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Research Article

Fuzzy Model of Hesitant Decision Making in Evaluating Business Plans Under Uncertainty (an Approach to Developing new Products)

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Abstract

The current research was conducted with the aim of designing a Intuitionistic fuzzy model of hesitant decision making in the evaluation of business plans under conditions of uncertainty as an approach for the development of new products while various researches have been conducted on the development of new products based on innovation. According to the previous researches, decision-making in the uncertain environment for choosing exogenous variables of the business development model based on the development of new products was not observed. Also in the evaluation of economic plans, the parameters are usually considered as certain whereas the investigation of uncertainty is considerably important. In this research, the main goal is to investigate and find factors affecting the feasibility of new product development plans and finally to obtain a method for evaluating new product development plans. For this purpose, 12 people were selected from the elite community and experts of the chemical industry using the theoretical purposeful sampling method. The results of Intuitionistic fuzzy analysis have shown that 6 exogenous variables were chosen as key variables in the selection and development of a new product in the organization. In this research, Intuitionistic fuzzy analytic hierarchy method has been used to determine the importance of exogenous variables that experts have applied in determining their importance. The significant importance of exogenous variables are the rate of certainty of investment in product development (0.239), new product acceptance share in the market (0.275), new product development strategy (0.209), attracting funds for applied research factor (0.077), passing standards and requirements (0.136), and funding for product development research (0.061). The dynamic product development model, which is based on the cause and effect relationship needs to be designed and tested in future studies to simulate the current and future decision-making performance.

Keywords: Fuzzy model; Decision making; Dynamic model; Product development

1. Introduction

The process of new product development is considered a competitive advantage for various types of today's production and service organizations. The fact that, what percentage of each organization's activities is spent on new product development in order to surpass its competitors, is an issue which is dependent on the current and strategic position of the organization in the market (Ferreras-Méndez et al., 2022). In order to be able to adapt to the environmental changes in the best possible way, the companies might stop the production and the supply of some products, or might apply the necessary changes in them. Besides, companies would develop new products according to the needs and the desires of their customers in different markets. Such an initiative is taken to sustain long-term business and increase the company's economic prosperity (Bailey et al., 2020). The importance of such developmental actions would depend on the type of their defined process and also the innovative type of the intended product (Knudsen et al., 2022). The development of a new product for the untapped parts of the market includes a set of activities, and a set of developmental guidelines which lead to partial or total changes and modifications in the products (Quigley et al. , 2023). Montero and et al consider products as "original" which have the following features: novelty for the world, being original for the company, and the originality of a newly-developed product for a new market (Montero et al., 2019). Other researchers believe that the three features which were just mentioned can lead to the development of a new product and attempts like making modifications in packaging or the application of a certain type of production, or a change in product distribution network should be considered as an approach of product development; besides, in most industries, successful development and commercialization of products is done when the company's approach is competitive and the business pays attention to the main competencies of the company (Cooper, 2019). In general, the goals of developing a new product are: satisfying customers' needs, adapting to the market, adapting to the environmental changes, increasing profit, customer satisfaction, and counteracting competitor's policies. In fact, the duty of an organization in developing a new product is to seek out opportunities to produce new products which increase the company's profit (Zhang et al., 2019). The development and production of a new product as well as the successful commercialization of improved products can shorten the life curve of products and help the company move from mass production to an individually-ordered one (Gann & Salter, 2020). These days, if manufacturers are willing to create added value and also encourage customers to buy their product, they should adopt a policy by which they show flexibility in attracting attention to and focusing on

