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A Model of Direct and Indirect Effects of Fuzzy-Front-End on New Product Development

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Abstract. At early stages of new product development, the effort to optimize is low and effects on the whole innovation process are high. Therefore, a deeper understanding of Fuzzy Front End and its success can help firms to be more successful in developing new products. We presented and tested a conceptual model of relationships among key variable sre lated to the Fuzzy Front End,execution phase of new product development projects and success of these project sat this study. Necessary information has been gathered from 28oil and gas companies in south of Iran. For the most part of study,received information support assumed relationship and claimed importance of Fuzzy Front End was confirmed. The results show importance of all sections involvement in new product development process to better communication and project success are achieved. This process can bespread by the initial planning for any new product development projects. The positive effect so freducing the technical and market un certainty during the Fuzzy Front End phase were discovered that it was measured by the deviation of the specifications and quality of communication. The Results of study indicate signifi can trole of reduction of technical uncertainty in efficiency of new product development projects and the importance of

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early planning to develop a mutual under standing and improve communication in the final stages of new product development process, the support.

Keywords: Fuzzy front end, Success of new product development, degree of newness

1. Introduction

Managing new product development (npd) process need to apply new management approaches. Most companies know that new product development delays can be influential on their interests. If we consider this effect as "delay costs", we can earn more profit by buying at lower cost (Reinertsen, 1994). Fuzzy front end (FFE) is one of the approaches that it can help to companies in this way.

FFE is a term that it refers to the first stage of new product development process and it is a period between generation an idea and approval for development. More opportunities for improving the innovation process are based on the early stages of npd (Smith and Reinertsen, 1991).

The Fuzzy Front End has attracted a lot of records. There are two viewpoints about fuzziness. the first phase is related to uncertainty and the second stage is about defects in the structure of product development process. However, the recent steps are vital to product development and 80 of production costs are spent in this process. This leads to spend more cost and time significantly (Kim and Wilemon, 2002).

The primary objective of this paper is to examine how a successful new product development. In order to be successful means a project be efficient enough. Overall, this article seeks to impact of the fuzzy front end on the success of new product development projects.

Above introduction cause to gain insight into the FFE, so a conceptual model has proposed at this paper and the model will be tested with structural equation modeling. After that, a brief Literature will be presented in the second part of the research and hypothesis with used conceptual model will be described in next part. Then more details about the used tools are presented. The fourth section contains data analysis and five section expressed Research results and findings related

to the structural model.
Then experimental results are discussed in section 6 and we provide a summary of key and managerial findings. Finally, this article will discuss about limitation and a direction for future research.

2. Literature

Documentations show that the smallest improvements in new product development process in an organization can have significant results. The idea selection and concept development stages of a new product development process come as the FFE, because it generally requires structured decision-making and accurate processes. Developing idea include to translate a raw idea to a strong concept that it is available by definition of its used technologies, identifying the interests of expected customers and evaluating market opportunities.(Montoya-Weiss & O'Driscoll , 2000).
Zhang and Doll (2002) offered a conceptual model as the Fuzzy Front End and success of new products development. This model is based on the uncertainty theory and it shows that FFE creates a vision of new product project team. FFE is defined in terms of environmental uncertainty at this model. This study describes a program of company's overall product development that it can help the project team in the face of FFE.
In recent decades, the number of documents about FFE has increased and more Details about it have obtained. Langerak and hultink (2004) tested their proposed model with structural equation models in Netherlands. They examined structural relationship between market orientation, proficiency in pre-development activities, new product performance and organizational performance. They focused on market-oriented firms and found partial support for the importance of market orientation and proficiency in pre-development activities.
Verworn (2008) tested of 497 new product development projects in Japanese manufacturing companies. Results showed that an initial technical and market reduction as well as initial planning prior to development have positive impacts on new product development project success. Af-

ter that Verworn (2009) investigated impact FFE on the success of new product development by a structural equation model and he tested his model in companies German measurement and control technique firms. The results of research show that degree of newness has been effective on the reduction of technical uncertainty, the deviation of the specification and efficiency.

