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A Study on Effective Factors on New Product Development with an Emphasis on Fuzzy Hierarchical Analysis Approach

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Abstract. Nowadays the new product and its importance are considered as an essential strategy for staying in business. Though the hi-tech industry has focused on value innovation and improving the quality of the new product development (NPD) process to drive new product performance, new product success has not changed dramatically over the years. This study presents a novel approach based on structural equation modeling (SEM) and fuzzy analytical hierarchy process model (FAHP) to explore how value innovation and quality of new product process affect NPD performance.
The survey contained industrial companies which are located in Fars province. The sample contains 98 people who were selected by random cluster sampling. The research was done using descriptive and applied method. Totally, 16 indicators have been collected and were classified in 3 groups of value innovation, quality and NPD performance. Results demonstrate that value innovation directly affects NPD performance and the quality of NPD processes has a nonlinear effect on NPD performance.

Keywords: Value innovation; new product development; fuzzy analytical hierarchy process; Structural Equation Modeling.

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1. Introduction

Rapidly changing technologies, intense competition, and dynamic customer needs and wants are rendering existing products obsolete, resulting in shorter product life cycles. The dilemma faced by management in high technology firms is that while the need for successful NPD is stronger than ever, new products success has not changed dramatically over the years [12]. Nowadays organizations have found that mere relying and trusting on traditional competitive factors are not sufficient and some concepts like speed and flexibility in competition are important instead. Changes in the tendency towards providing new products and services to market are the reason of this attitude. On the other hand should have been an appropriate response to the changing competitive market. Therefore, the new products will increase the profits of the company. Studies have suggested a wide range of factors that drive new product performance [5]. Most managers will agree that value innovation enables continuous growth and profits, and plays a vital role in new product development (NPD) in hi-tech industry [7]. In recent decades, the technology management literature has emphasized the importance of value innovation in creating and sustaining competitive advantage and in rejuvenating the enterprise [1] [2] [6] [7]. Further, the quality of NPD processes is also a major factor in new product performance [4] [5].

Increasing speed of technology development, short life cycles and increasing competition and turbulent economic climate of the twenty-first century increase the importance of product development. The main source of success in achieving competitive for the company's in the future is the successful development of new products and continuous improvement. With the increasing in the variety of products and volume of orders the survival curves of the products will be decreased. For example, a group of products in 1920s have a mean time to mass production about 28 years old and this period has decreased to 10 years in 1960. Estimates show that the number of new products that will be released in the next 5 years, will be twice as the products which have been supplied in last 5 years. This growth led to a 40 percent will lead to increase in sales and a 30 percent increase in corporate profits. So, changing rules

of competition in the business have increased the importance of delivering new products to market [3]. According to the study which was conducted in 1981, about 700 American companies, the results showed that about a third of the profits of these organizations are due to their new products while the profits of1970was a third. Due to these factors, new product development management process also requires the use of new approaches to management [17].

One of the critics to the development of new products is the complexity and uncertainty of the process of the development of new products. Many researches in this area studies have been considered different aspects of product value innovation but this knowledge has not been used in the real-world. Due to the importance of NPD process, this research will try to study the introduction of new product development and analyze value innovation and quality of NPD process to define their effect on the NPD performance.

2. Literature Revien

Development of a new product is a process within that the new product or service is launched to the market and consists of two parallel paths. The first way involves innovative ideas, product design and product engineering, and the second way involves research and market analysis. The success of this process can be measured through the determination of the indexes which reflects the degree of success or failure of these indexes. Some of the most important indicators that can help to the formulation of statements include value innovation, quality of NPD process, sales, and volume of customers, annual revenue growth and growing of the products portfolio. This term NPD is applied about the new products in the world and also about the application of the minimal change and improvement in existing product [3].

Lifetime of the products in the market is declining and the rate of product development is expected to double every five years. As a result, new products that meet customers' needs and desires is a key factor in maintaining and improving competitive advantage. Global economy with market segmentation has significant impact on the development of

new products and mass production has less importance than the level of mass customization.

Every company given the circumstances of its internal and external environment should perform a new plan for the development of new products. About the development of new products, there are two types of internal and external growth. The most important factors affecting domestic growth includes: value innovation in products, having focus on the labor market and using for skilled and qualified people in key posts. Key factors in the external growth includes having appropriate strategy staffing and financial control [18].