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their market. Of course, this should happen with an emphasis on product development strategy. Identifying changes in the needs and desires of consumers in different markets, with a continual competition in business, along with economic prosperity can lead to the implementation of new product development programs. The goal of developing new products can be a response to the customers' needs, adaptation to the market or adaptation to the environmental changes, increasing the profit, customer satisfaction and counteracting competitor's policies. The ever-increasing flow of development and production of new products and their successful release to the market can not only shorten the life curve of products but also help the company move from mass production to an individually-ordered one (Qureshi & Kang, 2020). The development of a new product and the recognition of its importance can be a new and risky approach for companies; however, the identification of key factors in this approach can help reduce the risk of decision making in management. Since managers seek effective strategies for new product development in the dynamic and competitive markets, the winners of an ever-changing market of the current world are those who lay emphasis on the development and creation of new products in order to guarantee their own survival (Mero & Haapio, 2022). The main concern of this article is to discover a way of investigating and finding factors affecting the possibility of new product development plans and eventually to acquire a way of evaluating new product development-albeit by considering all these parameters in industry. Generally, in economic plans, parameters are considered as definite; however, analyzing issues like risk factors and absence of certainty is of paramount importance. Therefore, it would not be wise to introduce such model parameters in evaluating other economic plans with absolute certainty. This research is an attempt to discover behavioral changes of allocating resources for process innovations as well as changes and improvements in various aspects of the entire product development during the interval time. Besides, in this dynamic research, an attempt has been made to introduce a study through which managers can get meaningful information because an investment portfolio and controllable variables for optimization of company profit have been thoroughly investigated. Since the development of new products requires various innovative plans, it is utterly important to understand the characteristics of innovation according to environmental changes. So far, much research on "developing new product based on innovation" has been done. Besides, there has been an increasing attention in studies with the concept of "systematic approach". Nonetheless, as far as the previous studies are concerned, there is a lack of attention to decision-making in an uncertain environment to choose exogenous variables of the development-based business model. The goal of this research is to suggest a policy by which different dynamic processes in new product development are linked.

2. Literature Review

In today's world of dynamic business, companies are fervently looking for ways to gain a competitive advantage so as to surpass their competitors. Undoubtedly, new product development is a starting point to entering this stage (Dehghani et al., 2022). Since the life cycle of products is shorter, there is a great deal of pressure to reduce the cost and time of product development (Ji et al., 2022). Speeding up the time to present a product to market can lead to higher sales. Therefore, it is very important to speed up the development projects. Poor process structure leads to unnecessary repetitions and such inefficiency causes a delay in introducing the product to the market which, in turn, results in the missing of sales opportunities. Although new products create new opportunities for companies, we should not ignore the significant risk that these products have (Chiu et al., 2022). Empirical studies have shown a high rate of failure of these products, especially in consumer markets. Therefore, much effort has been made not only to determine the success and failure factors but also to reduce the risks of such projects (Bailey et al., 2020). Despite the fact that the information about past studies on product development is available, there is no certainty in the process of developing new products (Huang et al., 2022).

Although new and innovative products are a decisive factor in gaining a competitive advantage for companies, they can create unfamiliar and complicated situation replete with uncertainty for the development team. In many industries, despite the great attention paid to new product development, unfortunately, the failure rate of projects is still high (Aljumah et al., 2022). Therefore, a considerable part of research is focused on how to make the new product development process more effective and efficient. Many reasons have been proposed to account for such failure; namely, organizations' lack of attention to success or failure factors, and the organizations inability to continuously evaluate these factors. In this regard, it is necessary that the factors of success or failure of new product development projects are identified, categorized and prioritized so that planners can take into account both these factors and the available resources and facilities to decide on the development and implementation of the mentioned programs (Neumann et al., 2022).

Successful development of a new product has important competitive advantages for a company. To develop a new product, a factory must be able to develop an innovative product that appeals to the customer and produce it in large quantities in order to obtain massive profits. Today, managers tend to go for products with such valuable features: products that can satisfy consumers' needs, products with high quality designs and production, products that have low competitive costs and finally the ones that are available to the customer on time (Qi et al., 2020). Some of these factors are essential to guarantee the success of a product. If these factors are not conspicuous, then the product will probably experience the expected or even complete failure (Chan et al., 2021). When the idea of product creation in the process of NPD is still maturing, company management needs more information to make decisions. The process in which information is collected and ideas are evaluated can facilitate the decision making process for new product production. Also, it is possible to prevent product failure in the market by limiting risks and hiding its factors (Li et al., 2021).

After different ideas are proposed, the selection of an idea for development depends on which idea has value that which product helps the success of that business. Selecting a good idea is very important for the future and the success of a business. By forming a NPD committee, it is easy to evaluate the ideas based on their potential appeal and eventually determine to what extent they are in line with the strategies and goals and resources of the organization. Although the process of developing a new product is complicated, identifying the success factors of products in different industries can help the organizations in improving the effectiveness of their products. Also organizations can take effective action through the audit of their organizational processes in terms of supporting key success factors (Thomas et al., 2019).

