CSCanada
Management Science and Engineering
Vol. 9, No. 4, 2015, pp. 7-14
DOI:10.3968/7942

ISSN 1913-0341 [Print]
ISSN 1913-035X [Online]
www.cscanada.net
www.cscanada.org

The Impact of IFFE on NPD Performance: The Moderating Effect of Customer Involvement and Supplier Involvement

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Supported by a Major International (Regional) Joint Research Project (71420107024); the Natural Science Foundation of China (NSFC) (71090403/71090400); Fund Program of Institute of Supply Chain Integration and Service Innovations at South China University of Technology.

Received 17 August 2015; accepted 8 November 2015
Published online 16 December 2015

Abstract

This study investigates the relationship among customer involvement in product design, supplier involvement in product design, the implementation of fuzzy front-end (IFFE) and new product development performance (NPDP) base on resource-based view and knowledge-based theory of the firm. Theoretical hypotheses have been empirically tested through 168 valid questionnaires from China manufacturing enterprises. The results show that the implementation of the fuzzy front end has a significant positive effect on the new product development performance. The positive effect of the implementation of the fuzzy front end of new product development performance is further strengthened when customer and supplier involve in product design. The related research results enrich the innovation theory and have a great significance for the enterprise management practice in the new product development.

Key words: Customer involvement; Supplier involvement; Implementation of fuzzy front-end; New product development performance

Liu, Y., & Sun, J. (2015). The Impact of IFFE on NPD Performance: The Moderating Effect of Customer Involvement and Supplier Involvement. *Management Science and Engineering*, *9*(4), 7-14. Available from: URL: http://www.cscanada.net/index.php/mse/article/view/7942
DOI: http://dx.doi.org/10.3968/7942

INTRODUCTION

With economic globalization and the rapid development of information technology, customer demand increasingly diversified and personalized, and the competition between enterprises is more vehemence. Focus of competition between enterprises is competition for innovation, and product innovation has become the embodiment of innovation. Product innovation can open up new market for the enterprise, make customers effectively distinguish the company product with competitors' similar products and make the enterprise get the competitive advantage which cannot be simulated. However, when innovation brings these advantages, it is also full of high risks at the same time. Product innovation is dynamic, complex and uncertain. Therefore, how to improve the enterprise product innovation, shorten the product life cycle, and improve the innovation performance has become a hot topic of enterprise practice and academic research question (Afonso, Nunes, & Paisana, 2008; Su & Rao, 2011; Sharma, 2012).

Existing research shows that: The innovation model of the modern enterprise has transformed from the traditional closed innovation of open innovation. Open innovation is defined that the enterprises seek innovation resources within and outside the enterprise, integrate the enterprise's innovation ability and the resources with the external resources, and find market opportunities through various channels. For manufacturing enterprises, supply chain upstream and downstream resources sharing is an important means of innovation success. This has led to that early cooperation of supply chain members is becoming more and more important when the enterprise carries on product innovation.

The innovation process is divided into three stages: Front end of innovation, product development, and commercialization (Ozer, 2007). The front end of innovation is also called fuzzy front-end (FFE). The FFE includes product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition (Khurana & Rosenthal, 1997). Existing researches have showed that the implementation of the fuzzy front end has a huge role in promoting the product innovation success (Cooper & Kleinschmidt, 1994). It is at this stage that critical decisions are made, not only with respect to the functionality of the product for the customer, but indeed the packaging, the logistical channels, the source of materials, as well as the selection of product and process technology that will provide the end user with the desired functionality (Petersen, Handfield, & Ragatz, 2005). Choices made during this stage are of paramount importance, because they condition the subsequent stages of development (Godoe, Vigrestad & Miller, 2014). Compared with the other phases, fuzzy front end stage is an informal development stage, and the decision-making cost is very low, but making innovation improvement at this stage has higher efficiency (Poskela & Martinsuo, 2009; Verworn, 2009). If the company cannot effectively manage the FFE, problems with unclear or incorrect product definitions will cause high costs and/or failure at later stages of NPD .Today, new product development (NPD) is managed systematically in most large companies. Stage-gate processes have been implemented to ensure that resources are allocated so as to provide the company with competitive new product. Still, many NPD projects and programs fail to meet objectives, and the root causes of these failures can often be traced to the front end (Florén & Frishammar, 2012). The effective management of the fuzzy front end is vital for the success of new product development (Evanschitzky, Eisend, & Calantone, 2012; Im, Montoya, & Workman, 2013) .

