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Full Length Research Paper

Developing a model for evaluating and prioritizing of new product development strategies under fuzzy environment

Ali Badizadeh[1]* and Sohrab Khanmohammadi[2]

[1]Department of Industrial Management, Faculty of Management and Economics, Science and Research Branch, Islamic Azad University, Tehran, Islamic Republic of Iran.
[2]Control Engineering Department, Faculty of Electrical and Computer Engineering, University of Tabriz, Tabriz, Iran.

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In the varying and uncertain environmental desires of customers, companies can not produce their current products forever. They apply different strategies to keep themselves competitive and effective in this altering environment. In this regard one of the key strategies is development of new products. New product development is one of the risky activities and is vital for survival and success of organizations. This paper introduces a model for evaluating and prioritizing new products development strategies. First, effective criteria and alternatives are identified. Then, the fuzzy multi criteria decision making method is applied to weight different measures and alternatives. In this paper, different new methods are introduced for calculation of fuzzy utilities and weights of criteria and prioritizing alternatives. For validation of the proposed model, it is applied for evaluation and prioritizing development strategies of new products in an automobile parts manufacturer. Compared to hierarchical process, the results of the proposed model were different. Also, identification and classification of effective factors for success of a new product development strategy is application of the proposed model.

Key words: New product development, strategy, multi criteria decision making, fuzzy logic.

INTRODUCTION

In the past, uncertain changing environment that customers, technology, needs of employees, financial and monetary system, and so on are changing in an ongoing manner, companies cannot trust in manufacturing their current products. As customers always demand more advanced products, they should also apply strategies to handle these customers' needs. The main strategies are: 1) developing new products, 2) adjustment of the present products to match new requirements and needs of customers. The two mentioned strategies are chosen to help the company gain more profit. New product development (NPD) is one of the important strategies for a company to survive in the competitive market. However, there are many obstacles in applying this strategy, and they include:

1) Drop in creativity in producing a new product
2) Increase in competitions in the global level
3) Increase in market segmentation and clustering
4) Increase in requirements imposed by governments

These mentioned obstacles may make applying the new product development strategy more costly, different, and risky. Each company introduces new products by applying the following strategies:

i. Firms' ownership
ii. Purchasing the license of products
iii. Design and development of new products
iv. Adjustment of current products
v. Supplying current products with new brands

*Corresponding author. E-mail: ali.badizadeh@yahoo.com. Tel: +98 21 44111394. Fax: +98 21 44538631.

Product innovation and the trend toward globalization are two important dimensions driving businesses today, and a firm's global NPD strategy is a primary determinant of performance (De Brentani et al., 2010). Many studies have been done on the concept of product development and innovation and much of what has been written tends to discuss this concept as a veritable tool for improving the life cycle of a product without substantial relation to market share enhancement (Iwu, 2010). Generally, increase in market share can affect on product development and innovation. Development of new products is one of the most risky activities for companies because of various uncertainties involved in the process. To tackle these uncertainties, evaluation and prioritizing of the new product development strategies play important roles. Uncertainties present in the process are either internal organizational or external environmental and contextual factors. Environmental factors are market (including customers, competitors, suppliers, and government) and technology. On the other hand, internal factors include marketing, engineering, and commercial processes. Therefore, managers of a company should consider all these uncertainties, quantify and model them, and finally, evaluate and select the best strategy for developing new products. In this paper, effective factors in evaluation and prediction new product development strategies are identified. Then, by the use of fuzzy logic (Zadeh, 1965) and group decision making, a new model is put forward for assessment and determining the priority of new products development strategies. This paper presents a comprehensive list of required criteria in prioritizing new product development strategies. Also, this paper presents a suitable and structured methodology for the evaluation of NPD strategies.

LITERATURE REVIEW

In order to keep pace with varying and risky market environment, companies are applying different strategies. New product development is a key strategy for profitability of companies. One important step in this strategy is decision making on selecting the best alternative for developing new products. Numerous researches have been performed regarding different methods of evaluation and selection of NPD strategy.

Bstieler and Gross (2003) considered the influence of uncertainties in effective environmental factors influencing the outcome of the NPD process. They consider two main environmental factors: market and technology. They conclude that uncertainties in market and technology may lead to instability in the new product development projects. Ozer (2005) studied the important factors which influence decision making in the process of new product evaluation. In this research, new product development is mentioned as a critical activity for companies to survive. Ozer (2005) stressed that companies may make two mistakes in decision making process on evaluation of new product development ideas: 1) companies may want to implement an idea of developing a potentially unsuccessful product; 2) companies may not want to develop a potentially successful new product. In this research, an efficient algorithm for assessment of a new product is proposed. The proposed algorithm includes the identification of effective factors in decision making of new product evaluation, determining the influence of each factor in evaluation, and finally presenting guidelines for decrease in negative effects of factors in the decision making. Frambach et al. (2003) have taken into account how relative insistence of business strategies influences new product and innovation development. They also considered the probabilistic role of market orientation and as a consequence, they opened the black box of relations between strategy and new product development activities. Lu and Yang (2004) showed that the involvement of marketing and research and development (R and D) leads to improvement in new product development activities in order to satisfy customer demands. They also indicate that environmental uncertainties, affect organizational structure and performance. The authors mentioned technological revolutions and disruption, and rate of change in technology as a number of technological uncertainty sources. Petrick and Echols (2004) presented that companies usually decide on new product development based on pressures, abilities, and investment return rate of each new product. The authors suggest that companies should notice the technological changes that are used in the development of new products. The main objective of the study is to limit investment in technologies that become obsolete very soon. Gehin et al. (2008) combined ideas of NPD with principles from concurrent engineering to develop design aids which permits designers to compare their products to Remanufacturable Product Profiles.

Lynn et al. (1999) studied the key factors required for success of a new product development project. They list 10 factors, including; 1) structure of new product development, 2) careful and clear supervision on new product development project team, 3) development and producing a product in a creative time, 4) analysis of product after manufacturing, 5) team- work skills, 6) good market understanding and prediction, 7) management team and its support, 8) use of experience gained from previous projects, 9) reliable project team, 10) experienced team. Kuen et al. (2009) investigate the critical factors that influence a successful project among manufacturing companies in Penang, Malaysia. They demonstrated empirically that project personnel competency and project mission are critical factors influencing the micro project success and as for macro project success, top management support and project mission are two main critical factors.

Ebrahim et al. (2010) studied critical factors for new product developments in SMEs virtual team. Lee et al.

(2011) examined the key success factors of new product development (NPD) performance from the perspectives of social capital, leadership, modularity and diversification of project team members.