Since the selection of an NPD project plays a major role in competitive markets, company managers needs the right tools to evaluate and prioritize these projects. They also need to find a way so that they can analyze and prioritize the development of new products. Such analysis and prioritization should be based on factors that are not the same for all industries. This type of information can be obtained through careful study and analysis of NPD for past successful products. This research provides the best decision-making tools by first understanding the implicit relationship of innovation in the organization to develop new products and then giving suggestions based on the types of innovation strategies. But the main value of this research lies in the fact that it presents a dynamic process of new product development through analyzing various relationships in regards to innovation and all this is done with modeling and quantifying the data. In other words, this research includes in itself structural elements of interaction process of product innovation based on new product development.

3. Research Framework

In this research, since we want to follow the footsteps of previous studies then we have presented: basic models of new product development based on R&D performance, the performance of process innovation and also the performance of product innovations. However, in order to identify systematic exogenous variables which can be used in selecting product development projects, we have used Table 1 to review the opinion of experts in the Delphi process so that exogenous variable can be selected.

Table 1
Exogenous variables in the dynamic system of product development

Group	Exogenous Variables	Source
1	The speed of technological change/acceptable product quality/ laws of innovation and intellectual property/the degree of product originality/new product development strategy/creating a new market/ technological capabilities for product development	Thomas et al., (2019), Qi et al., (2020)., Globocnik et al., (2020), Barrane et al., (2021), Graesch et al., (2021)
2	New needs of customers/ product imitability/ customer needs/R&D challenges/ attracting funds for applied research	Qi et al., (2020)., Thomas et al., (2019), Barrane et al., (2021) , Graesch et al., (2021), Yan and Dooley (2020), Gann and Salter (2020), Rouf et al., (2021)
3	Industrial policies and laws / new market development/ Innovation of competitors in the market / New product development cost / the vision and mission of the organization / strategic planning of the organization/ leadership style/ organizational management	Globocnik et al., (2020), Qi et al., (2020)., Graesch et al., (2021), Rouf et al., (2021), Laine et al (2020)
4	Workforce participation /availability of export markets/resources for investment and implementing projects/aspects of technical capability in design and production/highly-skilled workforce	Yan and Dooley (2020), Gann and Salter (2020), Rouf et al., (2021), Barrane et al., (2021), Chan et al., (2021)
5	Company's ability to compete in the market/share of product acceptance in the market / product life cycle / environmental analysis and evaluation/marketing capabilities	Globocnik et al., (2020),(Qi et al., (2020), Barrane et al., (2021), Chan et al., (2021)
6	Production risks / Willingness to take risks / Confidence/ new product development investment/ product development funding/ risk and sales uncertainty / risks of financing new product development/challenges in research and development / investment assurance in product development	Globocnik et al., (2020), Laine et al (2020), Graesch et al., (2021), Rouf et al., (2021)
7	Passing the required standards /the level of competence in competitors for product development/ laboratory equipment/the ability of making prototype / the time of carrying out product development projects	Rouf et al., (2021), Barrane et al., (2021), Chan et al., (2021)

4. Research Methodology

Since the main purpose of investigating a dynamic model of decision making in evaluating business plans in an uncertain approach is the development of a product, when it comes to implementation, the research methodology should be an exploratory-modeling one. In this research an attempt has been made to apply quantitative and qualitative techniques so that a dynamic approach to evaluating business plans is presented. Another feature of such modelling is being possible to be simulated in different decision-making scenarios. Figure 1 shows research implementation structure. The population of the research study includes senior organizational managers in the country's chemical industry.

In this research, a statistical sample is not required and in order to collect information the Panel Method with a maximum of 12 experts (selected from chosen companies) has been used. In this research, a dynamic modeling of project evaluation product development according to previous studies has been used.

The models of new product development are recognized based on research and development performance, process innovation performance and product innovation performance. But in order to identify exogenous system variables to select product development projects, the opinion of experts is used.