But the existing researches put the fuzzy front end stage, development stage and commercialization stage as a whole, and rarely make distinctions (Menguc, Auh, & Yannopoulos, 2014) . There is a lack of research into the nature of customer and supplier involvement in the new product development process, especially in the "fuzzy" front-end design stage. Consequently, the first objective of this study is to provide empirical evidence regarding how customer and supplier involvement in the design process affects new product performance. At present the explorations and researches to these problems are mostly limited to case analysis. There are few empirical studies. The second gap is the lack of understanding of the interaction between customer and supplier involvement in product design and implementation of the front-end process, and how these factors interact to affect new product performance. These problems make it difficult for people to get a clear understanding of the influencing mechanism that how the customer involvement and supplier involvement influence the fuzzy front end and NPD performance.

Therefore, how to make the customers and suppliers effectively participate in the product innovation in order to improve the performance of new product development is a theoretical and practical problem that the enterprises need to solve. From the perspective of resource-based view, this paper carries out an empirical research through the 168 questionnaires which are collected from the manufacturing companies in mainland China and Taiwan. Related research's conclusions can provide theoretical basis and guidance for the management of fuzzy front end stage, in order to make full use of suppliers and customers information, technology and resources to improve innovation performance.

1. THEORETICAL BACKGROUND

Effective design development requires resources that may be either owned by the organization or accessed externally through customers, suppliers, and other entities (Verona, 1999). From the perspective of resource-based view, the enterprise can enhance the independence and autonomy by obtaining and controlling the external resource so as to reduce the effects of environmental changes and improve the competitive advantage of enterprises, performance and the ability to resist risk. To effectively manage this resource dependency and reduce the influence of environmental uncertainty, companies tend to establish a good partnership with the resource owners to improve the control and influence of resources (Drees & Heugens, 2013). The most important resource owners and stakeholders are customers and suppliers. Their involvement can improve the creative ability of organization, and provide more excellent creative ideas. In the process of product innovation, customers and suppliers are powerful sources of enterprise competitive advantage. They can provide organizations with resources and knowledge which organizations lack of in the process of innovation (Verona, 1999; Perks, Cooper, & Jones, 2005) .

Fuzzy front end is also known as "concept generation stage", "product design phase". It is the phase that the product concept and the product definition are confirmed. This phase has a high degree of uncertainty, including: market uncertainty, technological uncertainty, and the resource of uncertainty (Herstatt, Verworn, & Nagahira, 2004). Some scholars found that 3000 ideas, which are generated in the fuzzy front end stage, can enter the formal product development stage is only 14, and only one eventually succeeds on the market. Front-end activities often take place in informal organizational settings, are often ill-defined (Montoya-Weiss & O'Driscoll, 2000), and are characterized by ad hoc decision making and by high degrees of complexity, uncertainty, and equivocality (Chang, Chen, & Wey, 2007). The front end is also a crossroads of complex information processing, tacit knowledge, and conflicting organizational pressures (Khurana & Rosenthal, 1998). These characteristics have brought the huge challenge to the enterprise product innovation. An "integrated problem solving" approach is that requires the early involvement of key stakeholders in the product development process and permits sharing of critical information upstream and downstream in the product development supply chain as necessary for executing NPD work (Wheelwright & Clark, 1992). In product design stage, customers and suppliers participate in firm-initiated practices that result in customers providing feedback, information, and knowledge to firms about how to improve the design. These feedback, information and knowledge can enable firms to engage in a learning process (Im, Montoya, & Workman, 2013). Through this collaborative involvement, innovation team can get the information about technology, market and competitors so as to reduce the uncertainty of product innovation (Wheelwright & Clark, 1992; Kim & Wilemon, 2002). The lower uncertainty on the front end stage, the smaller deviation of the later stage, the higher the success rate and efficiency of product innovation are. According to the resource-based view, when facing the uncertainty of external environment and competitors and conflicts within the organization, enterprises can obtain competitive advantage by getting the heterogeneous resources. Customer and supplier involvement in the early stages of product innovation can make the enterprise earlier access to unique resources and specific innovation ability (Wernerfelt, 1984).