Chang and Chen (2004) studied the influence of variables of the new product that has been developed and supplied to the market successfully. March-Chorada et al. (2002) presented competitive pressure, rate of technological changes, change in customer needs, development objectives, need to increase in market share, short life-cycle, top management pressure, and facile new ideas admission as the factors that push companies to commit new product development. Also, eight factors are introduced as the obstacles for innovation and development of new products. These factors are; 1) technological uncertainties, 2) increasing cost of innovative projects, 3) lack of top management support, 4) fear of previous failures, 5) conservative behaviors in the market, 6) uncertainty in product admission from market side, 7) product innovation failure rate, 8) problems and issues related to failure of product innovation. Based on this research, three factors of top management support, new product development planning, and market demand analysis are introduced as key success factors of new product development.

Cooper and Kleinschmidt (2007) studied success or failure of new product development by use of 10 measures: 1)success rate, 2) selling, 3) marginal profit, 4) technical success rate, 5)selling effect, 6) profit effect, 7) achieving the organization's selling objectives, 8) achieving organization's profitability objective, 9) profitability in comparison to Competitors, and 10) total success vis-à-vis competitors. Noke and Hughes (2010) examined strategies used by firms to reposition through creating a NPD capability. In doing so, they seek to resolve gaps in extant literature on NPD in mature SMEs.

Huang et al. (2002) defined new product development strategy as following : 1) investment for a new product which includes product development, better product to meet customers' needs better than competitors', and concentration and distinction of product, 2) considering market specifications by new product s that includes new market's features, customers, competitors, and new selling channels, 3) commitment and introducing the company's technical needs that includes percentage of research and development cost selling and determining research and development direction, 4) admitting the technology features in the new product which includes complex and advanced technologies and that is compatible closely with research and development resources. Chen et al. (2005) considered how uncertainties affect on new product strategies. The authors present uncertainties as mis-prediction of the environment and inability to predict effects of environmental changes. They suggest that uncertainties an be opportunity or threat for organizations. Their model includes 692 projects.

Akova et al. (2003) review the capacity of new product development in the electronic industry in Turkey. They collect data from 28 electronic device manufactures by use of questionnaire. The results show that most of small and big companies in electronic industry in Turkey have certain guidelines for new product development process and its implementation with high efficiency. Also, most of the companies assign enough resources for new product development strategies.

Thietart and Xuereb (1997) present that innovation and new product development project always face some uncertainties in technology, market, and competitors. The research aims at studying the effectiveness of different tools which are used by managers to understand and decrease the complexities and uncertainties in the innovation and new product development project. Nair and Radhadevi (2006) indicated that companies capacity and strength of relations with their shareholders. Soldatos and Hardy (2007) stated that new product development is the most important activity for survival and growth of organizations.

Most researchers have proposed using multi criteria decision making (MCDM) technique both in the crisp and fuzzy environments. Pun et al. (2010) developed a self-assessment model for measuring new product development performance: an AHP approach. They identified the performance criteria and developing the assessment model for managing NPD in industry. Lin et al. (2008) presented a framework that integrates the analytical hierarchy process (AHP) and the technique for order preference by similarity to ideal solution (TOPSIS) to assist designers in identifying customer requirements and design characteristics, and help achieve an effective evaluation of the final design solution. Feyzoğlu and Büyüközkan (2008) presented an integrated group decision-making approach for new product development using fuzzy Choquet integral. Ho and Tsai (2011) presented a novel approach based on structural equation modeling (SEM) and adaptive neuro-fuzzy inference system (ANFIS) to forecast value innovation and the effects of the quality of the NPD process on NPD performance. Wang (2009) applied the group decision-making scenario to assist business managers to measure the performance of NPD manipulates the heterogeneous integration processes and avoids the information loss effectively. Finally, they demonstrated the result of NPD performance evaluation for a high-technology company in Taiwan. Wei and Chang (2011) proposed a new approach based on fuzzy set theory and multi-criteria group decision making method into a NPD project portfolio selection model. Their model takes into account project performance, project delivery and project risk, and formulates the selection decision of NPD project portfolio as a fuzzy linear programming problem. Generally, after reviewing the literature in NPD strategy evaluation problem, we cannot find a structured approach for selection of NPD strategy with uncertain data. The problem of evaluation and selection of NPD strategy can be formulated as the MCDM problem. Thus, we propose a new Fuzzy-MCDM method for evaluation and selection of

