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Front-End Activities Promote Front-End Performance?—The Moderating Effect of Front-End Uncertainty

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Keywords: fuzzy front end; new product development; front-end activities; uncertainty; moderating role.

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I. Introduction

Economic globalization promotes the development of technology and business competition, innovation is the basis of long-term survival and development of enterprises, and a steady stream of creative sources is an important guarantee to maintain long-term competitive advantage. Fuzzy front end (FFE) is an important stage in the generation and screening of creativity, which has an important impact on innovation success and reducing R & D costs (Kien et al., 2001).

Cooper and Kleinschmidt (1994) studies show that the implementation of quality front-end activities and entered the development stage of the product before the project full definition and planning in enterprise new product development (NPD) play a crucial role in the process of. Therefore, the enterprise should effectively develop, cultivate and manage the front-end innovation activities to achieve good front-end performance. The existing researches on FFE mainly focus on the following four aspects: the definition and characteristics of FFE, the front-end performance and its mechanism, FFE and new product development performance, based on specific industries and products. The definition and characteristics of FFE is the basis for the follow-up study of FFE; the front-end performance is the direct result of changing the front-end activities through various management methods; NPD performance is affected by the front-end performance (Zhai, 2014). The key point of NPD's success lies in the "front-end activity", especially in the early development of the market related activities, the success rate of the NPD project is proportional to the time spent in the FFE phase (Cooper, 1988). However, FFE is the weakest link in the process of product innovation, the implementation of the front-end of the project innovation plays a decisive role, and affect the level of product quality, cost and time limit of the length to a great extent (Khurana and Rosenthal, 1997). Markham (2013) believes that most of the value of the new product is created in the front-end stage, the more mature the front-end program, NPD will be more successful. At the present stage, many managers in China are not fully aware of the concept and process of the fuzzy front end, and the front-end activities and their management have not been paid much attention to in the practice of NPD. What are the important effects of front-end activities on the performance of the front end, and whether the effective management of front-end activities directly affects the NPD performance is an important issue in the research field. This study is based on the theory of open innovation, from the creative source perspective, the front ends is divided into internal and external activities, focus on the relationship between the front and front end performance, and discusses the uncertainty in the regulatory role between front-end activities and front end performance for the first time. Under the background of building an innovation oriented country in China, it is more forward-looking, theoretical and practical value to select the front-end activities management of NPD project in manufacturing enterprises. The research results not only have theoretical implications for the promotion of front-end performance, but also have important practical significance for Chinese manufacturing enterprises to effectively manage NPD front-end activities.

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II. Literature Review and Hypothesis

a) *Fuzzy front end*

The new product development process is usually divided into three stages: fuzzy front end, project implementation and commercialization. The fuzzy front end refers to the early stage of New Product Development, roughly covers the idea generation project business plan is approved or termination of the development period, including the product idea generation and selection, concept development and definition, business plan and design (Khurana and Rosenthal, 1997). FFE stage management plays a decisive role in the successful implementation of new product development projects. Uncertainty refers to the difference between the amounts of information that an organization needs to perform a specific task. In order to reduce the uncertainty of FFE, it is necessary to collect a large amount of relevant information in the process of new product development. Research shows that, more reduction in the front-end stage of specifications is uncertain and product definition phase deviation follow-up projects are smaller, and the greater success rate of New Product Development (Souder and Moenaert et, 1992; al., 1995). In addition, Cooper (1988) points out that after the implementation of project, the commercialization of the new product will be successful and the mechanism of the fuzzy front-end stage technology and market uncertainty reduction needs to be further studied.

The fuzzy front end of uncertainty, the existing research has not yet formed a unified definition of standards. Different scholars from the perspective of division of the front stage of uncertainty, such as Lynn and Akgun (1998) pointed out that the uncertainty mainly comes from two aspects of market and technology. Kim and Wilemon (2002) think that this uncertainty comes from technology, market demand, resources and organization ability. Brun (2009) from the "theme" and "source" two aspects of division of uncertainty, the "theme", including product market, process and resources, on the other hand "source" mainly includes multiple meanings, novelty, effective and reliability. Souder and Moenaert (1992) that the front stage of uncertainty mainly for the demand, technology, competition and the required resources and other aspects of the uncertainty (O'Connor and Rice,2013) divided into market uncertainty, resource uncertainty, organizational uncertainty and technical uncertainty. Cao et al.(2016) from the market, resources, organization and technical uncertainty, such as four aspects to explore the impact of the fuzzy front end of new product development performance.