2. HYPOTHESES DEVELOPMENT

2.1 Relationship Between Project Performance and Market Performance

The end outcome of FFE is a clear product definition. According to the outcome of this phase, enterprise determines whether or not it should invest resources to develop the idea for a formal product development (Stevens, 2014). Prior researches tend to focus on the front-end process but just regard FFE as a pretreatment of information processing, and largely fail to define its outcome (Reid & De Brentani, 2004). But the outcomes of this stage play an important role for the enterprise decision-making and project establishment (Brentani & Reid, 2012). The outcome of the front-end stage is a corroborated product definition. A corroborated product definition implies that it has been subjected to critical tests and has withstood them. It is furthermore sufficiently clear, stable, and unambiguous, and has passed the tests of business and feasibility analysis. Core to the product definition is a product concept. Product concept is typically visualized in the form of pictures, drawings, three-dimensional models, or mock-ups. The product definition includes information about the target markets, customer needs, and product specifications as well as product positioning and product requirements. A well-defined product definition provides a clearer understanding of several important issues, including development time, costs, technical expertise, market potential, risk, and organizational fit. So the implementation of the fuzzy front end can help enterprises to effectively reduce the impact of the external environment uncertainty, enhance the autonomy and independence of the enterprise and make accurate market positioning and product positioning. Therefore, we propose the following hypothesis:

Hypothesis 1: There is a positive relationship between IFFE and NPD performance.

2.2 Customer Involvement in the Design Process

Many authors agree that integrating customers into design activities is important for new product performance (Crawford, Charles, Anthony & Benedetto, 2011; Lau, Tang, & Yam, 2010). Because end-user needs are usually very complex, and translating new designs into products that provide meaningful benefits to customers requires a deep understanding of customer needs. Let the customer participate in product design can provide enterprises with more good creative ideas, and also can help enterprises to make a more precise definition of the product. Customers have important ideas to contribute to product design and customers can share their knowledge about new product design, functions, and prototype assessment (Von Hippel, 2007). What's more, customers can effectively select the feasible scheme which greatly improves the success rate and the efficiency of product innovation. Extensive collaboration with end users allows customers' voices to be captured and facilitates the creation of effective user-oriented designs that enhance product performance (Veryzer & Borja, 2005). Better understanding of end user needs provides firms with distinctive resources that can lead to a competitive advantage. Consequently, failure to consider users' requirements and constraints in the design of new products often leads to major problems and even new product failure. Many companies have processes and infrastructures that are intended to elicit relevant information from customers and integrate it into the product design (Callahan & Lasry, 2004). From the perspective of resource-based view, the more communication with customers on the front end stage, the more timely access to relevant information and knowledge. In this way, companies gain the product differentiation and market differentiation to improve the new product development performance.

Hypothesis 2: Customer involvement positively moderates the relationship between IFFE and NPD performance

2.3 Supplier Involvement in the Design Process

Supplier involvement in design is defined as supplied input in the design phase of new product development that results in better information, technology, and efficiency. Prior research on ESI maintains that earlier involvement is always better (Li & Yang, 2011). Through supplier involvement in design, firms are able to identify and prevent potential future problems that could result in a major overhaul of the product or even a delayed product launch (Im, Montoya, & Workman, 2013). Previous studies also suggest that technology uncertainty can be mitigated through openly sharing cost and technology information with suppliers(Crawford, Charles, Anthony, & Benedetto, 2011; Lau, Tang, & Yam, 2010). In Japanese companies technological uncertainty drove closer relationships with first-tier suppliers through early involvement in product conception and planning (Veryzer & Borja, 2005). Supplier involvement can accelerate the pace of product innovation, shorten development cycles. Because suppliers are more likely to identify the potential problems in the early stages of product design, such as contradictory specifications, unrealistic designs. Besides shortening development cycles, supplier involvement has been shown to have a positive effect on other measures of performance such as lower development costs, improved design-for-manufacturability and enhanced product quality (Auster, 1992). Together these factors ultimately to improve performance.