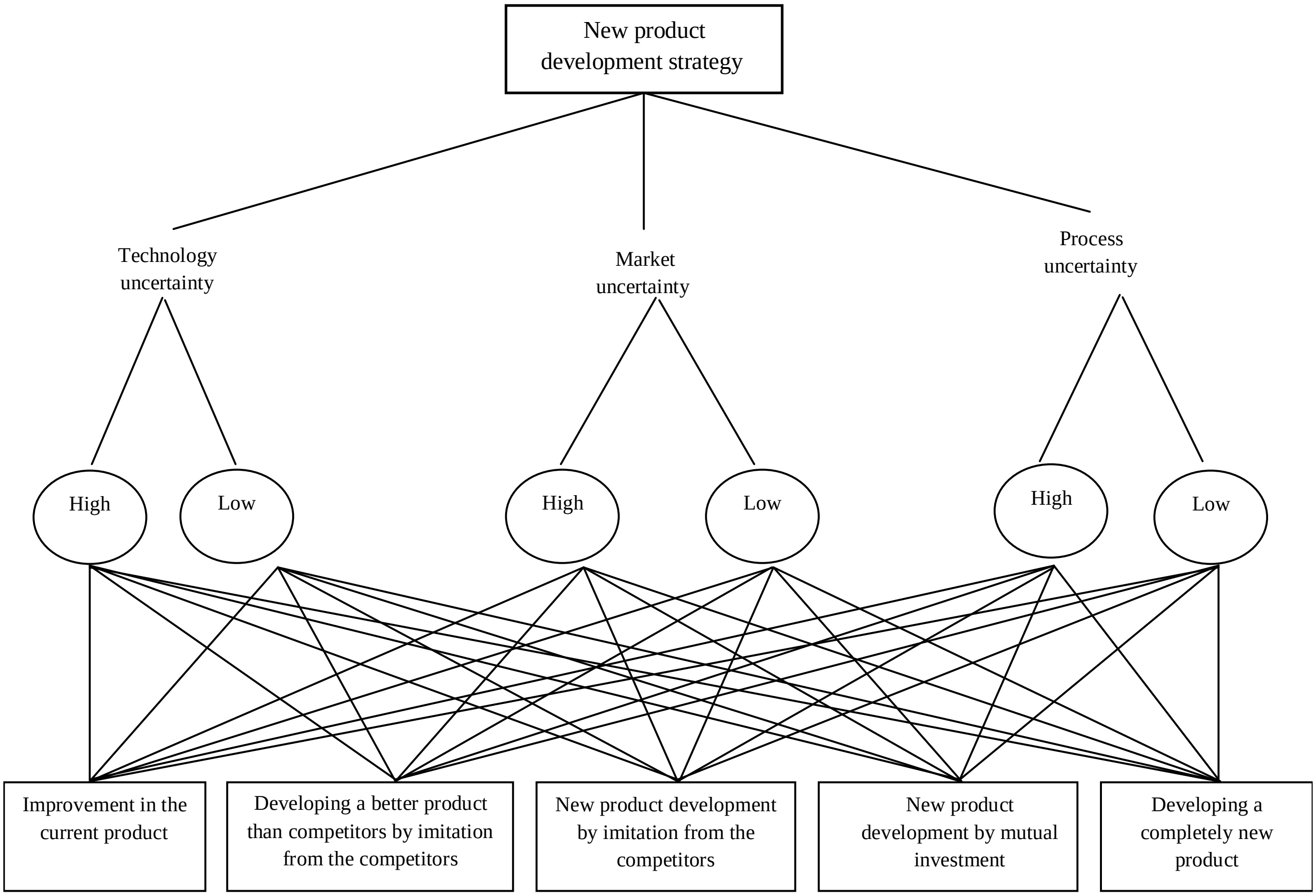

Figure 1. Hierarchical analysis model for new product development strategy selection.

NPD strategy in the paper.

After reviewing the research performed in new product development, the most important factors and critical roles in the success of new product development strategies have been gathered and shown in Figure 3. Moreover, factors and strategies extracted from review of previous research are indicated in Table 1:

PROPOSED MODEL

Here, a hierarchical analysis model is used to determine the best strategy for new product development. Comparisons and assigning the weights are completely different from the AHP model proposed by Saaty (1980). The hierarchical model should be able to break the existing complex decision problem into manageable components of different layers/levels (Azadeh et al., 2010).

Since fuzzy concept can handle uncertainty, ambiguity and vagueness environments especially in new product development, in this paper a new fuzzy AHP method is proposed to cover such situation. Fuzzy AHP method has been applied by many researchers for making decision in different fields (Azadeh et al., 2010, 2011; Iranmanesh et al., 2008; Naghadehi et al., 2009; Rezaie et al., 2009).

Azadeh et al. (2011) applied fuzzy AHP for assigning productive operators' in cellular manufacturing systems. Azadeh et al. (2010) used this approach in evaluating and selecting simulation software package. Fuzzy AHP is applied for evaluating effective factors of implementing knowledge management by Rezaie et al. (2009); evaluating risk of information technology projects by Iranmanesh et al. (2008); and selecting of optimum underground mining method for Jajarm Bauxite Mine by Naghadehi et al. (2009).

In the proposed model, two types of weighting called low-level and high-level are used. Also, because of uncertainties in on hand data, fuzzy logic concepts and fuzzy multi criteria decision making are applied. In the model, regarding the literature review, technology, market, and process are considered as the main criteria and uncertainties related to these main criteria which are considered in two levels (low and high) are taken into account as the sub-criteria. Alternatives or strategies extracted from the literature are: 1) developing a completely new product 2) new product development by

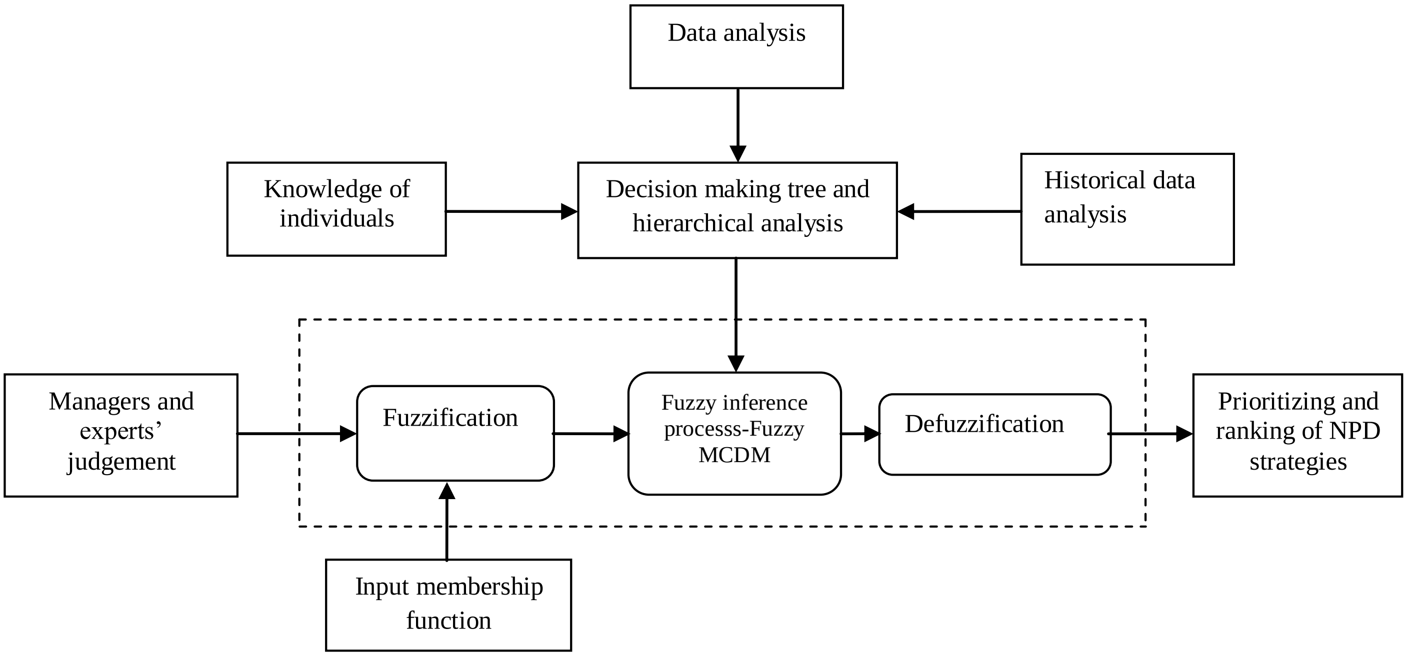

Figure 2. Conceptual model.

mutual investment 3) new product development by imitation from the competitors 4) developing a better product than competitors by imitation from the competitors 5) improvement in the current product. Figure1 indicates the criteria and sub-criteria.

Figure 2 indicates the conceptual model which is proposed in this paper. Based on this figure, firstly data are gathered and analyzed. The, experts answered questionnaires and with collaboration of historical data, decision making tree is sketched. As the there are some uncertainties in the data, the decision making tree should be handled by fuzzy inference system. Membership functions are set for input data.

The result of this process is the ranking the NPD strategies to select the best one. Figure 3 shows what is going to be performed during the execution based on the mentioned conceptual model sketched in Figure 2. Criteria and strategies are determined and decision making tree is provided.

Then, the factors and criteria are fuzzified by assigning the membership functions. At the end, using the fuzzy MCDM priority of each strategy is determined and the best strategy is selected.