b) *Front-end activities*

The strategic planning and opportunity recognize are the input of FFE and the specific project plan are the output by the FFE. This construct the FFE input and output model, pointed out that the front-end activities including task processing, concept formation, concept selection, concept definition, business analysis and project plan. (Nobelius and Trygg, 2002). Yu et al (2004) said that there are two main types of front-end activities: one is planning, including with product planning and project planning; the other one is related to creativity, including with creative production, creative development and creative assessment. According to Chen and Gao (2005) suggested about improving the front-end activities from the six aspects of development strategy such as new ideas, organizational activities, supplier involvement, customer participation, feasibility analysis and to reduce the ambiguity level as per the front end theory. It improves the performance of complex product significantly. In addition, the innovation of enterprise culture or atmosphere will affect the enterprise for creative collection or the degree of attention between NPD project team communication level and creativity will affect the project team and other departments of the enterprises are also affected. Markham (2013) believed that the front series of activities include the effects of preparation process, front-end resource supply and the front lead user has completed. The sequence of activities such as consensus on the front end performance was made and then found that the implementation of front-end control cost and eliminate the formal process of project. Although the literature suggests some front-end activities but without considering the various activities of the interaction, there is no scholars or managers pointed out what major activities have a positive impact on the performance of the front. On the basis of the existing research, including the actual China manufacturing enterprises mainly involved for the both main supplier and customer participation. The main front end activities are at the same time choosing internal subjects including learning strategy and information collection. Although there have been studies on these activities, but not at any analyzing the influencing factors of front end performance and NPD performance. The present study focused on the two points as followed. We will focus on the learning strategy, stakeholder participation and information gathering effect on front end performance. Whether uncertain have a moderating role on the relationships between the front end and front end performance play.

This study will study influence of the front-end activities on front-end performance and exploring the moderating effect of front-end uncertainty. The front-end activities include learning strategic (Poskela and Martinsuo 2009; Stevens 2014), stakeholders involvement (Schoenherr and Wagner 2016; Menguc et al., 2014; Wangner 2012) and information collection (Hart 1999; Olausson and Berggren 2012; Calabrese 1999; Pentina and Strutton 2007). These activities are all

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related to front-end information resources. Uncertainty is the greatest feature of the fuzzy front end in the new production development (Moenaert et al., 1995; Ozer 2007; Alam 2006; Verworn 2009; Verworn et al., 2008; Zhang and Doll 2001).

c) *The impact of fuzzy front end activities on FFE Performance*

i. *Learning strategic and FFE Performance*

The strategic orientation determines the learning activities of search scope, standard and integrated use of knowledge. The limited scope of attention will lead to inertia and cognitive basis will be conducive to the development of diversified exploration activities (Hsieh et al., 2016). Therefore, the strategic orientation of enterprise may be an important factor in determining the choice of learning methods. Companies with different strategic orientations may choose and promote different types of learning activities to achieve innovation. The enterprise's strategic orientation can be reflected in the use of resources, selection of competitive strategy and understanding of how to gain competitive advantage (Bacciotti et al., 2016). Different enterprises orientation will have different strategies, define different business scopes and adopt different resources and competitive strategies. There is a big gap among the knowledge technology and ability of a product innovation and existing technology of the enterprise. In order to realize independent innovation enterprise, we often need to learn new knowledge and skills (Moon and Han, 2016). Therefore, in the process of product innovation, it is often necessary to make a tentative study in unknown field. Exploratory learning helps to enterprises to collect new opportunities, new business development, new technology and the ability of exploring learning plan. Many scholars define new product development as an uncertainty reduction process (Lievens and Moenaert, 2000; Lester and Priore, 2004). Because uncertainty can lead to both positive and negative outcomes, refinements in this initial definition are required for application to project management. Perminova et al. (2008) defined "uncertainty as a context for risks as events having a negative impact on projects outcomes or opportunities". Those events have beneficial impact on project performance because the fuzzy front end involves high levels of uncertainty, the transformation of FFE to formal projects results from the coverage of different sources and overcoming uncertainties. The limited level of resources available during the FFE makes personal networks because they provide informal access to resources and expertise (Stevens 2014). Although rationality is difficult to achieve when uncertainty is exists. Learning strategies can contribute to issue identification and then to the adoption of options with the highest probability of success. Knowledge creation processes such as gathering more information, comparing it with existing knowledge, exchanging intensively with other members of team and creating scenarios can contribute to the optimization of choices for development teams (Matinheikki et al., 2016). Therefore, this study proposes the following hypotheses:

Hypothesis1: Learning strategic has a positive impact on front-end performance.

ii. *Stakeholders involvement and FFE performance*

If uncertainty reflects difference between the amounts of knowledge to perform a task and the amount of knowledge available in company (Galbraith, 1973) then development managers can overcome this gap by increasing available knowledge such as: empirical experience, recruitment of new expertise or processing of information in different ways. From this perspective, collecting enough information during go/no-gostages until rational decisions can be made will reduce the level of uncertainty (Cooper and Kleinschmidt, 1994; Verworn et al., 2008). For example: research has recommended increased communication between departments, specifically research and development and marketing, or even improvements in company information systems to gather, process, and structure the information (Moenaert et al., 1995; Montoya and Driscoll, 2000).