With considering above mentioned factors, the ability to the production and the development of products from external sources is acquired. One of the biggest influences on the approach of Western companies on the product development is derived from the developed concept by NASA in the 1960s which was considering to the management of complex large-scale defense projects. This approach consists of four consecutive phases: initial analysis (first phase), definition (Phase II), design (Phase III), Operations (Phase IV).

There are different studies based on the location and condition of the product unit in connection with an extensive study of the factors affecting the success of new product development. Market orientation and subsequent firm innovation are widely recognized to be essential for the survival and growth of organizations[1][2]. Value innovations require an organizational commitment to create a strong momentum for inside-in changes and advances in bringing inside-out value creating outcomes and attaining superior positions in the competition race [14]. Continuing success in delighting the customer, in turn, drives sustained increase in enterprise value. Aiman-Smith et al. (2005) defined value innovation as that innovation which occurs when organizational members are working on identifying better ways to serve their current customers, and on identifying new markets [1]. Dikmen et al. (2005) pointed out that value innovation is not a competition-based view of the firm, but instead is an endogenous growth theory and a resource-based view, where growth and innovation come from within the organization itself. Thus, innovations emerge from knowledge accumulated within the organization and

resource recombination chosen by the firm to produce a service/product [6].

Many organizations believing that technology innovation alone can create new wealth [7]. Irwin, Hoffman, and Lamont (1998) used a resource-based view to demonstrate the positive relationship between technological innovations and organizational performance [11]. Hurley and Hult (1998) showed that positive relationships between organizational innovations influenced the potential for good performance [10]. Aragn-Correa et al. (2007) showed the positive effect of firm innovation on performance [2]. In view of the positive relationships seen in previous research, we thus hypothesize:

Hypothesis 1. Higher value innovation will have a positive effect on NPD performance.

Cooper (1996) argued that a high quality new product process to guide product innovations from idea to launch is a critical success factor. New product processes have been found to fail for a number of reasons. First, inadequate up-front homework has been found to be a major cause of failure in product development [5]. Second, failure to define the product before development begins can cause both new product failure and serious delays in the development cycle. Third, many failed projects were moved too far into development without serious scrutiny. The lack of tough Go/Kill decision points meant too many product failures, resources wasted on the wrong projects, and a lack of focus. Fourth, an emphasis on quality-of-execution in many firms came about after internal studies revealed that too many projects suffered from weak, inconsistent work, with some of the most deficient areas being the market-related processes and routines at improving quality of execution of key tasks and activities throughout the process. Fifth, many companies discovered that not only was the quality of work unacceptable, but needed work such as market analysis, business assessment, and customer research, were simply not done or displayed hasty corner cutting. Finally, the new product process was inflexible or overly formalized, with stages and decision points that could be not skipped or combined, becoming a straightjacket for the [5].

Cooper and Kleinschmidt (2007) demonstrated that the strongest driver of profitability is the existence of a high-quality and rigorous new product process that emphasizes up-front homework, tough Go/Kill decision points, sharp early product definition, and flexibility. By contrast, merely having a formal new product process has no impact at all on performance. Cooper (1996) demonstrated that a high quality new product process had the strongest impact on new product performance. Hence, since high quality new product processes appear to yield positive NPD performance, we construct the following hypothesis:

Hypothesis 2. A high quality of NPD process will have a positive impact on NPD performance.

3. Conceptual Model of Research

After analyzing value innovation and the quality of NPD process, model in figure 1 chased as a conceptual model and the base of this research. In this model we will reviewed the hypotheses, considering three main variables of value innovation, quality of NPD process and NPD performance. The research hypotheses explore how value innovation and quality of new product process affect NPD performance. To measure value innovation 9 indicators including: Customer orientation, Agile decision-making, Business intelligence, Open communication, Empowerment, Business planning, Organization learning Meaningful work, Risk-taking culture. Quality of NPD is measured by four indicators: Solid up-front homework, Sharp, early product definition, Quality of execution throughout, A flexible process. And for NPD performance variable there are three indicators including Customer performance, Technology performance, and Market performance.