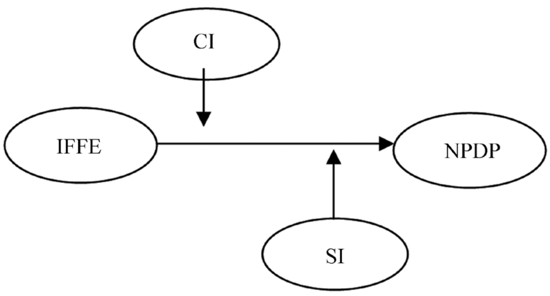
Hypothesis 3: Supplier involvement positively moderates the relationship between IFFE and NPD performance. Based on the above analysis, we put forward the model.

CI: Customer involvement

IFFE: The implementation of fuzzy front-end

SI: Supplier involvement

NPDP: New product development performance



3. RESEARCH METHOD

3.1 Sample and Data Collection Procedure

The data used for empirical analysis was collected from Chinese manufacturing enterprise in 2012-2013. Automotive suppliers, electronics, and machinery were selected as the three industries for the research, using a stratified sample consisting of traditional and high performance manufacturing plants. The scale of the enterprises which are surveyed is not less than 100 people. 198 questionnaires were received. After eliminating invalid questionnaire, we get 168 valid questionnaires. Recovery rate is 85%.

3.2 Measures

Multi-item measures were developed based on existing scales identified in the literature. All multi-item measures were based on 7-point Likert scales, from 1 (strongly disagree) to 7 (strongly agree). The items are reported in Table 1. We use 6 items to measure supplier involvement and customer involvement in the NPD process. The scale items measure both the extent and the timing of the involvement of each group and are developed using the existing literature on collaboration (Brown & Eisenhardt, 1995; Ittner & Larcker, 1997; Hartley, Zirger, & Kamath, 1997; Swink, 1999; Gerwin & Barrowman, 2002). For instance, the measurement items SUPINV2 (We partnered with suppliers for the design of this product) and CUSTINV3 (Customers were an integral part of the design effort for this project), are each a measure of the extent to which the focal firm collaborates with suppliers and customers in the product development process. Similarly, SUPINV1 (Suppliers were involved early in the design efforts in this project) and CUSTINV1 (We consulted customers early in the design efforts in this product) are each a measure of the timing of involvement with suppliers, and customers. The items for Implementation of the front-end process described the level of the effectiveness of the front-end process. It was composed of three items based on the scales reported in the studies of Koen, Ajamian and Burkart (2001), Smith, Herbein, and Morris (1999), Khurana and Rosenthal (1999). NPD Performance was measured by five items and reflected the complete product concept (Philip Kotler 1998).

3.3 Construct Validity

Following Anderson and Gerbing (1988), we refined the perceptual measures and assessed their construct validity by running a confirmatory factor analysis (CFA) with structural equation modeling. The CFA shows that each indicators loads significantly on its intended factor, indicating convergent validity among the items of each scale. As shown in Table 1, the measurement model fits the data satisfactorily (goodness-of-fit index GFI=0.916, confirmatory fit index CFI=0.964, incremental fit index IFI= 0.965; root mean squared error of approximation RMSEA=0.057), and all factor loadings are highly significant ($p<.05$), indicating the unidimensionality of the measures (Anderson & Gerbing, 1988). The fit indices presented above suggest a good fit of the model to the data.

CFA was run to assess the convergent validity of the measures. Two tests were used to assess convergent validity: Cronbach's alpha and the average variance extracted (AVE) by constructs (Fornell & Larcker, 1981). As shown in Table 1, the composite reliability coefficients ranged from 0.75 to 0.86, well above the usual 0.70 benchmark. The average variance extracted for every construct was above the 0.50 cut-off (Ibid.). Thus, these measures demonstrate adequate convergent validity. Discriminant validity was tested in authoritative ways. We performed a stringent test to determine whether the square root of the average variance extracted (i.e., the diagonals in Table 2) is greater than the correlations among constructs (i.e., the off-diagonal elements in Table 2) (Ibid.). An examination of Table 2 reveals that the diagonal elements of this matrix are significantly greater than the off-diagonal elements, indicating that each construct shares more variance with its measures than with other constructs. This result provides strong evidence of discriminant validity among the theoretical constructs.