Reliable information can effectively reduce the uncertainty and risk, continue to collect relevant technical innovation, market development, internal organization and external development and competition and other aspects of the information, pay attention to historical data, experience and intuition, so as to keep the channels for the flow of information in new product development team (Cao et al., 2015; Kim and Wilemon, 2002; Lievens and Moenaert, 2000). The research of Hoegl and Gemuenden (2001) shows that communication, cooperation, balances of the member contribution, mutual support and cohesion are great significance to team spirit construction. The innovation team of information sharing is helpful to the analysis of function can be increased and reducing variability function, promote new product development team to communicate information can effectively promote NPD project developed new products to meet customer needs (Pei et al., 2013). Under the background of open innovation fuzzy front end collect information not only from technical research and development personnel, marketing personnel, customer service staff and other internal participants, but also learn from suppliers, customers, competitors, universities and research institutions to reduce external participants can play an important role in guiding the practice of front-end uncertainty and improve the performance of NPD effectively. The integration of information flow (Hong et al., 2007).

Hypothesis 2: Stakeholders involved has a positive impact on front-end performance.

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iii. *Information collection and FFE Performance*

The ability of an enterprise to collect information determines resources that an enterprise can utilize in the FFE (Olausson and Berggren, 2012; Pentina and Strutton 2007). More information sources, greater the heterogeneity of information, diversity of information on the front-end innovation inspired more. Suppliers and users take participate in front-end activities, which can provide more information about product requirements, product specifications, product performance, part cost in the front end (Schemmann et al., 2016). Other stakeholders take participate in the front end, which can provide more information about market and price. Enterprise integrates information from stakeholders effectively to the front end of innovation, which ultimately may be integrated into RD project (Schoenherr and Wagner 2016; Hong et al. 2011). The empirical study shows that the knowledge sharing of customers, suppliers, competitors and internal subjects has a significant positive impact on the performance of front-end, and that measured by the degree of strategic matching (Hong et al., 2007; Reid et al., 2016). Jeppesen and Laursen (2009) found that will have a positive effect on the development of knowledge sharing leading users; with external related knowledge and full integration of different sources of lead user has a certain regulating effect. Supplier involvement on both sides of interactive relationship between the fuzzy front end (manufacturers and suppliers) has a significant positive impact on technological innovation ability of manufacturing industry. Manufacturing technology learning has a significant positive impact on technological innovation capability. Supplier participation positively influences the breakthrough in the fuzzy front end of innovation. An empirical study shows that supplier involvement in fuzzy front-end can significantly improve customer value (Hong et al., 2007). Li et al. (2013) and other research also shows that supplier involvement in NPD process has a significant positive impact on knowledge creation and innovation ability. The research shows that customer participation in enterprise incremental innovation is conducive to improve NPD performance, and suppliers to participate in incremental innovation and breakthrough innovation can improve NPD performance (Menguc et al., 2013). Customer participation in new products development can enable enterprises to shorten the development time, create competitive advantage and increase sales success.

Hypothesis 3: Information collection has a positive impact on front-end performance.