4. Research Methodology

Since the purpose of this study is the analysis of the effects of "value innovation" and "product quality" on new product performance this research is applicable and descriptive. This study consists of all indus-

trial firms in Fars province and the sample contains 98 people based on random choice method. The questionnaire consists 52 questions which consider and analyze the Likert scale which contains five choices from strongly agrees to strongly disagree and analyze the variables. The results of the analysis reliability of the questionnaire

Shows that the Cronbach's alpha coefficient was calculated for value innovation variable was (32 questions) 842%, for the quality of the product development process (16 questions) was 820%, and for new product development (6 questions) was 695.

According to the fact that the reliability of coefficients is more than 70%, it can be conclude that the questionnaire has appropriate reliability. Also, to assess the validity of the questionnaire, the study of literature and opinions of faculty members, consultants and industry experts were conducted. Mean test used to analyze the variables. For analyzing the effects of the variables the structural equation model and specially path analysis technique using Liserel software was used and hierarchical analysis used for criteria ranking.

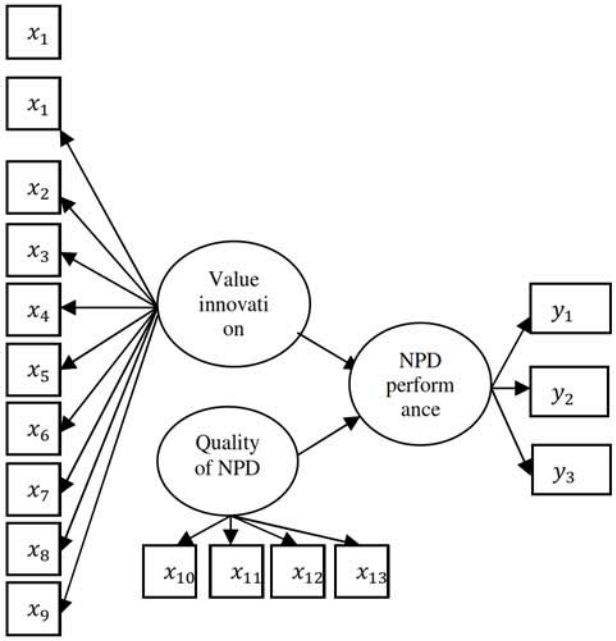

Figure 1: conceptual model research

5. Findings

Structural Equation Modeling is a comprehensive statistical approach to testing hypotheses about the relationships between observed and hidden variables and sometimes called causal model [9][13].

A complete structural equation model in the graph represents a combination of Path analysis and Confirmatory factor analysis. SEM models have a measurement model and a structural model. In the measurement model, each latent construct is modeled as a common factor underlying the associated measures. The structural model includes the relationships among the latent constructs. In essence, SEM assumes that the causal relationships are linear [9]. Results of confirmatory factor analysis for variables is obtained by the lisrel software. The output of the software in standard estimation is given below in figure 3.

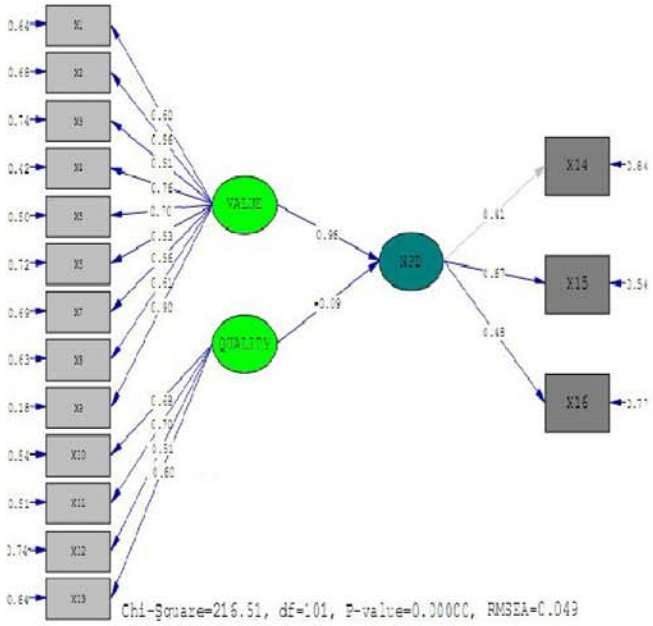

Figure2: Structural model in standard estimation

These outputs are also used to test the hypotheses. According to figure 3, the effect of value innovation on product development performance is 0.96 and the amount of significant is 3.59. And the effect of

the quality of NPD process on new product development performance is -0.09 and its significance is 0.62.