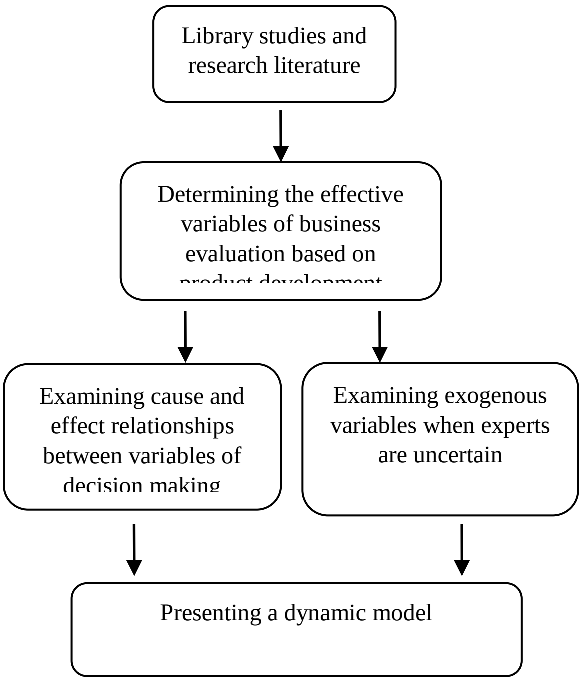

Fig .1. Research implementation structure

System Thinking is a common concept for understanding how causal relationships and feedbacks work in an everyday problem. Understanding a cause and an effect enables us to analyze, sort out and explain how changes come about both temporarily and spatially in common problems. This is referred to as mental modelling, i.e. to explicitly map the understanding of the problem and making it transparent and visible for others through Causal Loop Diagrams (CLD). In brief terms, system thinking is a science that deals with the organization of logic and integration of disciplines for understanding patterns and relations of complex problems. System thinking is also known as principles of organization or theory of self-organization and the way of using it involves "systemic" or "holistic thinking". It is a science based on understanding connections and relations between seemingly isolated things. In general terms system thinking is the mental modelling and science of structuring the logic and asking the relevant questions, but it also has practical applications through System Analysis and System Dynamics. (Shaker et al., 2022).

In a dynamic modelling, auxiliary or exogenous variables can be used to prevent the complexity of modelling and simulation of model behavior. In order to determine the exogenous variables in the dynamic system of product development, a questionnaire with 41 variables based on the literature of research has been designed and sent to all the 12 experts. Then data was collected according to Fuzzy Delphi methodology.

In the next step, based on the opinions of experts, the average effectiveness of each variable is calculated according to the following relationships.

$$A^{(i)} = \left(a_1^i, a_2^i, a_3^i\right), \qquad i = 1,2,3,\dots,n \tag{1}$$

$$A_m = \left(a_{m1}^i, a_{m2}^i, a_{m3}^i,\right) = \left(\tfrac{1}{n}\sum a_1^{(i)}, \tfrac{1}{n}\sum a_2^{(i)}, \tfrac{1}{n}\sum a_3^{(i)}\right) \tag{2}$$

In the mentioned mathematical equation $A^{(i)}$ shows the expert's idea on i and A_m shows the average of experts' ideas. The next step is de-fuzzing. In this research, the average value method is used. In this method, Left and Right separation which is not only easy but also contains membership function information has been used. The purpose of this usage was de-fuzzing. The amount of de-fuzzing by the mean value method is equal to:

$$S(A) = 1/2(S_L(A) + S_R(A))$$

$$S(A) = 1/2\left[(a_{2i} - \int_{a_{1i}}^{a_{2i}} f_{\bar{A}}(x)) + (a_{2i} - \int_{a_{2i}}^{a_{3i}} f_{\bar{A}}(x)) + \right] = \frac{a_{1i} + 2a_{2i} + a_{3i}}{4}$$

Intuitionistic Fuzzy hierarchical analysis technique will be applied in order to determine the exogenous variables that experts are hesitant to determine their importance. To perform the hierarchical analysis, first, the exogenous variables are compared in pairs based on the target. Different fuzzy analytic hierarchy process (FAHP) methods are typically developed for conventional fuzzy numbers (FNs), mainly triangular and trapezoidal FNs (Koulinas et al., 2019). The basic rules in the fuzzy analytic hierarchy process include the following:

Definition 1: The upper and lower bounds in the fuzzy analytic hierarchy set are defined as follows:

$$h^{-}(x) = \mathrm{Min}\ h(x)$$
$$h^{+}(x) = \mathrm{Max}\ h(x)$$

Definition 2: (h) is an intuitionistic fuzzy set which is defined as follows:

$$A_{env}(h) = \{x, \mu(x), V(x)\}$$

which we have in the above relation:

$$\mu(x) = h^{-}(x)$$
$$v(x) = 1 - h^{+}(x)$$

A triangular fuzzy membership function is used in the form of A=(a,b,c) as a set of fuzzy linguistic corrections that in the domain of the definition of A□ is the minimum and maximum elements for calculating A and C must be the same in linguistic terms as $\epsilon HS\ \{Si,\ldots..,sj\}$.