iv. *The moderating effect of front-end uncertainty*

Front-end uncertainty under environmental such as changing market conditions, emerging technological developments and evolving competition can cause confusion about project targets and how tradeoff decisions should be made(Zhang and Doll, 2001). High-tech industries also face these environment conditions. Front-end uncertainty implies vague and imprecise exogenous causes (i.e. environmental uncertainty) as well as the internal consequences of uncertainty (Zhang & Doll, 2001). The FFE itself is uncertain; a firm's competence and activities must reflect an innovative procedure to succeed in an environment full of uncertainties (Danneels & Kleinschmidt, 2001; Poskela and Martinsuo,2009). Customer's ambiguity, uncertainty technology and competition challenge the organization's ability to function solely on a rational basis. Customer uncertainty defined as lacking an understanding of customers and market leads to product development difficulties and failure based on uncertainty regarding: the demand for the kinds of products offered, appropriate product characteristics, and length of product life cycle. Technology uncertainty is defined as a lack of understanding regarding technology and manufacturing requirements for production based on uncertainty regarding: process functions or input characteristics specifications, suppliers' design, manufacturing capability, and meeting raw material standards. Such uncertainty may lead to launch delay and increased development costs. Competitor uncertainty is defined as a lack of understanding regarding actions undertaken by competitor's product development and technology adoption and so on. This may result in missed launch timing and directly undermine the focal firm's product market (Zhang and Doll, 2001).Contingency theorists have acknowledged that different kinds of uncertainty influence the optimal way of organizing management processes (Donaldson, 2001; Poskela & Martinsuo, 2009; Zhang and Doll, 2001). Previous research indicates that increased technology and market uncertainty reduce the usefulness of process formalization, thereby impacting project efficiency and success (Bstieler, 2005; Calantone et al.,1996; Dwyer & Mellor, 1991; Moenaert et al., 1995; Verworn, 2009;Verworn et al.,2008). In addition, literature indicates the degree of project uncertainty as a moderator in management–performance relationships (Bonner et al., 2002; Langerak et al., 2004; Poskela and Martinsuo, 2009). In high technology competitive environments, higher front-end uncertainty (related to customer, technology and competition),leads to an organization becoming more easily distracted, deviating to unknown strategic goals, being hindered in the process of decision-making and experiencing the prevention of accurate information being available to the project team. Therefore, hypothesize that these management activities impact FFE performance by the front-end uncertainty. When uncertainty is low, Scholars taking information-processing view often suggest that by reducing uncertainty as much as possible during FFE phase, the overall performance can be improved (Alam,

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2006; Moenaert et al., 1995; Verworn, 2009; Verworn et al., 2008). For example, Verworn et al. (2008) empirically identified positive relationships between the degree of market and technical uncertainty reduction during FFE and overall project success. Similarly, a survey of 144 innovation projects in Germany by Verworn (2009) highlighted the importance of reducing uncertainty early in FFE phase, because it was found to help improve the communication between participants and limit deviations from specifications later in the process. Alam (2006) conducted a qualitative study of 26 financial service firms and discovered that early involvement of customers helps firms generate more relevant ideas. Improve idea screening and shorten their development cycle time. Moreover, Moenaert et al. (1995) found that, on average innovation uncertainty had been reduced during the FFE in successful innovation projects as much as it had been during whole cycle in unsuccessful ones.

There is a great deal of uncertainty in front-end innovation environment and companies need to deal with a greater risk. When the uncertainty is low, companies can more accurately grasp the market and user needs. The project plan developed by enterprise in the front stage that's more likely to be approved for development and new product commercial success probability will be improved (Verworn 2009; Verworn et al., 2008).

Research has more specifically showed that a high degree of uncertainty can create significant difficulties for front-end projects. Technical uncertainty influences prototype development proficiency and moderate design change frequency. Market uncertainty influences both product launch proficiency and market forecast accuracy, but also moderate prototype development proficiency and design change frequency (Souder et al., 1998）.

If project participants face high levels of such uncertainties (i.e., an inability to close important information gaps) when engaged with front-end activities. The general prediction is that they are likely to face severe consequences and project failures (Herstatt and Verworn, 2004; Murmann, 1994).This prediction is strengthened by previous research, which has shown that successful front-end projects are characterized by low levels of uncertainty (Moenaert, 1995).

Hypothesis 4: uncertainty has moderating effects on the Relationship between learning strategic and front-end performance.

Hypothesis 5: uncertainty has moderating effects on the Relationship between stakeholder's involvement and front-end performance.

Hypothesis 6: uncertainty has moderating effects on the Relationship between information collection and front-end performance.

With the development of technology and business competition, it is more and more difficult for enterprises to develop new products. If the enterprise wants to obtain the success of the new product development, improve the sales volume and market share, we can start from the front-end activities management of the new product development and gain the long-term competitive advantage. The theoretical model of this study is shown in Figure 1 below.

