a response rate of 48%). Of these 124 firms, a total of 103 firms eventually completed and returned questionnaire (the final response rate of 41.2%).

4. Data Analysis and Findings

While previous studies [1,44] have suggested the three conditions for demonstrating mediating effects, the current study adopts specific steps of data analysis from the research by Chryssochidis and Wong [5].

Firstly, to assess if there is an association between the six hypothesized mediating variables and the independent variable, Pearson's correlation analysis was conducted. Table 1 shows that, with the exception of formalization in derivative projects and specialization, positive correlation are found between product variety degree and the

[Table 1] Inter-correlations Among the Variables[1)]

Variables	PV	TechP	Profit	DCp	DCd	Fp	Fd	Spe	SP	PlatV	Emp
Product Variety (PV)	1.00										
Technical Performance (TechP)	.29 b	1.00									
Profit	.44 c	.33 b	1.00								
Decentralization in platform projects (DCp)	.29 b	.26 b	.26 a	1.00							
Decentralization in derivative projects (DCd)	.30 b	.30 b	.24 a	.92 c	1.00						
Formalization in platform projects (Fp)	.22 a	.26 b	.40 c	.49 c	.46 c	1.00					
Formalization in derivative projects (Fd)	.15	.27 b	.35 c	.48 c	.48 c	.90 c	1.00				
Specialization (Spe)	.14	.32 b	.20 a	.30 b	.27 b	.41 c	.32 b	1.00			
Spatial Proximity (SP)	.18†	.38 c	.25 a	.11	.17†	.26 b	.25 a	.36 c	1.00		
Platform Variety (PlatV)	.49 c	.22 b	.36 c	.21 a	.24 b	.13	.03	.10	.13	1.00	
Number of Employees (Emp)	-.09	-.16	-.04	-.14	-.12	.03	-.05	.18†	.04	.00	1.00
Mean	4.70	4.98	4.82	4.76	4.73	5.26	5.18	4.32	4.96	4.51	1117
SD	1.56	0.92	1.00	1.50	1.60	1.04	1.12	1.22	1.27	1.58	2056

1) Correlation analysis is conducted for assessing **the first condition** of mediating effects

† : Significant at $p<.10$, a: Significant at $p<.05$, b: Significant at $p<.01$, c: Significant at $p<.001$

mediating variables : decentralization of NPD decision-making in both platform projects (r = 0.29, p<0.01) and derivative projects (r = 0.30, p<0.01), formalization in platform projects (r = 0.22, p<0.05), spatial proximity (r = 0.18, p<0.10). The first requirement for mediation was not supported for the formalization in derivative projects and specialization, which was excluded from subsequent regression analysis [1,44].

Secondly, in order to assess the second requirement, the dependent variable was regressed on the independent variable with the simultaneous inclusion of the two control variables (i.e. platform variety and firm size). Table 2 and 3 show that product variety significantly associated with the dependent variable : technical / operational performance (b = 0.22, p<0.05, R^2=0.11) and profitability (b =0.35, p<0.01, R^2=0.23). The second requirement is supported.

Thirdly, the dependent variable was regressed on the independent and relevant mediating variable, in the presence of the control variables The occurrence of mediating effects is confirmed if a significant association is sustained between the mediator and the performance, while the impact of product variety on the performance is reduced when the control and mediating variables are included [1]. Table 2 and 3 respectively display the results of the regression analysis predicting technical performance and profitability.

Table 2 shows that decentralizations in both platform projects (b = 0.17, p<0.10) and derivative projects (b = 0.21, p<0.05), formalization in platform projects (b = 0.27, p<0.01), and spatial proximity (b = 0.35, p<0.01), were significantly associated with technical and operational performance. Moreover, the impact of product variety, in the presence of the control variables, on technical performance (b = 0.22, p<0.05,22'=0.11) was reduced after controlling for: decentralization in both platform projects (b = 0.18, p>0.10,22'=0.14) and derivative projects (b = 0.17, p>0.10,22'=0.15), formalization in platform projects (b = 0.16, p>0.10,22'=0.18), and spatial proximity (b = 0.16, p>0.10,22'=0.23). On the other hand,22' is significantly improved after the in,=0.11) wasdecentralization in both platform (F=3.3, p<0.10) and derivative projects (F=4.4, p<0.05), formalization in platform projects (F=8.1, p<0.01), and spatial proximity (F=14.3, p<0.01). Consequently, the three requirements for mediation were supported for decentralization in platform and derivative projects, formalization in platform project and spatial proximity.