$a = Min\{a_L, a_M, \ldots \ldots, a_R\} = a^i{}_L$

$c = Max\{a_L, a_M, \ldots \ldots, a_R\} = a^i{}_R$

To calculate b, it is necessary to calculate the community of all OWA operators.

$$b = OWA_W(a^i{}_L, a^i{}_M, a^{i+1}{}_M \ldots, a^j{}_M)$$

It is worth mentioning that Geometric mean method to form the following aggregated matrix according to the following relationship has been used.

$$a'_{ij} = \left(\prod_{l=1}^{k} a_{ijl}\right)^{\frac{1}{k}} \qquad l = 1,2,\ldots..,k \quad i,j = 1,2,\ldots.,n$$

To calculate the triangular fuzzy set associated with uncertain fuzzy numbers is used.

Pairwise comparison calculations of the new product acceptance share variable in the market to the pass level variable standardization and requirements will be performed.

To calculate M, it is necessary to calculate the community of all OWA operators.

$$M = OWA_W(a^i{}_M, a^i{}_M, a^{i+1}{}_M \ldots, a^j{}_M) = \frac{1}{i}\sum_{i=1}^{i} a^i{}_M$$

$$L_{C4} = (\prod_{j=1}^{4} ci\,j)^{1/4}$$
$$M_{C4} = (\prod_{j=1}^{4} ci\,j)^{1/4}$$
$$U_{C4} = (\prod_{j=1}^{4} ci\,j)^{1/4}$$

In the next step, we calculate the weight of the criteria based on the geometric mean values on the highest number in the fuzzy scale. The next step is de- fuzzing. De- fuzzing is the method of converting a set of fuzzy numbers into non-fuzzy values. The amount of de-fuzzing by the mean value method is equal to:

$$S(A) = \frac{L_{1i} + 2M_{2i} + U_{3i}}{4}$$

Therefore, based on the analysis, exogenous variables in the state of uncertainty, which is finally approved by organizational experts were added to the basic causal model. Finally, the key variable of passing the standard and requirements is also considered an external factor. Every new product that is produced to be sold in the market must meet the quality standards and legal requirements set by the government or related institutions.

5. Result

In this section, designing a cause-effect model for business plan evaluation has been attempted. Feedback loop in the dynamic system method are generally connected and closed loops of cause and effect. The sign or pole of each link shows how the variables affect each other. Therefore, the cause and effect loop diagram (CLD) can be used as a simple map for communication in a closed system of causal relationships.

The shift in variable of labor productivity is not in the same line with the variable of funding and average production cost. It means that the more the average productivity increases the more the average production cost decreases. Similarly, the results of the change between the two variables of labor productivity, capital and pressure to change the production process are not in the same direction. This issue is also true for the two variables of distinguishing product features and the need for a new feature of the production line. The relationships between these variables are shown in Figure 2 with a negative sign. This Figure just represents the processes of applying this new model which doesn't mention the budget required for each sector. Also clarifies that the new products launching leads us to innovations and some difficulties in changing the process throughout the loop. In the designed CLD, placing the sign (-) on the end of the link means that the change between two variables will not occur in the same direction. Reinforcement loops have several features. They reinforce each other, i.e. they integrate the changes of the same direction with more changes without stopping. They continue to reinforce a particular behavior. Loops R1, R5 and R6 are reinforcing or increasing loops. On the other hand R2, R3 and R4 loops are decreasing or stabilizing ones. After analysis of 6 cause and effect loops, we have integrated the variables of the dynamic model of new product development to be used for business development. As it can be seen in the following diagram the preliminary cause and effect model is designed based on the methods used by past researchers and process connection between dynamic loops.