The results of the confirmation or rejection of the hypothesis can be seen in table (3).

Table1: Confirm or deny hypothesis

Confirm or deny	Significance	Effect	hypothesis
Confirm	3.59	0.96	Value innovation on NPD performance
Deny	0.62	-0.09	Quality of NPD process on NPD performance

Also different indexes have been used to analyze fitness of the model, Goodness and badness indicators.

Goodness indicators of models are: goodness-of-fit index (GFI), adjusted goodness-of-fit index(AGFI), incremental fit index (IFI), normed fit index (NFI), the more their value, they are better. A suggestion for such measures is 0.9.

Also indicators for the badness of the model are x 2/df and root mean square error of approximation (RMSEA), and the lower their value, the better their fitness. The limit $x2$/df is 3 and the limit of the number RMSEA is 0.8.

The results of the fitness of model can be seen in table (4), as a whole, these tests provide strong evidence of the discriminant and convergent validity of our measures.

Table2: Fitness of model

Indicator	value
X^2/df	2.143
RMSEA	0.049
GFI	0.97
AGFI	0.93
NFI	0.92
CFI	1.00
IFI	1.01

In order to determine the best indicators among two effective variables value innovation and quality of NPD process, Fuzzy analytical hierarchy process is used. After establishing duad matrices, weight vectors should be determined using this method. In summary, the results of calculation of and their rates are presented as follows.

Table 3: Duad comparison matrices quality of NPD process

	solid up-front homework	sharp & early product definition	quality of execution throughout	flexible process
solid up-front homework	1	0.75	0.208	0.375
sharp & early product definition	1.5	1	0.208	0.375
quality of execution throughout	5	5	1	1.5
flexible process	3	3	0.75	1
	10.5	9.75	2.166	3.25

Table 4: weight vectors Of quality of NPD process

	solid up-front homework	sharp & early product definition	quality of execution throughout	flexible process
solid up-front homework	0.095238095	0.076923077	0.096029548	0.115384615
sharp & early product definition	0.142857143	0.102564103	0.096029548	0.115384615
quality of execution throughout	0.476190476	0.512820513	0.461680517	0.461538462
flexible process	0.285714286	0.307692308	0.346260388	0.307692308

Table 5: Duad comparison matrices of value innovation

Total	Risk-taking culture	Meaningful work	Organization	Business planning	Empowerment	Open communic	Business intelligenc	Agile decision-	Meaningful work	
5.333	0.75	0.75	0.208	0.375	0.75	0.375	0.375	0.75	1	Meaningful work
6.083	0.75	0.75	0.375	0.208	0.375	0.375	0.75	1	1.5	Agile decision-making
11.125	0.75	1.5	1.5	0.75	0.375	0.75	1	1.5	3	Business intelligence
16.75	1.5	3	1.5	0.75	1.5	1	1.5	3	3	Open communication
14.125	0.75	0.375	3	0.75	1	0.75	3	3	1.5	Empowerment
16.5	1.5	0.75	0.75	1	1.5	1.5	1.5	5	3	Business planning
13.875	0.75	0.75	1	1.5	0.375	0.75	0.75	3	5	Organization learning
12.125	1.5	1	1	1.5	3	0.375	0.75	1.5	1.5	Meaningful work
10.75	1	0.75	1.5	0.75	1.5	0.75	1.5	1.5	1.5	Risk-taking culture