In this paper, strategies for new product development are identified by literature review and Delphi method. The tool used for data gathering is the questionnaires which data related to criteria and their importance and the value of strategies than each other are collected. In the questionnaires, data are uncertain and linguistics variables "very much (VM), much (M), medium (MD), low (L), very low (VL)" are assigned to each criterion and strategy regarding each expert's preference. To fuzzify the collected data, bell shape membership function is used as follows:

$$\mu_C(x) = \frac{1}{1 + d(x-c)^2} \quad (1)$$

Where, C and d represent fuzzy value and width of shape (scale factor), respectively. Also, x is the universe set and c is medias (0 for VL, 0.25 FOR L, ….). To control the shape of membership function effectively instead of scale factor, a shape factor S which shows the membership value of border points is used. The value of S is calculated as thus (Khan mohamadi et al., 2000):

$$\frac{1}{1 + d[(0or1) - \frac{1}{2}]^2} = s \Rightarrow \frac{1}{1 + \frac{d}{4}} = s \Rightarrow d = \frac{4}{s} - 4$$

Thus, the membership function is:

$$M_C^{(X)} = \frac{1}{1 + ((\frac{4}{s}) - 4)(x-c)^2} \quad (2)$$

Each expert assigns a weight to each criterion. As a number of experts are asked to do that, it is essential to assign just a number to each factor. Thus, average of all weights for a criterion is computed thus:

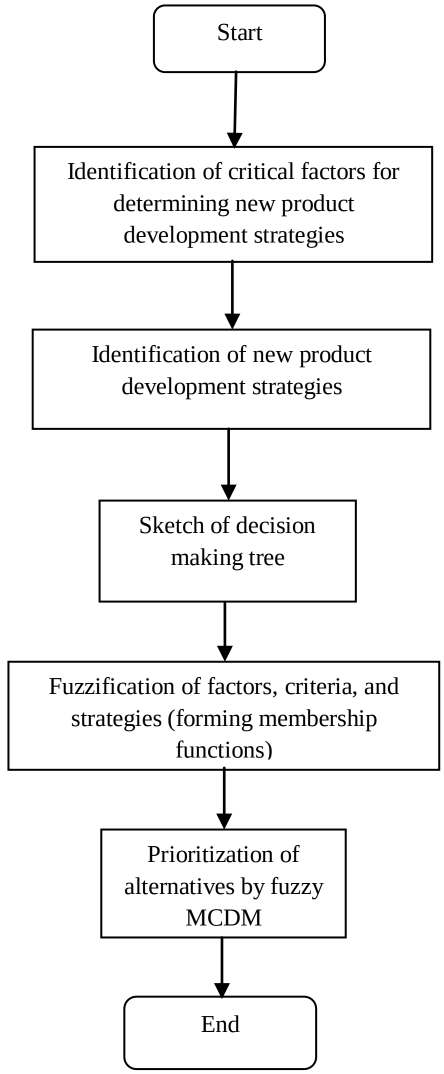

Figure 3. Executive model.

$$Wi = \frac{\sum_{k=1}^{p} p_{ki}}{p} \quad (3)$$

Where p_{ki} is the weight of criterion i assigned by expert k. Then, by setting C=Wi in Equation (2), we have:

$$M_C^{(X)} = \frac{1}{1+((\frac{4}{s})-4)(x-c)^2}.$$

As mentioned in this paper, two levels are used for weighting, low-level and high-level. The low-level and high-level weights are calculated by Equations (4) and (5), respectively:

$$w_{il} = \frac{\sum_{k=1}^{p} p_{kil}}{p} \quad (4)$$

$$w_{iu} = \frac{\sum_{k=1}^{p} p_{kiu}}{p} \quad (5)$$

Where, p_{kiu} and p_{kil} indicate high-level and low-level weights assigned to factor i by expert k, respectively.

Precision of decision maker is calculated by the difference between low-level and high-level weights. In equation (6), s is the shape factor introduced earlier:

$$S = w_{iu} - w_{il} \quad (6)$$

Table 1. Factors and strategies extracted from review of previous research for NPD.

Row	Researchers	Factors
1	Bstieler and Gross (2003)	Environmental uncertainty, Market uncertainty, Technological uncertainty, Organization resources, Investment return (efficiency),Efficiency, Profitability Technology change, Idea of new product, Pre-development activities, Project team features, Product concept development
2	Ozer (2005)	Market status
3	Frambach et. al. (2003)	Organization strategy, Reaction strategy, Active strategy, Leadership cost strategy, Distinctive strategy, Focus strategy, Competition orientation, Market orientation
4	Lu and Yang (2004)	Environmental uncertainty, Market uncertainty, Technological uncertainty Cooperation of R and D with marketing, NPD strategy with minimum improvement in present market, NPD strategy with maximum improvement in present market
5	Petrick and Echols (2004)	Environmental uncertainty, Technological uncertainty, Market status, Mutual investment strategy, Organization resources, Investment return (efficiency)
6	Zahay et al. (2004)	Organization resources, Internal information of organization, External information of organization
7	Lynn et al. (1999)	Product development structure, Product development team, Top management support, Access to resources of materials supply, Change in laws and rules
8	Chang and Chen (2004)	Investment return (efficiency),Involvement in technology leadership Involvement in market leadership, Selling percentage, Efficiency, Customer satisfaction, Technical success rate
9	March-Chorda et al. (2002)	Market uncertainty, Technological uncertainty, Organization resources, Top management support, Competitive pressure increase, Technology change rate, Customer demand change, Development goals, Market share increase Product life cycle, Market demand analysis, Idea of new product
10	Cooper and Kleinschmidt (2007)	Trade effect, Organization resources, Product development structure, Product development team, Top management support, Selling percentage, Technical success rate, Market demand analysis, Profitability, Definition of NPD strategy, Idea of new product, Pre-development activities, Project team features, Product concept development, Organization culture and environment, Product distinction, Products portfolio, Market, Technology, Packaging improvement strategy, Product improvement strategy, Strategy of revision in products Completely new product strategy, New product in the world strategy
11	Cheng-Jen et al. (2007)	Organization resources, Product development structure, Selling percentage Profitability, Definition of NPD strategy, Technology change, Strategy of being the first in market, Quick imitation from competitors strategy, Strategy of quick imitation from competitors and entering to market with delay, Knowledge management
12	Chen et al. (2005)	Market uncertainty, Technological uncertainty, Market, Technology
13	Akova et al. (2003)	Organization resources, Product development structure, Product development team, Top management support, Strategy of being the first in market, Quick imitation from competitors strategy, strategy of quick imitation from, Competitors and entering to market with delay, Product distinction, NPD strategy with minimum improvement in present market, NPD strategy with maximum improvement in present market, NPD strategy with minimum improvement in new market

Table 1. Contd.