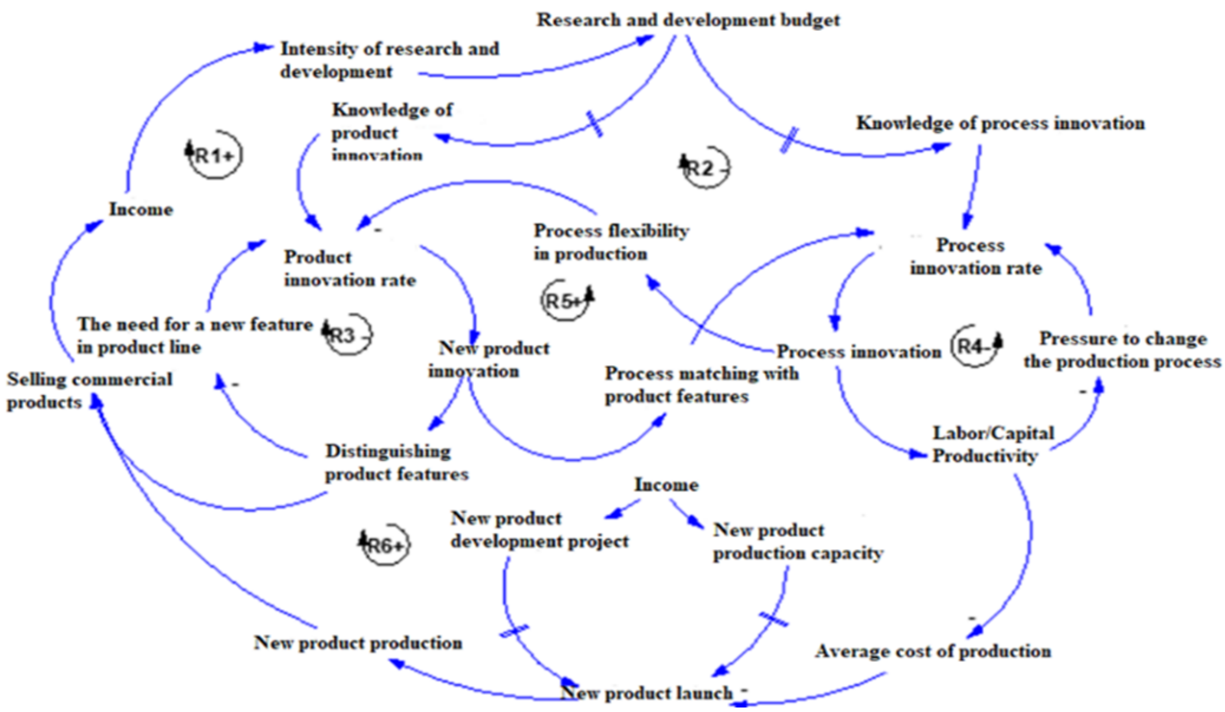

Fig. 2. Basic causal model of new product development

In a dynamic modelling, auxiliary or exogenous variables can be used to prevent the complexity of modelling and simulation of model behavior. In order to determine the exogenous variables in the dynamic system of product development, a questionnaire with 41 variables based on The results of the analysis of experts' answers in the second round can be seen in Table 3.

the literature of research has been designed and sent to all the 12 experts. Then data was collected according to Fuzzy Delphi methodology. Qualitative variables are defined as triangular fuzzy numbers in Table 2.

Table 2
Definition of linguistic variables

Linguistic variables	symbol	Triangular fuzzy number		
		a_1	a_2	a_3
Very low	VL	0	0	2
low	L	1	3	5
Average	M	3	5	7
high	H	5	7	9
Very high	VH	8	10	10

Table 3
The results from the experts' point of view in the second round

Row	Exogenous variables in the dynamic system of product development	The Level of acceptance				
		Very low	low	average	high	Very high
1	Technological capabilities for product development	1	1	3	3	4
2	Implementation time of product development projects	1	1	4	0	6
3	Aspects of the technical capability of design and production	1	2	4	2	3
4	Certainty of investment in product development	0	0	1	5	6
5	Competitors' ability in product development	0	3	3	4	2
6	Production risks	4	2	1	4	1
7	Customers' new needs	0	0	5	4	3
8	The speed of technological change	1	2	3	3	3
9	New product acceptance share in the market	0	0	0	6	6
10	Strategic planning of the organization	1	2	3	3	3
11	Vision and mission of the organization	1	2	3	3	3