[Table 2] Results of Regression Analysis Predicting Technical/ Operational Performance

		Step 1	Step 2 (Including Mediating Variables)			
			Decentralization in platform project	Decentralization in derivative project	Formalization in platform project	Spatial Proximity
Step 1[1]	Product Variety	.22 a				
	Platform Variety	.11				
	Company Size	-.13				
Step 2[2]	Product Variety		.18	.17	.16	.16
	Platform Variety		.10	.09	.11	.09
	Company Size		-.11	-.11	-.15	-.16†
	Mediating Variable		.17†	.21 a	.27 b	.35 b
R^2		.11	.14	.15	.18	.23
F-value for change in R^2 due to inclusion of the mediating variable			3.3†	4.4 a	8.1 b	14.3 b
t-statistic for indirect effects [3]			2.12 a	2.27 a	2.32 a	2.01 a

1): Regression analysis is conducted for assessing **the second condition** of mediating effects

2): Regression analysis is conducted for assessing **the third condition** of mediating effects

3): Sobel [34] provided an approximate significance test for the indirect effect of an independent variable on a dependent variable via a mediating variable (see also Venkatraman [38]).

† : Significant at p<.10, a: Significant at p<.05, b: Significant at p<.01, c: Significant at p<.001

[Table 3] Results of Regression Analysis Predicting Profitability

		Step 1	Step 2 (Including Mediating Variables)			
			Decentralization in platform project	Decentralization in derivative project	Formalization in platform project	Spatial Proximity
Step 1[1]	Product Variety	.35 b				
	Platform Variety	.19 †				
	Company Size	-.06				
Step 2[2]	Product Variety		.32 b	.33 b	.28 b	.32 b
	Platform Variety		.18	.09	.11	.09
	Company Size		.00	-.00	-.03	-.02
	Mediating Variable		.13	.09	.31 c	.16 †
R^2		.23	.24	.24	.32	.26
F-value for change in R^2 due to inclusion of the mediating variable			1.2	1.2	12.5 b	3.8†
t-statistic for indirect effects [3]			1.79†	1.34	2.66 b	1.60

1): Regression analysis is conducted for assessing **the second condition** of mediating effects
2): Regression analysis is conducted for assessing **the third condition** of mediating effects
3): Sobel [34] provided an approximate significance test for the indirect effect of an independent variable on a dependent variable via a mediating variable (see also Venkatraman [38]).
† : Significant at p<.10, a: Significant at p<.05, b: Significant at p<.01, c: Significant at p<.001

Table 3 shows that formalization in platform projects (b=0.31, p<0.001) and spatial proximity (b = 0.16, p<0.10) were significantly associated with product family profitability. Additionally, the impact of product variety, in the presence of the control variables, on product family profitability (b =0.35, p<0.01, R^2=0.23) was reduced after controlling for: formalization in platform projects (b = 0.28, p<0.01, R^2=0.32); spatial proximity (b = 0.32, p<0.01, R^2=0.26). In each case, R^2 is significantly improved after inclusion of formalization in platform projects (F=12.5, p<0.01) and spatial proximity (F=3.8, p<0.10). Consequently, the three requirements for mediation was supported for formalization in platform projects and spatial proximity.

5. Discussion

The study's results confirm the importance of the need to explore NPD issues within the context of a contingency framework. The results support the hypotheses concerning mediating effects concerning of decentralization in derivative projects and spatial proximity.

On the other hand, the findings concerning mediating effects of centralization in derivative projects and formalization in platform projects contrast with this study's hypothesis. According to the findings, as firms increase product variants within a product family, operational performance is also dependent on a lower level of centralization of NPD decision-making in derivative product development. The result contradicts traditional theory suggesting that decentralization is less effective when NPD task environments in a project are certain as they are usually in derivative projects.