3. The Research Hypotheses

The starting point for research was a robust analysis of the records and it was followed by the conceptual model. Framework of this research will be affected by three approaches:

1- Contingency approach
2- approach of processing information
3- behavioral approach

The contingency approach developed within organization theory (Lawrence and Lorsch, 1986) and the theory assumes that different approaches are required to deal with different situations and conditions. Several researchers have proposed Contingency approach for new product development (Khurana and Rosenthal, 1998). Depending on contextual factors such as the degree of newness of a new product to a firm, different management approaches take on different levels of significance (verworn, 2009).

In this research, we are faced with four variables: success, execution, FFE and contextual factors. Important factors associated with each variable were identified by reviewing documents, and relationships between these factors and items for assessing them successfully were discovered. There are very few studies concerning the front end activities. Based on this studies and exploratory interviews, a conceptual model was presented that it shows in Figure 1.

i. The success of new product development project

First, three success criteria were considered. Most observed projects have been very effective. But impact of FFE on the effectiveness of the NPD project could not be found. So this impact was ignored. Two

remaining criteria were efficiency and overall satisfaction of R & D manager with the new product development process and its results.

ii. Execution Phase of new product development project Two factors were selected to describe the execution stage of product development. They are Deviation from the specifications that we defined during the FFE and communication within FFE work group. Deviations of the specifications consist of these factors: changes in the target market, technical concepts, Project objective, Project responsibilities, deviations from planned procedures.

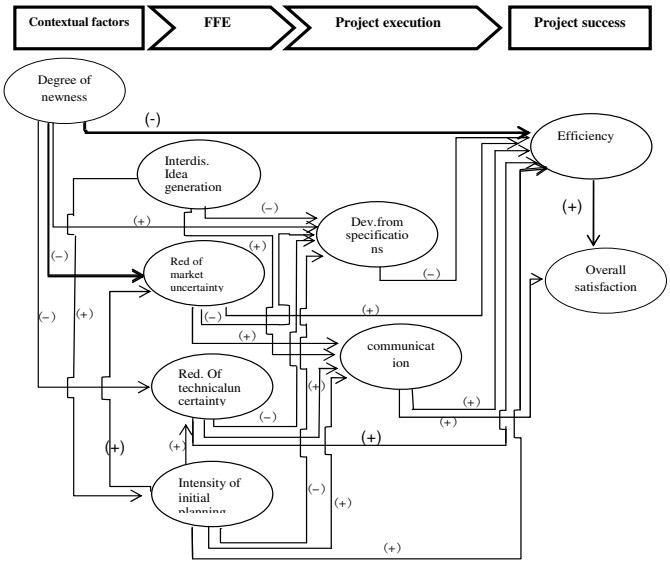

Figure 1: conceptual (structural) model (Verworn, 2009)

Hypothesis (1): Deviations of the specifications during the project execution phase negatively affect the efficiency of new product development projects.

Hypothesis (2): Good communication during the project execution phase positively affects the efficiency of new product development projects.

Hypothesis (3): Good communication during the project execution phase positively affects overall satisfaction with new product development projects.

Hypothesis (4): efficiency of new product development projects posi-

tively affects the overall satisfaction with these projects.

iii. Front end phase Four main factors are suggested in Conceptual model that these improve communication and reduce deviations in the npd project. These factors determine efficiency and overall satisfaction of R & D managers with regards to the project. Four factors related to these variables are: interdisciplinary ideas generation and selected, market uncertainty, reduction of technical uncertainty and intensity of initial planning prior to development. A viewpoint of developed team, sharing goals and planning cause to tasks are defined clearly and project goals are identified. If we combine all tasks in the start of process for example during generation an idea and assessing it, a shared vision and common purpose can be developed, communication can be improved and this combination leads to less involvement during the project execution phase (verworn, 2009). Factor of interdisciplinary idea generation and selection is process of involving the various tasks in generating and selecting new product ideas. The idea generation is combination of an organizational need, problem or opportunity along with the aim of satisfying this need and solving a problem or capitalizing on an opportunity (Verworn, 2009). The idea assessment phase is critical in regards to deciding which ideas are put forward for development. Given that decisions must frequently be made without having all relevant information at hand, idea assessment is a necessary step in the innovation process; however, it is accompanied by a high degree of uncertainty. Therefore, most researchers use an interdisciplinary group for idea generation and selection.

Hypothesis (5): Initial planning prior to development is positively affected by the participation of different functions during the idea generation and selection phase.