12	The company's ability to compete in the market	0	2	4	0	0
13	Environmental analysis	2	2	5	1	2
14	Facilitating risks	3	3	4	2	0
15	Risk and the uncertainty of sale	0	2	4	0	0
16	Acceptable quality of the product	0	2	4	0	0
17	New product development strategy	0	0	0	5	7
18	Product life cycle	3	3	4	2	0
19	Imitability of the product	2	2	2	6	0
20	The level of product originality	1	1	4	3	3
21	Investment resources and project implementation	0	2	4	3	3
22	Attracting funds for applied research	0	0	0	7	5
23	Capability of making prototype	0	7	4	1	0
24	Laboratory facilities and equipment	0	7	4	1	0
25	Passing standards and requirements	0	0	2	5	5
26	Leadership style	0	7	4	1	0
27	Highly-skilled workforce	2	3	4	4	0
28	Laws protecting innovation and intellectual property	4	2	6	0	0
29	Cost of new product development	1	2	3	3	3
30	Research and development challenges	0	2	4	3	3
31	Willingness to take risk	0	2	4	4	2
32	Organizational management	0	1	5	5	1
33	Workforce participation	4	2	4	2	0
34	Marketing capabilities	0	2	4	4	2
35	Funding for product development research	0	0	2	5	5
36	Customers' needs	0	2	5	5	0
37	Innovation of competitors in the market	0	5	5	2	0
38	The availability of market for export	0	5	4	3	0
39	Development of new markets	0	1	4	7	0
40	Creating a new market	0	2	4	6	0
41	Industrial policies and laws	0	2	4	6	0

In the next step, based on the opinions of experts, the average effectiveness of each variable is calculated.

The next step is de-fuzzing. The amount of de-fuzzing by the mean value method is shown in Table 4:

Table 4
De-fuzzing in the first and second round and the difference level

	Exogenous variables of product development	Fuzzy numbers (step 2)			De-fuzzing 2	De-fuzzing 1	The absolute value of the difference
		a_3	a_2	a_1			
1	Technological capabilities for product development	7.92	6.58	4.75	6.46	6.40	0.06
2	Implementation time of product development projects	7.92	6.92	5.08	6.71	6.74	0.03
3	Aspects of the technical capability of design and production	7.33	5.83	4.00	5.75	5.75	0.00
4	Certainty of investment in product development	9.33	8.33	6.33	8.08	8.08	0.00
5	Competitors' ability in product development	7.67	6.00	4.00	5.92	5.96	0.04
6	Production risks	5.92	4.08	2.75	4.21	4.21	0.00
7	Customers' new needs	8.42	6.92	4.92	6.79	6.79	0.00
8	The speed of technological change	7.50	6.00	4.17	5.92	5.99	0.07
9	New product acceptance share in the market	9.50	8.50	6.50	8.25	8.20	0.05
10	Strategic planning of the organization	7.50	6.00	4.17	5.92	5.92	0.00
11	Vision and mission of the organization	7.50	6.00	4.17	5.92	5.82	0.10
12	The company's ability to compete in the market	3.17	2.17	1.17	2.17	2.27	0.10
13	Environmental analysis	6.50	4.83	3.17	4.83	4.93	0.10
14	Facilitating risks	5.58	3.58	2.08	3.71	3.71	0.00
15	Risk and the uncertainty of sale	3.17	2.17	1.17	2.17	2.17	0.00
16	Acceptable quality of the product	3.17	2.17	1.17	2.17	2.17	0.00
17	New product development strategy	9.58	8.75	6.75	8.46	8.43	0.03
18	Product life cycle	5.58	3.58	2.08	3.71	3.73	0.02
19	Imitability of the product	6.83	4.83	3.17	4.92	4.92	0.00
20	The level of product originality	7.67	6.17	4.33	6.08	6.18	0.10
21	Investment resources and project implementation	7.92	6.42	4.42	6.29	6.29	0.00
22	Attracting funds for applied research	9.42	8.25	6.25	8.04	8.04	0.00
23	Capability of making prototype	6.00	4.00	2.00	4.00	4.19	0.19
24	Laboratory facilities and equipment	6.00	4.00	2.00	4.00	4.18	0.18