[Table 4] Summary of Hypotheses Tests

	Mediating Variable	Dependent Variable	Test Result
H1	Decentralization in platform projects	Technical/Operational Performance	Supported
		Profitability	X
H2	Decentralization in derivative projects	Technical/Operational Performance	Contrary to hypothesis
		Profitability	X
H3	Formalization in platform projects	Technical/Operational Performance	Contrary to hypothesis
		Profitability	Supported
H4	Formalization in derivative projects	Technical/Operational Performance	X
		Profitability	X
H5	Specialization	Technical/Operational Performance	X
		Profitability	X
H6	Spatial Proximity	Technical/Operational Performance	Supported
		Profitability	Supported

A possible explanation is that although project environments in derivative product development are relatively certain, derivative projects also need to solve uncertain problems, which include positioning derivative products without cannibalization between product variants, and integration between platform and non-platform components. Another explanation is that, an organic approach to NPD structures for both platform and derivative projects is required to improve NPD performance of platform or derivative projects[37].

Another research finding contrasts with those of previous studies that advocated that less formalization improves NPD performance when NPD task environments are highly uncertain[14, 27]. One possible explanation is that, in order to achieve high performance of product family as a whole, firms may need some formalization in platform projects. Sundgren[36] proposes that firms seeking to expand platform-based product variety need a formalized process of developing and finalizing the physical interfaces between platform and end-product unique subsystems, which secures the robustness of the platform and sustains high levels of product family performance. Recent NPD studies also suggest that although too much formalization may be negative on NPD performance, firms need formal rules and structured approaches for new product development[4] as well as formal review activities across NPD stages[33].

This study makes a contribution to the product development literature by showing the impact of platform-driven product variety on product family performance, gauged in operational and financial indicators, is mediated by NPD structural features. Moreover, the study provides support for the relevance of using fit theory to examine the relationships between firms' strategic orientation, NPD structural features and the performance.

The research findings also have practical implications for managers adopting the platform approach. Our study suggest that greater utilization of a platform than competitors can enhance product family technical/operational performance and profitability. However, technical/operational performance of product family is secured largely through NPD structural features (i.e., decentralization in both platform and derivative projects, formalization in platform project, spatial proximity). In particular, spatial proximity plays the critical role in increasing product variety with high performance in both tehcnical success and profitability. On the other hand, specialization does not significantly mediate the relationship between product variety and the performance. This suggests that managers need to develop NPD structures in which NPD organizational units are integrated and cooperated.

The current study contains a number of limitations that should be taken into account when interpreting the findings. First of all, there is high correlation between structural features in platform and derivative projects. That is, decentralization (or formalization) in platform projects could be considered as the same variable as one in derivative projects. However, this study analyses these features respectively in order to analyze the relationships between these variables and product variety(or NPD performance). For example, formalization in platform project is significantly correlated with product variety, while formalization in derivative projects is not. However future studies need to obtain the variables in platform and derivative projects from different source with independent procedures. Moreover, this study measures decentralization using a single item scale, which may result in the inability to estimate the measurement errors of the corresponding constructs. Future studies should develop multiple variables for the constructs to increase measurement reliability.

References

[1]Baron, Reuben M. and Kenny, David A., "The moderator-mediator variable distinction in social psychological research", *Journal of personality and social psychology*, Vol. 51, No. 6, pp.1173-1182, 1986.

[2]Bayus, B. L. and Putsis, W. P., "Product proliferation: an empirical analysis of product line determinants and market outcomes", *Marketing Science,* Vol. 18, No. 2, pp. 137-153, 1999.

[3]Child, John., "Organization structure and strategies of control: a replication of the Aston study.", *Administrative Science Quarterly,* Vol.17, pp.163-177, 1972.

[4]Christiansen, John K. and Varnes, Claus J., "Formal rules in product development: sensemaking of structured

approaches", *Journal of Product Innovation Management,* Vol.26, No.5, pp.502-519, 2009.

[5]Chryssochodis, G. M. and Wong, Veronica, "Customization of product technology and international new product success: Mediating effects of new product development and rollout timeliness", *Journal of Product Innovation Management*, Vol. 17, No. 4 pp. 268-285, 2000.

[6]Clark, Kim B. and Fujimoto, T., *Product Development Performance: Strategy, Organization, and Management in The World Auto Industry,* Harvard Business School Press, Boston, 1991.

[7]Cooper, R. G. and Kleinschmidt, E. J., "Benchmarking the firm's critical success factors in new product development", *Journal of Product Innovation Management,* Vol.12, No.5, pp.374-394, 1995.

[8]Darroch, J., "Drucker on marketing: an interview with Peter Drucker", *Journal of the Academy Marketing Science,* Vol.37, pp.8-11, 2009.