14	Thietart and Xuereb (1997)	Market uncertainty, Technological uncertainty, Mutual investment strategy Organization resources, Internal information of organization, External information of organization, Product development structure, Product development team, Top management support, Quick imitation from competitors strategy, Technology, Competition
15	David (2010)	Organization resources, Technology change rate, Product life cycle, Competition Industry growth, Organization ability in R&D
16	Nair and Radhadevi (2006)	Technological uncertainty, Mutual investment strategy
17	Soldatos and Jurate (2007)	Reaction strategy, Active strategy, Organization resources, Product development structure, Top management support, Definition of NPD strategy, Organization culture and environment, NPD strategy with minimum improvement in present market
18	Fox et al. (1998)	Environmental uncertainty, Market uncertainty, Technological uncertainty, Process uncertainty
19	Frambach et al. (2003)	Reaction strategy, Competition orientation, strategy of quick imitation from competitors and entering to market with delay.

Preferences tables are formed by preference values of factors. To calculate the preference of a criterion than others, linguistic preferences are used for computing the high-level and low-level weights. Fuzzy weights of upper limit and lower limit for each criterion and strategy i, are computed by equations (7) and (8):

$$\mu_{wiu}(xk) = \max\left\{\frac{1}{n}\sum_{j=1}^{n}\mu_{ij}(xk), 1-\frac{1}{n}\sum_{j=1}^{n}\mu_{ji}(xk)\right\} \quad (7)$$

$$\mu_{wil}(xk) = \min\left\{\frac{1}{n}\sum_{j=1}^{n}\mu_{ij}(xk), 1-\frac{1}{n}\sum_{j=1}^{n}\mu_{ji}(xk)\right\} \quad (8)$$

$\mu_{wiu}(xk)$ and $\mu_{wil}(xk)$ show the membership values of kth element of universe set in the fuzzy weights w_{iu} and w_{il}. n indicates the number of criteria or strategies $\mu_{ij}(xk)$ shows the membership value of kth element of fuzzy set in linguistic values in the ith row and jth column of preference table.

Decision making for this problem, based on Figure 2 which indicates the conceptual model, is done regarding the criteria and alternatives in a hierarchical manner. Firstly, importance of main criteria is calculated by preferences table. Then, low-level and high-level weights of each criterion are assigned by equations (7) and (8). Afterwards, membership functions of main criteria and sub-criteria are set by equations (1) and (2). Then, fuzzy relationships are used to calculate the importance of criteria as follows:

$$\mu_R(x,y) = \mu_{A\times B}(x,y) = \min\{\mu_A(x), \mu_B(y)\} \quad (9)$$

$$Criteria_{i,i=1,2,\ldots,n} = (mwc1, mwc2, \ldots mwcn)$$

Then, importance of strategies is calculated by the use of criteria, preferences tables and linguistic values. Low-level and high-level importance of alternatives is computed by Equations (7) and (8). The importance of alternatives is shown in $Utility_{i,i=1,2,\ldots,n}$ matrix as:

$$Utility_{i,i=1,2,\ldots,n} = \begin{bmatrix} mwa1c1 & mwa1c2 & . & . & . & mwa1cm \\ mwa2c1 & mwa2c2 & . & . & . & mwa2cm \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ mwanc1 & mwanc2 & . & . & . & mwancm \end{bmatrix}$$

For ranking the alternatives, fuzzy MCDM is used.

CASE STUDY: EXPERIMENT AND RESULTS

To validate the proposed model, a company dependent to an automobile manufacturing industry in Iran is considered. Data are collected from top managers and experts in the R and D, engineering, finance and trade departments who are involved in the new product development processes. 20 questionnaires were distributed between these experts and managers. As mentioned,

Table 2. Preferences table for main criteria.

NPD strategy	Technology uncertainty	Market uncertainty	Process uncertainty	Wu
Technology uncertainty	Much	Medium	Much	0.67
Market uncertainty	Medium	Very much	Much	0.75
Process uncertainty	Medium	Medium	Much	0.58
Wl	0.58	0.67	0.75	

Table 3. Strategies preferences in high technology uncertainty.

High technology uncertainty	S1	S2	S3	S4	S5	Wu
S1	Low	Low	Medium	Medium	Medium	0.4
S2	Much	Very much	Medium	Medium	Very much	0.75
S3	Much	Low	Much	Much	Medium	0.6
S4	Medium	Very low	Low	Low	Low	0.25
S5	Much	Low	Much	Much	Much	0.65
Wl	0.6	0.35	0.55	0.55	0.6	

Table 4. Preferences of strategies in low technology uncertainty.

Low technology uncertainty	S1	S2	S3	S4	S5	Wu
S1	Very much	Very much	Medium	Very much	Medium	0.75
S2	Low	Low	Medium	Medium	Low	0.35
S3	Low	Medium	Low	Low	Medium	0.35
S4	Medium	Medium	much	Much	Medium	0.6
S5	Medium	Much	Low	Much	Very much	0.65
Wl	0.5	0.55	0.45	0.65	0.55	

Table 5. Preferences of strategies in high market uncertainty.

High market uncertainty	S1	S2	S3	S4	S5	Wu
S1	Very much	Medium	Medium	Medium	Much	0.65
S2	Medium	Much	Much	Medium	Medium	0.6
S3	Medium	Medium	Very much	Much	Much	0.7
S4	Medium	Medium	Low	Medium	Medium	0.45
S5	Medium	Medium	Medium	Medium	Very much	0.55
Wl	0.6	0.55	0.6	0.55	0.65	

three main criteria, technology uncertainty, market uncertainty, and process uncertainty are asked to be weighted. Table 2 indicates the results of preferences for main criteria in association with the evaluation and prioritizing the NPD strategies.

Also, Tables 3 to 8 show preferences tables for strategies considering each of sub-criteria. The results of importance and priority of strategies after implementing the proposed model are indicated in Tables 9 and 10 and Figures 4 to 11. Figures 4 to 11 show the importance of each strategy r egarding the sub-criteria. For example, Figure 4 indicates that strategy 1 is the best when the uncertainties in market, technology and process are the minimum. In other words, producing a completely new product in this situation is the best strategy. The reason is that in this situation, information about market, technology, and process is most precise. Thus, the manufacturing of the new product which would be successful.

To validate the proposed model, AHP model introduced by Saaty (1980) is also implemented to the case study. The results of the proposed model and AHP are compared. The results of importance of strategies after

Table 6. Preferences of strategies in low market uncertainty.

Low market uncertainty	S1	S2	S3	S4	S5	Wu
S1	Very much	Much	Much	Very much	Medium	0.8
S2	Low	Low	Low	Low	Very low	0.2
S3	Low	Medium	Medium	Medium	Low	0.4
S4	Medium	Much	Much	Much	Much	0.7
S5	Low	Much	Medium	Medium	Much	0.55
Wl	0.45	0.6	0.55	0.6	0.45	

Table 7. Preferences of strategies in high process uncertainty.