Table 6: weight vectors of value innovation

Risk-taking culture	Meaningful work	Organization learning	Business planning	Empowerment	Open communication	Business intelligence	agile decision-making	meaningful work	
0.0141	0.0141	0.0391	0.0704	0.141	0.0704	0.0704	0.141	0.188	Meaningful work
0.124	0.124	0.0617	0.0342	0.0617	0.0617	0.124	0.165	0.247	Agile decision-making
0.068	0.135	0.135	0.067	0.034	0.068	0.089	0.135	0.270	Business intelligence
0.089	0.180	0.089	0.044	0.089	0.059	0.896	0.180	0.180	Open communication
0.054	0.027	0.214	0.054	0.071	0.053	0.312	0.213	0.107	Empowerment
0.091	0.047	0.067	0.092	0.092	0.092	0.092	0.304	0.182	Business planning
0.055	0.055	0.073	0.109	0.028	0.055	0.055	0.217	0.361	Organization learning
0.125	0.083	0.083	0.124	0.248	0.031	0.062	0.124	0.124	Meaningful work
0.094	0.069	0.140	0.070		0.069	0.140	0.140	0.140	Risk-taking culture

Based on Conceptual model of the research, research hypotheses were proposed in two hypotheses.

First hypothesis-higher value innovation will have a positive effect on NPD performance.

Second hypothesis-The high quality of NPD process will have a positive impact on NPD performance. Structural equation modeling was used to test the hypotheses.

Results related to the first hypothesis: This hypothesis is confirmed, means that the value innovation has a positive effect on new product development performance.

These results are consistent with findings from previous researches. People like Aiman-Smith in 2005, Cooper & Kleinschmidt in 2007, Dillon in 2005, Hurley & Hult in 1998, Varela & Benito in 2005 reached to a similar conclusion about the effect of value innovation on product development[1][5][7][10][19]. Value innovation is the main force driving factor in competition and the economic success [15].

Results related to the second hypothesis: this hypothesis is not accepted. Fig.2 shows that there was no statistically significant relationship between quality of NPD process and improvement in NPD performance. A clue may lie in the research of other scholars [16]. Over the past two decades, some of the senior managers used stage-gate process to control the new product development process in their organization. Widespread use of the stage-gate can be a violation of the second assumption. While, Cooper in 1996 proved the high quality of the new product development process has impact on its performance.

The index is calculated based on the final weights and suing those indexes can be classified. The tables (7) and (8) represent the best indicators of process quality, and value innovation.

Table 7: Final weights of value innovation variable

Customer orientation	0.08260339
Agile decision-making	0.074288077
Business intelligence	0.042892118
Open communication	0.025678216
Empowerment	0.041485248
Business planning	0.029091727
Organization learning	0.040367929
Meaningful work	0.039410682
Risk-taking culture	0.038468328

Table 8: Final weights of quality of NPD processes variable

Solid up-front homework	0.056
Sharp & early product definition	0.0668
Quality of execution throughout	0.280
Flexible process	0.182

As is shown in table 7, customer orientation is the variable that has most significant impact in value innovation variables. And about the quality variable, Quality of execution throughout has the highest weight. Accordingly, the company can focus on more effective measures to take the more successful process of developing a new product.

6. Conclusion

According to the results of the first hypothesis, value innovation has a positive impact on new product development performance and hence it is recommended for managers to look for opportunities for value innovation in the organization. Some of the opportunities for value innovation are as follows:

• Considering the complementary products and services, identification of products and services that may be used, along with your product.

• Considering alternative products: alternative products and services have different functions and forms but has the same destination. The space between alternative industries provides valuable opportunities for value innovation.

• Focus on non-customers: Instead of focusing on customers, they should focus on non-customers. And instead of focusing on customer's differences, they should focus on must have a strong common points which are valuable for buyer. This focus allows companies to reach borders

beyond the current demand and to attract mass new customers who did not exist before.

According to the results of fuzzy hierarchical analysis, customer orientation is the variable that has most significant impact in value innovation variables, Therefore it is recommended to organizations to focus on develop NPD based on customer knowledge management framework, the customer's knowledge should be elicited and converted to a pattern of consumer's need towards the products attributes. And about the quality variable, Quality of execution throughout has the highest weight so recommended to organizations, investment in quality control segment.

7. Suggestions for Furder Research

According to the results, researches can be done in this regard:
1. Other factors affect new product development performance.
2. Predicting the performance of new product development using structural equation modeling.
3. Predicting value innovation performance with neural networks and their comparison.
4. There should be a framework for measuring value innovation in firm.
5. Provide indicators to measure value innovation activities.

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