Hypothesis (6): The participation of different functions during the idea generation and selection phase reduces deviations from specifications during the project execution phase.

Hypothesis (7): communication during the project execution phase is positively affected by the participation of different functions during the idea generation and selection phase.

Hypothesis (8): reducing market uncertainty during the fuzzy front end decreases deviations from the specifications during the project execution phase.

Hypothesis (9): reducing market uncertainty during the fuzzy front end positively impacts on the communications during the project execution phase.

Hypothesis (10): reducing market uncertainty during the fuzzy front end positively impacts on the efficiency of new product development projects.

Hypothesis (11): The reduction of technical uncertainty during the fuzzy front end decreases deviations from specifications during the project execution phase.

Hypothesis (12): reduction of technical uncertainty in the fuzzy front end positively impacts on communication during the project execution phase.

Hypothesis (13): the degree of reduction of technical uncertainty during the fuzzy front end positively impacts on the efficiency of new product development projects.

Hypothesis (14): Intensity of planning prior to the start of development positively impacts on the degree of reduction of market uncertainty during the fuzzy front end.

Hypothesis (15): Intensity of planning prior to the start of development positively impacts on the degree of technical uncertainty during the fuzzy front end.

Hypothesis (16): Intensity of planning prior to the start of development decreases deviations from specifications during the project execution phase.

Hypothesis (17): planning intensity prior to the start of development positively impacts on communication during the project execution phase.

Hypothesis (18): planning intensity prior to the start of development positively impacts on the efficiency of new product development projects.

Iv. Contextual factors With regard to our model, we focused on contextual factors at this sector. Works in the Literature have found the

degree of newness of a new product development project for a company as a key contextual factor (Griffin, 1997). As we were taking an information-processing view on new product development, the degree of newness determines how much information must be gathered by a firm to develop a new product. A high degree of newness makes it more difficult to reduce market and technological uncertainty, hampering project efficiency (Moenaert et al., 1995).

Hypothesis (19): Less reduction in market uncertainty during the fuzzy front end is resulted by a higher degree of newness of the initial product concept.

Hypothesis (20): Less reduction in technical uncertainty during the fuzzy front end is resulted by a higher degree of newness of the initial product concept.

Hypothesis (21): More deviation from specifications during the project execution phase is resulted by a higher degree of newness of the initial product concept.

Hypothesis (22): Lower efficiency of the new product development process is resulted by a higher degree of newness of the initial product concept.

4. Research Method

In the present study, we extract a model that it is based on a theoretical framework and backgrounds. Then, based on correlation analysis, the relationships between the variables are measured and Competency of model is determined by the structural equation model.

In this research, the main variables are the success of new product development, execution of new product development projects, Fuzzy Front End (FFE) and a degree newness of a new product development project.our research Statistical Society is directors of research and development (R & D) of oil and gas companies in south of Iran.

Required information has been collected from 28 questionnaires that it is determined by experts. This questionnaire has been extracted from the background, and it is standard. Therefore it has required validity. Its reliability is set by Cronbach's alpha for the entire questionnaire and

for each factor related to each variable which it will show in Tables 1 and 2.

Table 1: calculation of Cronbach's alpha

Questionnaires question	Cronbach's alpha
24	0.824

Table 2: Cronbach's alpha related to each factors

factors	Number of indicator	Cronbach's alpha
Overall satisfaction	3	0.766
efficiency	3	0.749
deviations from specifications	3	0.858
communication	2	0.921
Interdisciplinary idea generation and selection.	3	0.731
Reduction of market uncertainty	2	0.701
Reduction of technical uncertainty	2	0.948
intensity of initial planning	4	0.745
Degree of newness	2	0.766

5. Findings

We have been used Correlation coefficient to consider the relationships between components of research Variables and to test the hypotheses.

Kendall tau method was used to calculate correlation coefficient that the general conclusion will show in Table 3.
After calculating the internal correlation between the factors, it is necessary to ensure the accuracy of the measurement model. Therefore, we used confirmatory path analysts and we gained the measurement model. This analysis has been done by structural equation modeling and AMOS software. The results of correlation table and measurement model shows in Figure 2. Of the 22 tested hypotheses, eight were rejected (see dotted lines in Fig. 2).
After the above process, we use goodness of fit index in AMOS software to determine the suitability of the measurement model. We use five indicators that they are RFI , NNFI , NFI , AGFI , and GFI . Optimizes of indicators and the results are summarized in Table 4. All indicators confirm the appropriate measurement model.