High process uncertainty	S1	S2	S3	S4	S5	Wu
S1	Very low	Low	Low	Low	Low	0.2
S2	Very much	Very much	Much	Medium	Low	0.7
S3	Medium	Medium	Medium	Very much	Very much	0.7
S4	Low	Medium	Low	Low	Very low	0.25
S5	Medium	Much	Low	Much	Very low	0.45
Wl	0.45	0.6	0.4	0.55	0.35	

Table 8. Preferences of strategies in low process uncertainty.

Low process uncertainty	S1	S2	S3	S4	S5	Wu
S1	Very much	Very much	Much	Much	Medium	0.8
S2	Very low	Medium	Low	Low	Very low	0.2
S3	Very low	Low	Medium	Very low	Medium	0.25
S4	Low	Much	Much	Medium	Medium	0.55
S5	Medium	Much	Much	Much	Medium	0.65
Wl	0.35	0.65	0.6	0.45	0.4	

Table 9. Results of importance of strategies in 8 states.

State	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5
1	0.5006	0.4747	0.4732	0.4847	0.4816
2	0.4352	0.4635	0.4655	0.4477	0.4406
3	0.472	0.4518	0.4727	0.4571	0.4699
4	0.434	0.4386	0.4648	0.4325	0.4406
5	0.4615	0.4691	0.4432	0.4277	0.4626
6	0.4352	0.4654	0.4416	0.4108	0.4352
7	0.4588	0.4432	0.4427	0.4277	0.4581
8	0.434	0.4386	0.441	0.4108	0.4352

implementing the proposed model using AHP are indicated in Tables 11. Comparison of the results of AHP and the proposed model indicates that the results are completely different. In fact, the ranking of strategies got from the AHP model are the same in all eight states of main criteria. However, the ranking of strategies resulted from the proposed model implementation changes through eight states. Thereby, proposed methodology enable decision maker.

According to Table 11, this paper presents a unique

Table 10. Priority of strategies in 8 states using proposed methodology.

State	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
1	1	4	5	2	3
2	3	2	4	5	1
3	3	1	5	4	2
4	3	5	2	1	4
5	2	5	1	3	4
6	2	3	5	1	4
7	1	5	2	3	4
8	3	2	5	1	4

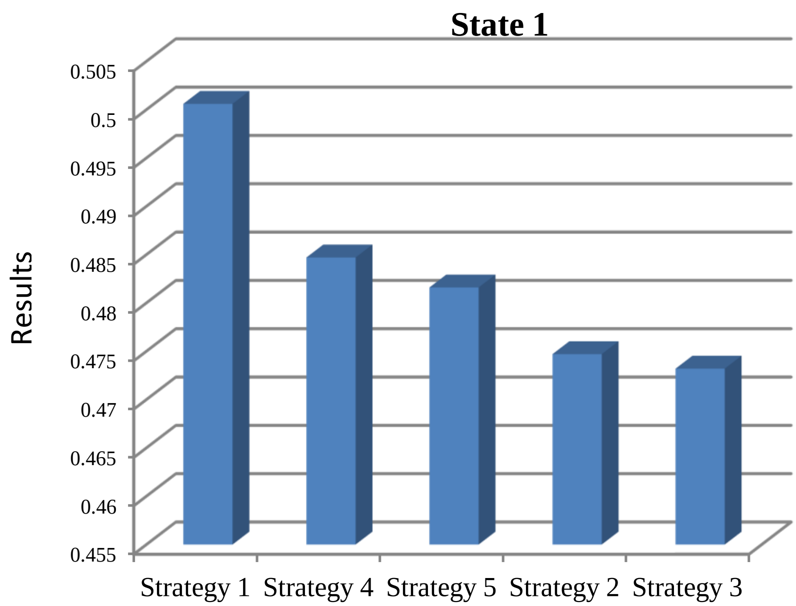

Figure 4. Prioritizing of strategies in low uncertainties of market, technology and process.

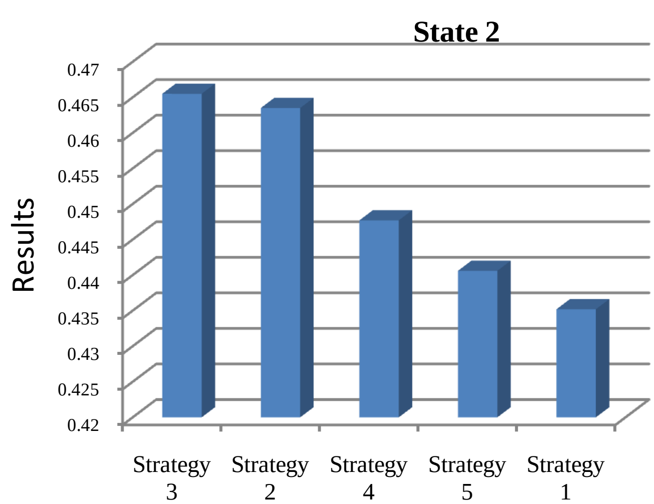

Figure 5. Prioritizing of strategies in low uncertainties of market and technology.

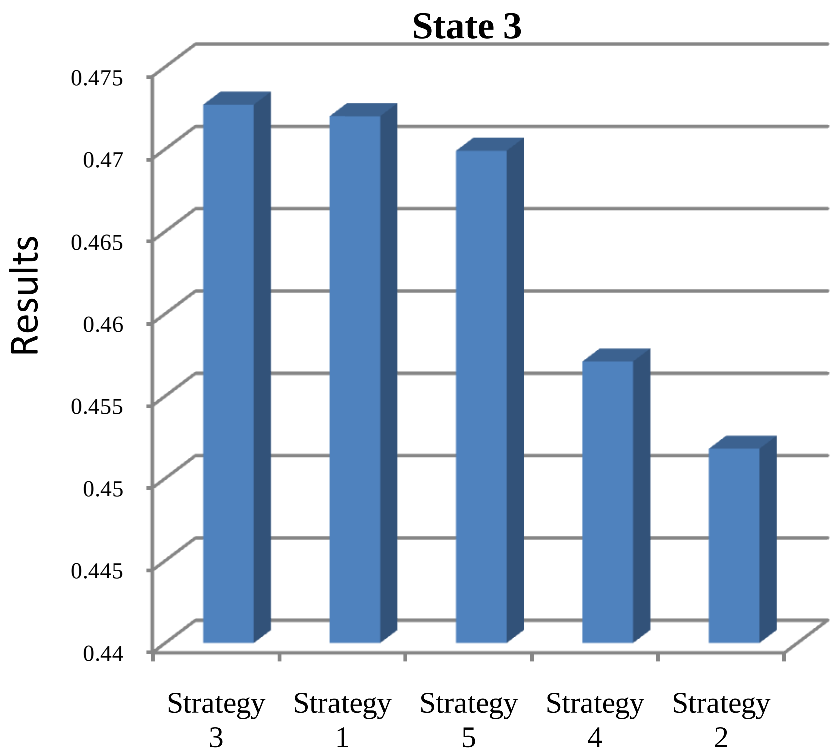

Figure 6. Prioritizing of strategies in low uncertainties of process and technology and high market uncertainty.