Table 1
Results of Confirmatory Factor Analysis.

Constructs and scale items	SFL
Customer Involvement (Cronbach's *a*=0.771, CR=0.773, AVE=0.531)	
1. We consult customers early in the design of new products.	0.704
2. Customers are frequently consulted about the design of new products.	0.741
3. Customers are an integral part of new product design efforts	0.741
Supplier Involvement (Cronbach's *a*=0.783, CR=0.778, AVE=0.541)	
1. Suppliers are involved early in product design efforts.	0.670
3. Suppliers are frequently consulted during the design of new products.	0.726
2. We partner with suppliers for the design of new products.	0.804
Implementation of the front-end process (Cronbach's *a*=0.751, CR=0.752, AVE=0.502)	
1. We draw upon many sources and methods in identifying new product development opportunities.	0.704
2. We obtain additional information to help in translating new product development opportunities into specific business, market and technology decisions.	0.718
3. We use processes such as direct contact with customers/users, linkages with cross-functional teams and collaboration with other companies and institutions to translate product development opportunities into concrete ideas.	0.704
NPD Performance (Cronbach's *a*=0.881, CR=0.864, AVE=0.562)	
1.Performance (functionality)	0.607
2.Durability (life expectancy)	0.821
3.Reliability (time between failures)	0.867
4.Conformance quality	0.814
5.Aesthetic appeal of this product	0.609
Chi-square	107.528
Degrees of freedom	70
GFI	0.916
Comparative fit index (CFI)	0.964
Incremental fit index (IFI)	0.965
RMSEA	0.057

Note. a: Cronbach's alpha, CR: composite reliability, AVE: average variance extracted, SFL: Standardised factor loadings.

Table 2
Descriptive Statistics and Pearson Correlation Matrix.

Variables	Mean	S.D.	1	2	3	4
1. Customer involvement	4.193	0.702	**0.729**			
2. Supplier involvement	3.829	0.783	0.609**	**0.734**		
3.Implementation of the front-end process	4.141	0.665	0.684**	0.644**	0.709	
4. NPD performance	3.734	0.559	0.311**	0.210**	0.346**	**0.752**

4. ANALYSIS AND RESULT

We applied to multiple moderated regressions to test the proposed model (Liu et al., 2009b). The baseline models (Models 1, Table 3) contain control variables. The control variable is not significant (p>.01). Additional regression analyses (Model 2, Table 3) demonstrate that IFFE (implementation of the front-end process) has a main effect on NPD Performance (p<.01 or lower). Including this variable significantly increases the predictive power of Model 2 (ΔR^2=0.140, F=14.243, p=.005), in explaining the variance of NPD performance. Thus Hypothesis 1 is supported.

Table 3
Effect of IFFE on NPD Performance: Moderated Regression Analysis

Variables		NPD Performance			
		Mode 1	Mode 2	Mode 3	Mode 4
Control variables	Industry	0.155	0.136	0.065	0.066
Independent variables	Implementation of the front-end process (*X*1)		0.187**	0.160**	0.233**
	Customer Involvement (*X*2)			0.112	
	Supplier Involvement (*X*3)				0.02
Interaction terms	*X*1**X*2			0.093**	
	*X*1**X*3				0.105**
Adjusted R^2		0.035	0.14	0.195	0.194
ΔR^2		0.035	0.105	0.055	0.054
F		6.099	14.243**	9.864**	9.834**

Note. * $p < .01$, ** $p < .005$

Model 3 find that the interactions between customer involvement and IFEE ($X1*X2$) are significantly and positively associated with NPD performance (p<.005), IFFE has a positive effect on the NPD performance, and the control variable is not significant (p>.01), which lends support to Hypothesis 2.