Table 3: correlation calculation

	Overall satisfaction	efficiency	deviations from specifications	communication	Interdisciplinary idea generation and selection.	Reduction of market uncertainty	Reduction of technical uncertainty	intensity of initial planning	Degree of newness
Overall satisfaction	1.000	.347*	.386*	.341*	.340*	-.010	.299	.273	-.131
efficiency	.347*	1.000	.511**	.370*	.431**	.237	.270	.262	-.169
deviations from specifications	.386*	.511**	1.000	.192	.260	-.003	.361*	.364*	-.056
communication	.341*	.370*	.192	1.000	.613**	.321	.474**	.171	-.104
Interdisciplinary idea generation and selection	.340*	.431**	.260	.613**	1.000	.299	.163	.312	-.313*
Reduction of market uncertainty	-.010	.237	-.003	.321	.299	1.000	.095	-.046	-.226
Reduction of technical uncertainty	.299	.270	.361*	.474**	.163	.095	1.000	.154	.239
intensity of initial planning	.273	.262	.364*	.171	.312	-.046	.154	1.000	.091
Degree of newness	-.131	-.169	-.056	-.104	-.313*	-.226	.239	.091	1.000

Table 4: indexes of goodness

	criterion	mount	limit
۱	GFI	۰/۹۲۵	Nearly one
۲	AGFI	۰ /۹۱۹	Nearly one
۳	NFI	۰ /۹۰۷	> ۰ /۹۰
۴	NNFI	۰ /۹۳۳	> ۰ /۹۰
۵	RFI	۰ /۹۰۱	> ۰ /۹۰

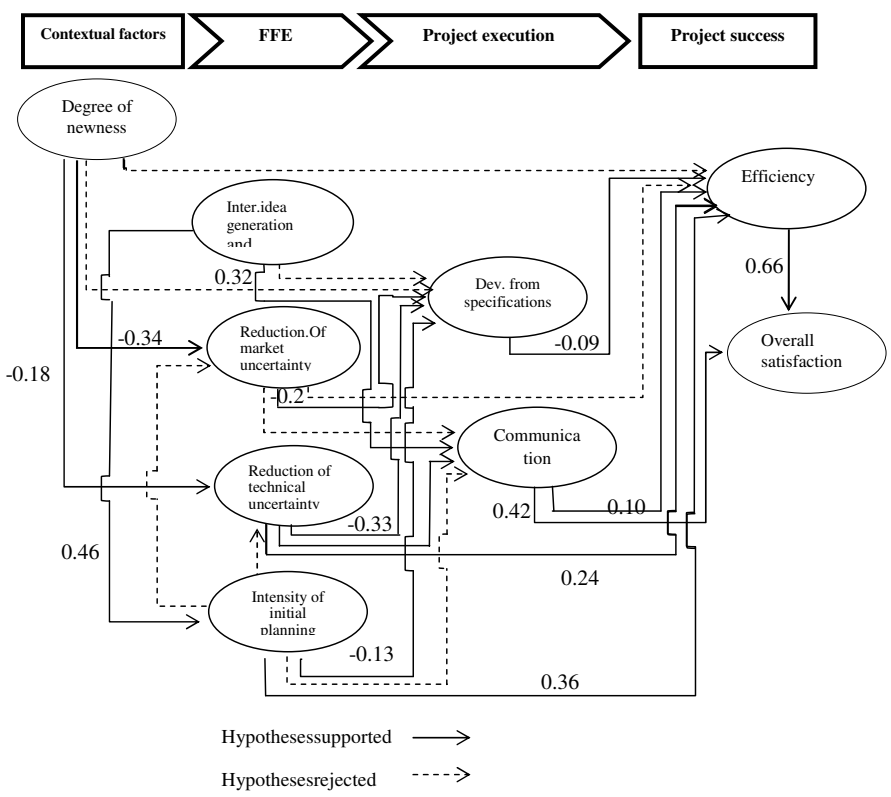

Figure 2: Results of the structural equation model

6. Conclusion

Of hypotheses 1 and 2, the deviations from specifications in the project negatively affect efficiency and communication affects efficiency positively. Quality of communication has an important role in satisfaction of R & D Employees (Hypothesis 3) that this quality was affected by efficiency. (Hypothesis4). The results widely support the "leverage effect" of FFE on new product development process. Leverage effect means effect of front end factors on execution phases and then effect of execution on success phases (front end factors? project execution? success).