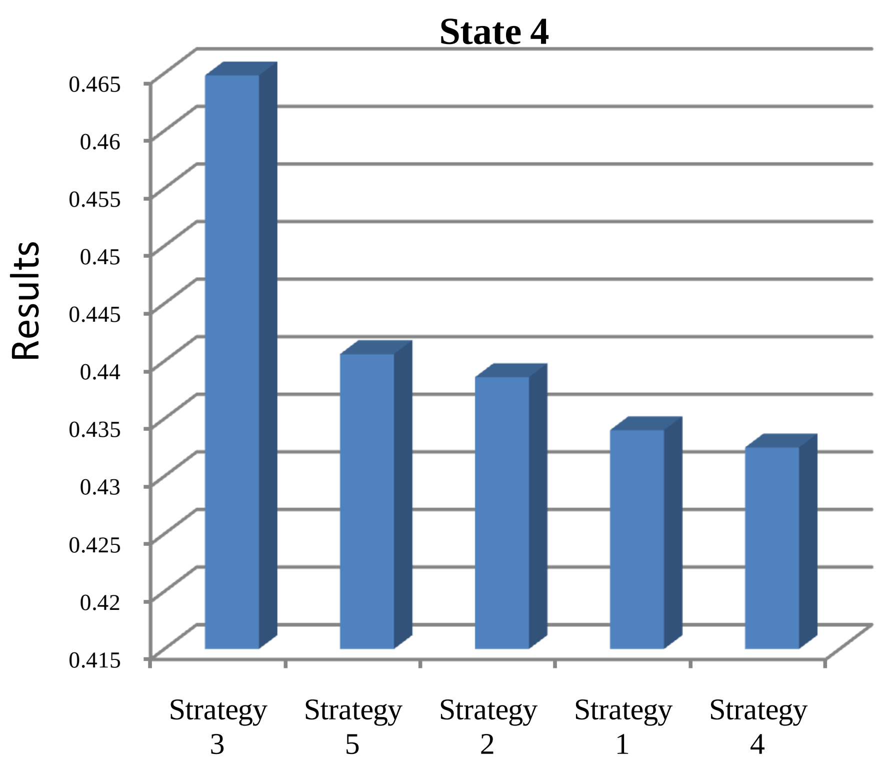

Figure 7. Prioritizing of strategies in low uncertainties of technology and high uncertainties of market and process.

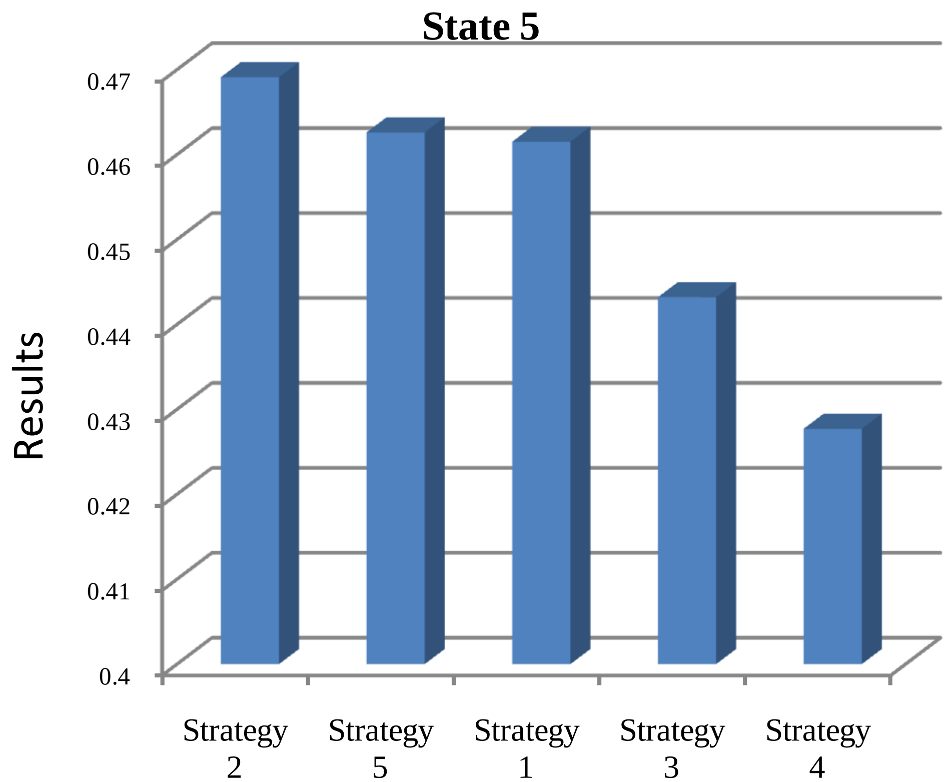

Figure 8. Prioritizing of strategies in low uncertainties of market and process and high uncertainty of technology.

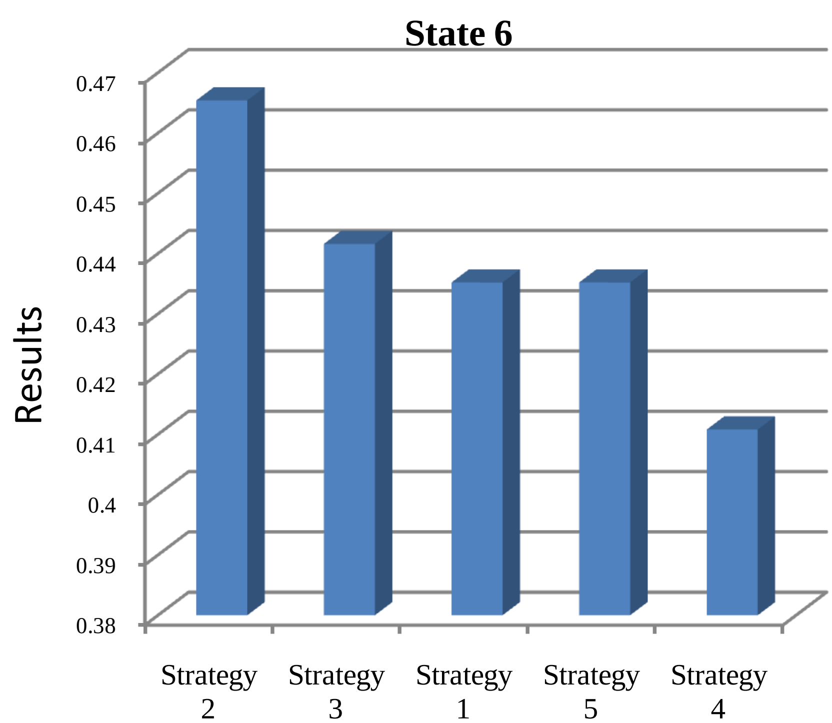

Figure 9. Prioritizing of strategies in low uncertainties of market and high uncertainty for technology and process.