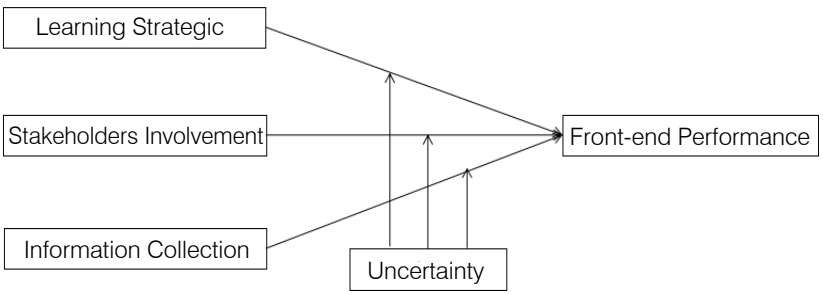

Fig.1: The theoretical model of this study

III. Research Design

a) *An empirical study based on china's manufacturing enterprise*

i. *Questionnaire design and statistical methods*

We collect data by a large sample of questionnaire survey. In order to ensure the content of validity questionnaire survey, in reference to formation on the basis of existing literature. We obtain final questionnaire through the field visits, communicate with enterprise management personnel to listen to expert opinion, scholars conducted several rounds of optimization of the questionnaire. The questionnaire consists of two parts. The first part is the basic information of respondents truthfully filled, including gender, age, education, work experience, job categories, enterprise scale, ownership and firm age. The second part is subjective items on the learning strategic, stakeholders involvement, information collection, uncertainty and front end performance, by the Likert 7 scale (Likert type scale) means the understanding for each problem, "1" means "strongly

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disagree", "7" means "very much agreed". The questionnaire analysis method mainly includes the following three kinds:

1) Descriptive statistical analysis: The basic information of the respondents were analyzed, we employee SPSS18.0 to calculate the frequency and percentage the degree of education, work experience, job category, enterprise scale, ownership, firm age and industry etc..
2) Reliability and validity analysis: Cronbach's Alpha coefficient method was employed to measure the correlation between items and to measure the consistency of each variable and scale.
3) Structural equation model analysis: AMOS18.0 software is employed to test goodness of fit and path analysis of conceptual model of this study.

ii. *Data collection and sample descriptive statistics*

The questionnaire is mainly distributed via website and through the screening of qualified students in the MBA/EMBA and senior management training courses in a university. The paper questionnaires were issued and respondents monitored and recovered. On the other hand, we through the field visits, telephone or e-mail and other ways to contact a company with the subjects and as the research in the enterprise contact, and then he will send the questionnaire. This method can ensure the questionnaire recovery rate and quality. This study is to improve the reliability of results, according to the National Bureau of standards for China's manufacturing industry classification. we choose four typical industries with faster product updates and new product development project more, including general equipment manufacturing industry, computer communications and electronic equipment manufacturing, pharmaceutical manufacturing and automobile manufacturing enterprises. In order to improve the quality of questionnaire, the respondents company's senior management, technical director, R&D Manager, senior R&D personnel and marketing personnel, etc. The survey issued a total of 300 questionnaires, the recovery of questionnaire 232, excluding unqualified questionnaire get a valid questionnaire of 196, the effective recovery rate was 65.3%. Table 1 is descriptive statistics of the basic characteristics of respondents. The investigation object of this research is mainly related to staff of the state-owned enterprises and private enterprises in Hubei Province. Foreign enterprises are relatively small in Hubei province, and foreign technology development generally depends on the parent company.

Table 2: Descriptive statistics of the basic characteristics of samples (N=196)

Variable	items	Number	Percentage (%)	Variable	items	Number	Percentage (%)
Education	Junior college and below	46	23.5	Work age	1-3years	95	48.5
	Undergraduate	91	46.4		3-5years	65	33.2
	master	54	27.6		5-10years	31	15.8
	doctor	5	2.5		》10years	5	2.5
Job	R&D	60	30.6	Firm size	《100	58	29.6
	Marketing	44	22.4		101-300	48	24.5
	Management	50	25.5		301-500	27	13.8
	Production	7	3.6		》501	63	32.1
	Logistics	10	5.1	Firm age	1-5years	61	31.1
	Finance	15	7.7		6-10years	67	34.2
	Other	10	5.1		11-25years	38	19.4
industry	General manufacturing	61	31.1		》26years	30	15.3
	Computer, communications and other electronic equipment	52	26.5	ownership	State-owned enterprise	71	36.2
					Private enterprise	65	33.2
	Pharmaceutical	47	24.0		Foreign funded enterprises	36	18.4
	Automotive	36	18.4		Other	24	12.2

iii. *Descriptive statistics of control variables and scales*

The three control variables are firm size, firm age and industry. The firm size represented by the number of employees, including "1" express "and below 100", "2" means "101-300", "3" means "301-500", "4" means "more than 501". Firm age: "1" means "1-5", "2"

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means "6-10", "3" means "11-25", "4" means "26 years"; industry of "1" means the general equipment manufacturing industry "," 2 "means" computer, electronic and communication equipment manufacturing industry "," 3 "means" the pharmaceutical industry "," 4 ""automobile manufacturing industry". The descriptive statistics and correlation coefficients of each variable table are shown in table 3.