[9]Datar, Srikant, Jordan, Clark, Kerkre, Sunder, Rajiv, Surendra and Srinivasan, Kannan., "New product development structures and time-to-market", *Management Science*, Vol.43, No.3, pp.452-464, 1997.

[10]DeVellis, R. F.. *Scale Development: Theory and Application.* Applied Social Research Methods Series, 26, California: Sage Publication Inc, 1991.

[11]Dewar, Robert D. and Dutton, Jane E., "The adoption of radical and incremental innovations and empirical analysis", *Management Science,* Vol.32, No.11, pp.1422-1433, 1986.

[12]Fisher, Marshall L. and Ittner, Christopher D., "The impact of product variety on automobile assembly operations: empirical evidence and simulation analysis", *Management Science*, Vol.45, No.6, pp.771-781, 1999.

[13]Griffin, A. and Page, A. L, "PDMA success measurement project: recommended measures for product development and failure", *Journal of Product Innovation Management*, Vol.13, No.6, pp.478-496, 1996.

[14]Gupta, Ashok, Raj, S. P. and Wilemon, David., "A model for studying R&D-marketing interface in the product innovation process", *Journal of Marketing*, Vol.50, pp.7-17, 1986.

[15]Ittner, C. D. and Larcker, D. F., "Product development cycle time and organizational performance", *Journal of Marketing Research*, Vol.34, pp.13-23,1997.

[16]Jaworski, B. J. and Kohli, A. K., "An examination of collaboration in high-technology new product development process", *Journal of Product Innovation Management*, Vol.15, No.3, pp. 237-254, 1998.

[17]Jiao, Jianxin, Simpson, Timothy W. and Siddique, Zahed., "Product family design and platform-based product development: a state-of-the-art review", *Journal of Intelligent Manufacturing,* Vol.18, No.1, pp.5-29, 2007.

[18]John, G. and Martin, J., "Effects of organizational structure of marketing planning on credibility and utilization of plan output", *Journal of Marketing Research* Vol.21, pp.170-183, 1984.

[19]Kekre, S. and Srinivasan, K., "Broader product line: a necessity to achieve success", *Management Science*, Vol.36, No.10, pp.1216-1231, 1990.

[20]Kessler, E. H. and Chakrabarti, A. K., "Speeding up the pace of new product development", *Journal of Product Innovation Management*, Vol.16, No.3, pp.231-247, 1999.

[21]Liker, Jeffrey K., Collins, Paul D. and Hull, Frank M., "Flexibility and standardization: test of a contingency model of product design-manufacturing integration", *Journal of Product Innovation Management*, Vol.16, No.3, pp.248-267, 1999.

[22]MacDuffie, John Paul, Sethuraman, Kannan, and Fisher Marshall L., "Product variety and manufacturing performance: evidence from the integration automotive assemble plant study", *Management Science*, Vol.42, No.3, pp.350-369, 1996.

[23]Meyer, Marshall W., *Structure, Symbols, and Systems: Readings on Organizational Behaviour*, Boston: Little, Brownand Company, 1971.

[24]Meyer, M. H., Tertzakian, P. and Utterback, James M., "The product family and the dynamics of core capability", *Sloan Management Review*, Vol.34, No.3, pp.29-47, 1993.

[25]Meyer, M. H., Tertzakian, P. and Utterback, J. M., "Metrics for managing research and development in the context to the product family", *Management Science,* Vol.43, No.1, pp.88-111, 1997.

[26]Miller, G. A. and Conaty. Joseph., "Differentiation in organizations: replication and cumulation", *Social Forces*, Vol.59, No.1, pp.265-274, 1980.

[27]Olson, E. M., Walker, O. C., Jr. and Ruekert, R. W., "Organizing for effective new product development: the moderating role of product innovativeness", *Journal of Marketing*, Vol.59, No.1, pp.48-62, 1995.

[28]Pine, B. J., *Mass Customization: The New Frontier Business Competition,* Harvard Business School Press,

Boston, 1993.

[29]Pugh, D. S., Hickson, D., Hinings, C. R. and Tuner, C., “Dimensions of organization structure”, *Administrative Science Quarterly*, Vol.13, pp.65-105, 1968.

[30]Rafii, Farshad and Perkins, Sam., “Cross-functional integration: moving beyond physical co-location”, *Design Management Journal, summer*, pp.62-68, 1995.