Degree of people involvement of different tasks did not show an effect on the deviations from specifications during the project (hypothesis 6), But it effects on the reduction of market uncertainty (hypothesis 8) and reduction of technical uncertainty (hypothesis 11). The initial planning of new product development has an impact on the deviation from the specifications, so the hypothesis 16 was confirmed.

Of four front end factors, the interdisciplinary idea generation and selection and reduction of technical uncertainty effect on the quality of communication in the execution project phase (hypotheses 7 and 12), Two other factors, market uncertainty and the intensity of initial planning do not have impact on communication (Hypotheses 9 and 17). Gathering individuals from different parts whit different functions reduce conflicts in the final stages and improve project.

In this study, in addition to the leverage effect, two of the four front end factors have a direct impact on the project success. The findings show the reduction of technical uncertainty and the intensity of initial planning during the project has a positive impact on efficiency, as a result they have a positive role in the project success (Hypotheses 13 and 18). Focusing on assumptions did not find this effect about the market uncertainty (hypothesis 10) consequently, this hypothesis was not confirmed.

There is an interdisciplinary approach to the idea generation and selection in our research that it has strongest influence on improving communication within team during the development process. Also, when information is shared in the early stages, less deviation from the char-

acteristics occurs during the project.

At first, we assumed the reduction of market and technological uncertainty before the start of the cost intensive development phase directly cause to reduce deviations from targets specified during the fuzzy front end (hypotheses 8 and 11).after testing hypothesis, we concluded the reduction of market uncertainty do not have an impact on communication but the reduction of technical uncertainty improves communication within project team and between key function such as marketing and R & D.at present paper, the reduction of technical uncertainty is important than the reduction of market uncertainty that we can explain it by technical specifications of the projects analyzed.

In many new product development projects, when uncertainty is high during the fuzzy front end phase, we can obtain a draft of our plans at beginning and details are added during the project. The initial planning usually has less impact on efficiency directly. Intensive front end planning leads to enhance a common understanding of project functions and milestones. For this reason, adding initial planning phase improves communication within the project team. This study supports the contingency theory prediction. Except for Hypotheses 21 and 22, other hypothesized relationships for degree of newness were confirmed. Also, high degree of newness makes more difficult reduction of technical uncertainty (Hypothesis 20) and this was correct for reduction of market uncertainty too(Hypothesis 19).

Our result in current paper confirmed "leverage effect" that Wheelwright and Clark (1995) stated. They recommended shifting top management's attention from the prototype or launching phase to the fuzzy front end of innovation, as the managers of many companies focus on the phases with the least chance to influence results (verworn, 2009).of course, reward systems and promotion practices that consider only the sales results of new products are reason for this. "Leverage effect" of FFE suggests more investment in the early phases of innovation projects is more valuable.

R & D directors should emphasize on initial reduction of technical uncertainty, when there is a need to improve deviations, communication, efficiency, or R & D managers' overall satisfaction. reduction of technical uncertainty can be decreased by conducting feasibility studies and

setting up clear technical specifications.
The results show degrees of newness effect on efforts spend on technical uncertainty, deviations from specifications and efficiency. But results do not mean that firms only follow incremental innovations. However, when pursuing technological innovations, realistic goals and additional resources allocated to the fuzzy front end could help to minimize negative effects of high technological uncertainty (verworn, 2009).

601 Limitations
In this section, we discuss about limitation that there is in current paper. One of limitation is related to respondent. Some of them did not have information about new product development process and its method. Some factors was neglected that they have more effect on success of new product development. Finally, due to the focus on the gas and oil sector, most of the projects in this study were technology-driven.

602 Suggestions for future research
We applied this model in a specific industry, future research can be applied it in different industries. Also future research can find other factor for variable and explain model with more details.

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