Table 3: Descriptive statistics and correlation coefficient

Variable name	1	2	3	4	5	6	7	8
learning strategic	1							
stakeholders involvement	0.416**	1						
information collection	0.366**	0.335**	1					
Uncertainty	0.340**	0.336**	0.359**	1				
Front-end performance	0.424**	0.438**	0.421**	0.311**	1			
Firm size	0.492**	0.475**	0.543**	0.401**	0.421**	1		
Firm age	0.412**	0.521**	0.404**	0.411**	0.456**	0.121*	1	
Industry	0.553**	0.512**	0.498**	0.553**	0.478**	0.501**	0.479**	1
Mean value	5.13	5.20	5.19	5.37	5.15	4.91	5.09	5.12
Variance	0.93	0.70	0.86	0.79	0.78	1.21	0.56	0.87

*Note: * * indicates that the path coefficient is significant at the P<0.01 level; * indicates that the path coefficient is significant at the P<0.05 level*

b) Variable measurement

The variables to be measured in this study are learning strategic, stakeholder's involvement, information collection, uncertainty and front-end performance. All scales in reference to recognized literature at home and abroad in the mature scale, according to the characteristics of this study, combined with the actual situation of our country's manufacturing enterprises are modified; this can ensure the reliability and validity of the measurement scale. The learning strategic goals are defined as giving purpose and direction to the work of the team; we created a five-item scale based upon some scholars' conceptualization (Kim & Wilemon, 2002a; Verworn, 2009; Zhang & Doll, 2001; Poskela and Martinsuo 2009; Stevens 2014). Stakeholder's involvement are Including internal personnel, suppliers, customers, competitors and other intermediaries. We created a five-item scale based on some scholars' conceptualization (Choenherr and Wagner 2016; Menguc et al., 2014; Wangner 2012).

Information collections includes of R & D personnel, marketing personnel, other technical personnel to the market, technology resources, other aspects and establish a scientific information collection system as well as information communication work mode. We created a four-item scale based on some scholars' conceptualization (Hart 1999; Olausson and Berggren 2012; Calabrese 1999; Pentina and Strutton 2007). The front-end uncertainty was adapted from three measures and operationalization Zhang and Doll (2001). Customer uncertainty is defined as the lack of determining customer needs in regard to the product. Technology uncertainty is defined as uncertainties regarding manufacturing capability and design technology. Competitor uncertainty is defined as not understanding competitors' technology and product development. We measured front-end uncertainty according to seven items. As discussed earlier, in FFE performance certain aspects, such as scope and profit have yet to be fixed. Our primary concern in measuring this construct was to identify a scale that would enable the assessment of the efficiency and effectiveness of FFE performance according to the NPD performance's conceptualization (Chen et al., 2010; Verworn et al., 2008; Wagner, 2010). This study based on previous research. The front-end activities results would help further research results based on the perspective of 4 evaluation indexes: front end performance has a clear product development goal; the formation of product definition clear; the project team to reach a consensus on the New Product Development; the general development strategy of product development strategy and enterprise consistent. The variables for all variables are shown in Table 4.

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Table 4: Variables measurement

Variables	Measures item	References
Learning strategic	LS1:Guiding vision (security) for the exploration of potential applications	Kim & Wilemon, 2002a; Verworn, 2009; Zhang & Doll, 2001; Poskela and Martinsuo 2009; Stevens 2014
	LS2:Creating personal networks and using them in informal exchange of information	
	LS3:Organising convergence between client0s expectations and firms solutions	
	LS4:Seeking to be exposed to problems encountered by clients and divisions	
	LS4:Sourcing expert users of the category of products and associating them in formal or informal networks through common interests	
Stakeholders involvement	SI1: Customers participate in FFE before new product development and provide demand information	Choenherr and Wagner 2016; Menguc et al., 2014; Wangner 2012
	SI2: Suppliers to participate in the new product development cooperation before the design of new products	
	SI3: We understand the advantages and disadvantages of competitors before the new product development	
	SI4: We cooperate with R&D department before new product development	
Information collection	IC1: We set up a new information collection model for new product development	Hart 1999; Olausson and Berggren 2012; Calabrese 1999; Pentina and Strutton 2007
	IC2: We have established a working way of information exchange	
	IC3: We collect information about the market, customers and suppliers in the front-end stage	
	IC4: We collect information about technology, materials and so on	
Uncertainty	U1:We are uncertain of appropriate product characteristics	Verworn et al., 2009; Verworn, 2009;Poskela and Martinsuo 2009;Zhang and Doll ,2001
	U2:We are uncertain of the length of product life cycles	
	U3:We are uncertain of the amount of aggregate product demand	
	U4:We are uncertain of the process functions or input characteristics specification	
	U5:We are uncertain of the suppliers' design and manufacturing capability	
	U6:We are uncertain of competitors' product development	
	U7:We are uncertain of competitors' technology adoption	
Front-end Performance	FP1: We have a clear goal of product development	Chen et al., 2010; Verworn et al., 2008; Wagner, 2010
	FP2: We form a clear product definition	
	FP3: Our project team has reached a consensus on NPD	
	FP4: Our product development strategy is consistent with the overall development strategy of the enterprise	