Model 4 shows interactive effects ($X1*X3$) between IFFE on NPD performance and the moderating effect of supplier involvement. We find support for H3 that supplier involvement enhances the effectiveness of IFFE in improving NPD performance (p<.005). Collectively, the interaction effects account for a significant increase in R^2 from 0.140 to 0.195. The control variable is not significant (p>.10).

5. DISCUSSION

The main objective of this study is to investigate the impact of supply chain innovation mechanisms (i.e. customer involvement and supplier involvement) on NPD performance. Using a database of 168 valid questionnaires from China manufacturing enterprises, we examined the direct impact of IFFE on NPD performance, and how this effect is moderated by customer involvement and supplier involvement. Our analysis results show IFFE has a positive and linear relationship with NPD performance. Secondly, the results suggest that the positive effect of IFFE on NPD performance is further strengthened when the level of customer involvement and supplier involvement is higher. Theoretical and applied implications of these findings follow.

5.1 Theoretical Implications

Knowledge-based theory believes that enterprise is an operational organization that centres around the knowledge activities, including knowledge creation, transfer and utilization. Enterprise innovation is essentially a process of knowledge acquisition, integration, and creation.

Implementation of the front-end is process of tacit knowledge integration and creation. The quality of business decisions depends on the relevant knowledge and information which are based on. The main job of the fuzzy front end is to match decision with knowledge and information. Through the implementation of the fuzzy front end, the knowledge of the customers and suppliers is integrated, absorbed and utilized. According to the consolidated knowledge, enterprise makes more effective decisions so as to enhance the new product development performance. But the body of the fuzzy front end is not only the product innovation team of enterprise, it should also include customers, suppliers. Previous studies just regard the customers and suppliers as the owners of innovation resource, and their role of integrator and creator of knowledge are ignored. According to the professional of the knowledge, even if enterprise collected all the knowledge, information and ideas of innovation from customers and suppliers, it also cannot make full use of these. Because that only the owners of the knowledge can we truly achieve the maximization of the value of knowledge. So under the background of open innovation, the role of the customer and supplier should be transformed from the traditional counterparty into participants in product innovation. Their involvement can help enterprises to carry out the creative management and value creation, promote the implementation of the fuzzy front-end and ultimately improve product innovation performance.

5.2 Managerial Implications

As enterprise managers, they need to understand the relationship which is very important to improve the innovation performance among customer involvement, supplier involvement, the implementation of fuzzy front-end and new product development performance. Now many enterprises pay more attention to customers' suggestions and ideas, design a series of online feedback platform and offline activities to communicate with customers. This kind of attention is just to gather more information so that enterprises have a deeper and more comprehensive understanding of customer needs.

Enterprises do not regard the customer as member of the product innovation, still take them as the external environment variable, and do not let the customer really involve the product design. Especially in China, although the customer is one of important members in the supply chain, but their role is still defined as the goods recipient. By contrast, many foreign companies provide a variety of online and offline channels to allow customers actively participate in product innovation, and let the customer become the main body of innovation. The enterprise serves as a guider and implementer in product innovation, realizes the "customization" in a real sense, and forms the enterprise's core competitiveness. So China's manufacturing enterprises should pay more attention to the role of customers and suppliers, set up an efficient platform for the interaction and cooperation, and provide a good atmosphere of learning and cooperation. Let them fully participate in the process of product innovation, give full play to their strengths, and share professional knowledge and innovation experience. By three parties participation in the product innovation which includes customers, suppliers and internal product innovation team, manufacturing companies achieve the unity of customer demand orientation, supplier's technical support, and determination of the feasibility of product innovation. Manufacturing enterprises should also let the customer and supplier involve in the early stages of product innovation. If the enterprises do not let the customer and suppliers involved in the early stages, the role of the customer and supplier will not be made full use of.

5.3 Limitations and Future Research

However, the stakeholders of product innovation include customers, suppliers, manufacturers, external competitors and partners. This study just focus on the customers and suppliers, it doesn't take manufacturers and the members outside of the supply chain into consideration. They are also an important source of ideas and information, future research should take these stakeholders into consideration. Secondly, product innovation can be divided into progressive innovation and breakthrough innovation. Previous studies found that the participants involved in different types of product innovation will produce different effects. This study does not make a distinction. Future research can be more detailed classification.

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