[31]Ruekert, R. W., Walker, Orville C., Jr. and Roering, Kenneth J., “The organization of marketing activities: a contingency theory of structure and performance”, *Journal of Marketing*, Vol.49, pp.13-25, 1985.

[32]Sanderson, Susan W. and Uzumeri, Mustafa V., "Managing product families: The case of the Sony Walkman", *Research Policy,* Vol.24 No.5, pp.761-782, 1995.

[33]Schmidt, Jeffrey R., Sarangee, Kumar R., and Montoya, Mitzi M., “Exploring new product development project review practices”, *Journal of Product Innovation Management*, Vol.26, No.5, pp.520-535, 2009.

[34]Sobel, M. E., “*Asymptotic confidence intervals for indirect effects in structural equation models”*, In S. Leinhart(ed.), Sociological Methodology, SanFrancisco: Jossey-Bass, pp.290-312, 1982.

[35]Song, Michael, Berends, Hans, van der Bij Hans and Weggeman, Mathieu, “The Effect of IT and Co-location on Knowledge Dissemination”, *Journal of Product Innovation Management,* Vol.24, No.1, pp.52-68, 2006.

[36]Sundgren, Niklas., “Introduction interface management in new product family development”, *Journal of Product Innovation Management,* Vol.16, No.1, pp.40-51, 1999.

[37]Tatikonda, Mohan V., “An empirical study of platform and derivative product development projects”, *Journal of Product Innovation Management*, Vol.16, No.1, pp.3-26, 1999.

[38]Venkatraman, N., “The concept of fit in strategy research: toward verbal and statistical correspondecorres*Academy of Management Review*, Vol.14, No.3, pp.423-444, 1989.

[39]Walker, Orveille. C. Jr. and Ruekert, R. W., "Marketing's role in the implementation of business strategies: a critical review and cenceptual framework", *Journal of Marketing*, Vol.51, pp.15-33, 1987.

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Appendix A. The Measures of NPD Structural Features[1)]

Construct (Eigen-value)	Measures	Factor Loadings	Corrected inter-item correlation	α
Specialization (F1 : 2.17)	NPD related functional groups are highly departmentalized	0.89	0.72	0.81
	NPD related jobs were highly divided into unique element	0.90	0.75	
	NPD participants had relatively narrow job description focusing on a limited range of NPD tasks	0.74	0.52	
Spatial Proximity (F1 : 1.46)	Participants in NPD activities were widely dispersed geographically	0.85	0.46	0.64
	NPD related functional groups were located close to each other	0.85	0.46	
Decentralization in platform projects (F1 : 1.08)	NPD related decision-making authority was extended down to or at least shared with lower level managers who were in charge of certain NPD activities	0.73	0.08	0.15
	One functional group dominated NPD related decision making	0.73	0.08	
Decentralization in derivative projects (F1 : 1.07)	NPD related decision-making authority was extended down to or at least shared with lower level managers who were in charge of certain NPD activities	0.73	007	0.15
	One functional group dominated NPD related decision making	0.73	0.07	
Formalization in platform projects (F1 : 2.18)	Project management rules and procedures were formalized	0.83	0.63	0.81
	Formal project management rules and procedures were actually followed	0.88	0.71	
	Formal progress reviews were held	0.83	0.64	
Formalization in Derivative projects (F1 : 2.32)	Project management rules and procedures were formalized	0.85	0.67	0.85
	Formal project management rules and procedures were actually followed	0.90	0.77	
	Formal progress reviews were held	0.88	0.72	
1) Principal component factor analyses were used to verify unidimensionalilty in each of structural features				

Appendix B. The Measures of NPD Performance

Construct	Measures	Factor Loadings	Corrected inter-item correlation	α
Technical Operational Performance (F1 : 1.99)	The technical success of product families has been high compared to investment	0.71	0.55	0.65
	The average NPD cycle time has been shorter than that of competitors	0.67	0.44	
	The overall product quality higher than that of competitors	0.80	0.39	
	Using a single platform, company has been able to generate derivative products within product families more economically than competitors	0.63	0.36	
Profitability (F2 : 2.06)	Product family program has successfully met profit objective	0.84	0.61	0.77
	The profitability of product family has been greater than the amount of investment	0.84	0.60	
	The profitability of product families has been greater than that of competitors	0.84	0.60	