c) Reliability and Validity test

First of all, we have reliability analysis for learning strategic, stakeholder's involvement, information collection, uncertainty and front-end performance by using the software of SPSS18.0, consistency coefficient (Cronbach α) representative sample reliability. If it is greater than 0.7 that means it carried higher reliability. The results are shown in table 4. Item-general correlation coefficient (CITC) were all greater than 0.35, the coefficients of variables are greater than 0.7, which shows good internal consistency between the measurement items and scale has high reliability. In addition, this study tests the validity of CFA measurement model by AMOS18.0. Standardized coefficient can be seen from table 4, the standardized coefficient is greater than 0.5($P < 0.001$), which shows that the questionnaire has reached the requirements of validity. Through the analysis of reliability and validity is concluded that the measurement index has a strong explanatory power to the corresponding variables, which indicates that the internal quality and construct validity of the better model.

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Table 5: Standardized coefficient of each item (N=196)

Variable name	Code	CITC	Delete the item α	Cronbach α	Standardized coefficient
Learning strategic	LS1	0.668	0.703	0.713	0.735
	LS2	0.702	0.713		0.718
	LS3	0.713	0.721		0.778
	LS4	0.732	0.715		0.786
	LS5	0.695	0.703		0.723
Stakeholders involvement	SI1	0.768	0.813	0.762	0.819
	SI2	0.757	0.762		0.784
	SI3	0.721	0.732		0.738
	SI4	0.686	0.738		0.745
Information collection	IC1	0.741	0.762	0.815	0.814
	IC2	0.712	0.745		0.827
	IC3	0.784	0.784		0.830
	IC4	0.720	0.713		0.789
Uncertainty	UN1	0.678	0.783	0.856	0.818
	UN2	0.735	0.803		0.814
	UN3	0.758	0.802		0.797
	UN4	0.731	0.746		0.752
	UN5	0.698	0.722		0.743
	UN6	0.783	0.788		0.794
	UN7	0.754	0.768		0.783
Front-end performance	FP1	0.731	0.773	0.805	0.801
	FP2	0.742	0.769		0.711
	FP3	0.721	0.782		0.813
	FP4	0.698	0.721		0.789

d) Model fitting and path analysis

As can be seen from table 5, the model has good reliability and validity and the structural equation model is established by AMOS18.0. The effective samples of this study reached 196 copies, under the sample capacity. Measured values of skewness and kurtosis are far lower than the critical standard at a reasonable range, the sample data of each item obey normal distribution, and it can be used for maximum likelihood parameter estimation method. The fitting index of the model, as shown in table 6, has reached the requirements of the Structural Equation Model.

Table 6: Results of model fitting (N=196)

	χ^2	χ^2/df	RMSEA	NFI	GFI	CFI
Result value	360.0	1.706	0.059	0.931	0.915	0.929
Reference range	>0	<3	<0.06	>0.9	>0.9	>0.9

We can see that the hypothesis of H1, H2 and H3 are established from the results of path analysis in table 5.

Table 7: Results of path analysis (N=196)

Path	Standardized path coefficients	Path coefficient	C. R.	Results
H1: Learning strategic→Front-end performance	0.294**	0.345	7.109	accept
H2: Stakeholders involvement→Front-end performance	0.420***	0.570	6.308	accept
H3: Information collection→Front-end performance	0.454**	0.510	4.274	accept

*Note: ** indicates that the path coefficient is significant at the P<0.01, * indicates that the path coefficient is significant at the P<0.05.*

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e) Hierarchical regression analysis