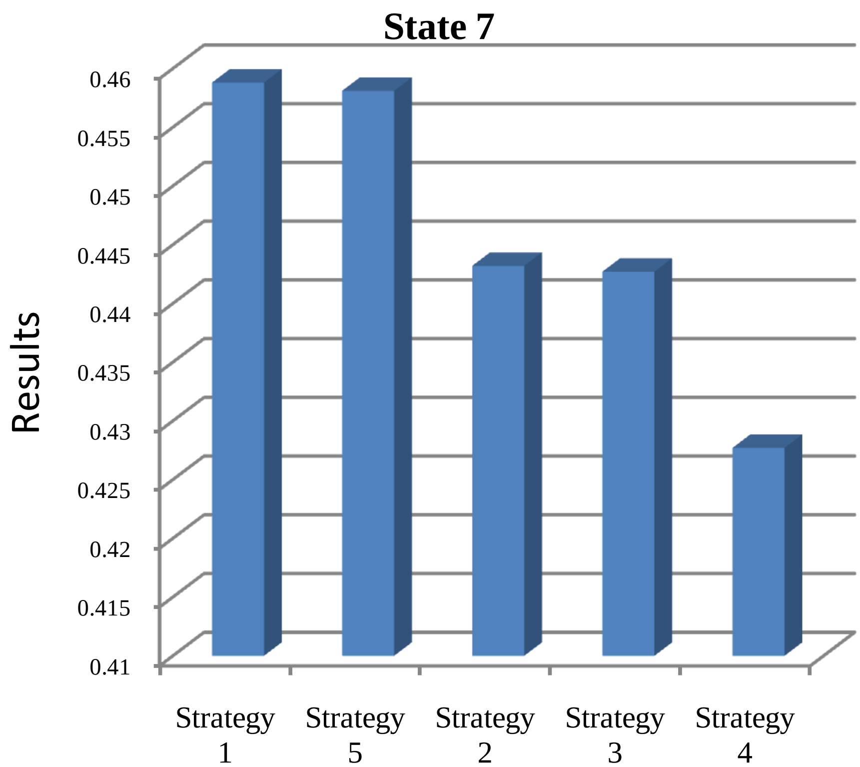

Figure 10. Prioritizing of strategies in low uncertainties of process and high uncertainty for technology and market.

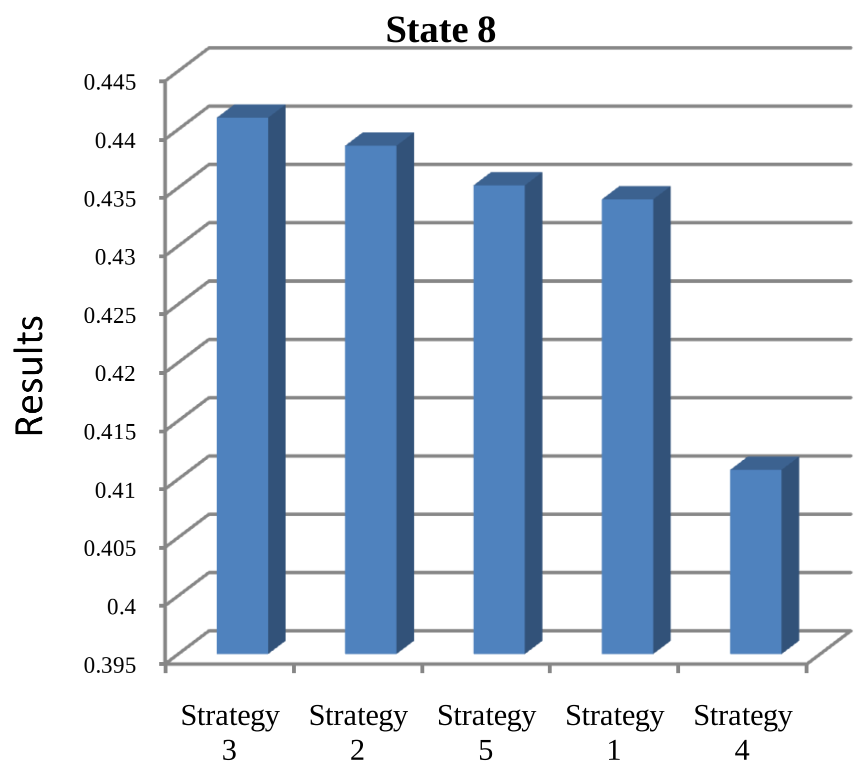

Figure 11. Prioritizing of strategies in high uncertainties of market, technology and process.

Table 11. Priority of strategies in 8 states using AHP.

Strategy	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8
1	0.525	0.525	0.489	0.468	0.445	0.432	0.435	0.425
2	0.173	0.203	0.217	0.228	0.272	0.277	0.283	0.287
3	0.137	0.103	0.155	0.167	0.160	0.169	0.168	0.175
4	0.104	0.103	0.090	0.087	0.077	0.075	0.074	0.072
5	0.061	0.066	0.049	0.050	0.045	0.046	0.040	0.041

framework which has several advantages over the AHP. Also, this paper presents a simple and applicable framework in the complex situations to overcome this problem in the fuzzy environment.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This paper aimed at introducing a model for evaluation and prioritizing new product development strategies. In this research, three uncertainties were considered as the most important factors in selecting and implementing NPD strategies. These uncertainties are:

(1) Market uncertainty
(2) Technology uncertainty
(3). Process uncertainty which is related to internal issues of the organization.

For each main factor, two states, low and high, were studied. To provide the final model, decision making tree and importance or preference of factors that others in each state were considered. A new approach was used to weight the factors and strategies. Also, to determine the importance of each strategy than factors, fuzzy AHP model was used. Low-level and high-level weights were calculated by linguistic preferences. Membership functions of each of criteria and strategies were calculated by linguistic preferences. In addition, prioritizing of strategies was done by fuzzy MCDM. The results of the proposed model were compared with the results of implementing the AHP. The comparison showed that in different states, different strategies were selected while the results of the AHP showed that in all states just one strategy was selected. Thus, the proposed model leads to selecting different strategy in different situation. Therefore, the results of the proposed model would be more reliable than that of AHP. As the future, implementation of the proposed model and fuzzy approach in other case studies are suggested to test the validity of the proposed model much more.

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