This study used hierarchical regression analysis to test the moderating effect of uncertainty. Due to this need of regulation effect, the hierarchical regression analysis is employed on the basis of relevant variables and the results are shown in table 8. First of all, the author examines the effect of control variables on performance and the model 1 only include the control variables such as firm size, firm age, industry and so on. As shown in model 1, the regression coefficient of firm age and industry is not significant. The effect of two control variables on the front-end performance of new product development is not significant. The regression coefficient of firm size is 0.117, significant at the level of $P<0.100$, indicating firm size has a positively relationship with the front-end performance, which shows that better enterprise front-end performance is the larger firm size. However, the Adjusted R2 of model 1 and F value is not significant indicating that the interpretation model 1 is very weak. Therefore, effect of control variables on the front-end effect is not obvious. Secondly, the author add independent variables on the basis of model 1 to test independent variables on the dependent variable in model 2-3, and add variable (uncertainty) in model 3 on the basis of model 2. As shown in model 2 and 3, the regression coefficient of learning strategic, stakeholders involvement, information collection and uncertainty at least level of $P<0.050$ significantly and the Adjusted R2 of model 2 and model 3 reached 0.347 and 0.398 respectively, F-test was on the $P<0.001$, the independent variable cab strong explanatory front end performance. Adjusted R2 in model 3 is larger than in model 2, which shows that model 3 can better explain the front end performance and also shows that uncertainty plays an important role in explaining the front end performance. Finally, the author examines the moderating effect of uncertainty on the relationship between independent variables and the front-end performance. Learning strategic, stakeholder's involvement, information collection and the interaction of uncertainty are added to the model 4-6 in turn. As shown in model 4-6 the interaction coefficient is significantly negative. The uncertainty has a negative moderating effect on the relationship between the front-end activities and the front-end performance.

Table 8: Sample hierarchical regression analysis results (N=196)

	Model	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Firm size	0.117*	0.072	0.062	0.056	0.061	0.047	0.049
Firm age	0.008	0.028	0.017	0.013*	0.032	0.021	0.023
industry	0.011	0.020	0.015	0.013	0.007	0.011	0.012
LS		0.221**	0.219**	0.312***			0.218**
SI		0.432***	0.398**		0.412**		0.382**
IC		0.312***	0.289***			0.299**	0.289**
UN			0.387**	0.341**	0.304***	0.334***	0.293***
LS×UN				-0.287**			0.198**
SI×UN					-0.102**		0.107**
IC×UN						-0.148***	0.112**
R^2	0.023	0.356	0.472	0.378	0.344	0.296	0.228
Adjusted R^2	0.009	0.347	0.398	0.341	0.101	0.269	0.415
F-value	2.011	28.342**	30.231***	27.961***	27.232**	26.881**	22.341***

IV. Conclusion and Discussion

This study confirmed the learning strategic effects, stakeholder's involvement, and information collection on the front-end performance, particularly concerning manufacturing industries. Due to its complexity, in the early stage of product development an organization can quickly develop team vision and shared purpose. Also can define clear, realistic project targets and lead the project team in the right direction, to enhance the front-end performance.

a) Research conclusions

First, learning strategic has a positive impact on front-end performance. Enterprises build organizational learning system through the establishment of a detailed learning strategy to learning methods are scientific, learning objectives with strategic and forward-looking. Learning strategy provides a clear strategic direction for the new products development so that the front-end activities are more targeted.

Second, Stakeholders involvement has a positive impact on front-end performance. This shows that the front-end activities through different

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mechanisms to promote the front-end performance. Internal staff take contribute in the front-end activities as soon as possible to share their information and knowledge as well as integrated into the front-end project planning book. The enterprise can strengthen the trust between customers to enhance customer dependence through the relationship between investments and improve the enthusiasm of customers involved in the front-end activities. Realizing customer knowledge sharing customer demand will be unified into the NPD initial project planning. The possibility of new product development is greatly improved. Suppliers involved in the front-end process and interaction with manufacturing enterprises that not only can realize the sharing of resources and knowledge. At the same time, supplier can provide a large number of possible market information in interaction process and ideas evoked for product innovation and promote enterprises to progress the front end performance.

Third, Information collection has a positive influence on front-end performance. The more market information collected by R&D personnel in the front-end stage that stronger the pertinence of the customer's needs. Effective technical information can predict technical difficulties that may exist in later stage and reduce the risk of subsequent research and development.

Fourth, the front-end uncertainty has moderating impact relationship between learning strategic and FFE performance, as well as between learning strategic and FFE performance. Particularly regard in to technology uncertainty and competitor uncertainty. Customer uncertainty of front-end has moderating impact learning strategic to FFE performance.

Fifth, the uncertainty has a negative moderating effect on relationship between Stakeholders involvement and front-end performance. This shows that the front-end uncertainty is comparatively high although the suppliers, consumers, competitors and intermediaries involves in the front stage. But it is limited in depth and width without covering all aspects of information. When the front-end uncertainty is low, suppliers, consumers, competitors and R&D team internal communicate to produce more creative for forming project planning, which can be developed to provide more effective creative. Sixth, the uncertainty has a negative moderating effect on the relationship between information collection and front-end performance. When the uncertainty is relatively high, research team needs to collect more information thereby increasing the difficulty of information collection and reducing the role of information collection. While front-end uncertainty is relatively low and the research team to grasp the information sufficient to accurately grasp the market demand to meet the technical needs of new product development. New Product Development project will also reduce the difficulty.

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