25	Passing standards and requirements	9.08	7.92	5.92	7.71	7.67	0.04
26	Leadership style	6.00	4.00	2.00	4.00	4.00	0.00
27	Highly-skilled workforce	6.17	4.17	2.50	4.25	4.25	0.00
28	Laws protecting innovation and intellectual property	5.00	3.00	1.67	3.17	3.23	0.06
29	Cost of new product development	7.50	6.00	4.17	5.92	5.78	0.14
30	Research and development challenges	7.92	6.42	4.42	6.29	6.24	0.05
31	Willingness to take risk	7.83	6.17	4.17	6.08	6.08	0.00
32	Organizational management	7.92	6.08	4.08	6.04	6.04	0.00
33	Workforce participation	5.33	3.33	2.00	3.50	3.50	0.00
34	Marketing capabilities	7.83	6.17	4.17	6.08	6.18	0.10
35	Funding for product development research	9.08	7.92	5.92	7.71	7.74	0.03
36	Customers' needs	7.50	5.50	3.50	5.50	5.50	0.00
37	Innovation of competitors in the market	6.50	4.50	2.50	4.50	4.50	0.00
38	The availability of market for export	6.67	4.67	2.67	4.67	4.55	0.12
39	Development of new markets	8.00	6.00	4.00	6.00	6.07	0.07
40	Creating a new market	7.67	5.67	3.67	5.67	5.54	0.13
41	Industrial policies and laws	7.67	5.67	3.67	5.67	5.60	0.07

According to Table 4 and the differences between the averages of two steps using distance relationships between fuzzy numbers and minimum difference of 2%, the experts were in total agreement regarding all the variables. To select variables, finally number 7 was considered as the selection threshold. Therefore, all the variables whose de-fuzzing score is above 7 were approved by experts as final evaluation.

ID4: Certainty of investment in product development
ID9: New product acceptance share in the market
ID17: New product development strategy
ID22: Attracting funds for applied research factor
ID25: Passing standards and requirements
ID35: Funding for product development research

The basic rules in the fuzzy analytic hierarchy process include the following based on Definition 1&2.

A triangular fuzzy membership function is used in the form of A=(a,b,c). Table 5 shows verbal variables to fuzzy numbers using the given scale.
According to Table 6, experts do not hold the same opinion in some cases. Therefore, to make the opinions similar, we consider them in the following mode.

C1: The investment certainty factor of new product
C2: New product acceptance share in the market
C3: New product development strategy
C4: Attracting funds for applied research factor
C5: funds attracting factor for Product development research
C6: Passing standards and requirements

To calculate the triangular fuzzy set associated with uncertain fuzzy numbers is used. Table 7 presents the triangular fuzzy sets obtained by the OWA operator from the numbers in the above table.

Table 5
Definition of verbal variables

Linguistic variable	Code	Triangular fuzzy number		
		U	M	L
Extremely high importance	AHI	9	9	7
Very important	VHI	9	7	5
Relatively high importance	ESHI	7	5	3
Not important	WHI	5	3	1
Almost the same importance	EHI	3	1	1
exactly equal	EE	1	1	1
not important	ELI	1	1	0.33
Weak significance	WLI	1	0.33	0.2
Relatively low importance	ESLI	0.33	0.2	0.14
Very little importance	VLI	0.2	0.14	0.11
Absolutely unimportant	ALI	0.14	0.11	0.11

Table 6
Integration of opinions in the hesitant state of communication

Exogenous variables	C1	C2	C3	C4	C5	C6
C1	EE	ESHI, AHI	WLI,VLI	VHI	VLI,WLI,ALI	AHI
C2		EE	EHI,ESHI	ESHI	VHI	AHI, ESHI, WHI, EHI
C3			EE	EHI	VHI	ELI
C4				EE	EHI, ELI	VLI,WLI,ALI
C5					EE	VLI,WLI,ALI
C6						EE

Table 7
Values of fuzzy triangular set of communication

Exogenous variables	C1			C2			C3			C4			C5			C6		
C1	1.00	1.00	1.00	3.00	7.00	9.00	0.10	0.20	1.00	5.00	7.00	9.00	0.11	0.20	1.00	7.00	9.00	9.00
C2	0.11	0.14	0.33	1.00	1.00	1.00	1.00	3.00	7.00	3.00	5.00	7.00	5.00	7.00	9.00	1.00	4.50	9.00
C3	1.00	5.00	10.00	0.14	0.33	1.00	1.00	1.00	1.00	1.00	1.00	3.00	5.00	7.00	9.00	0.33	1.00	1.00
C4	0.11	0.14	0.20	0.14	0.20	0.33	0.33	1.00	1.00	1.00	1.00	1.00	0.33	1.00	3.00	0.11	0.20	1.00
C5	1.00	5.00	9.09	0.11	0.14	0.20	0.11	0.14	0.20	0.33	1.00	3.03	1.00	1.00	1.00	0.11	0.20	1.00
C6	0.11	0.11	0.14	0.11	0.22	1.00	1.00	1.00	3.03	1.00	5.00	9.09	1.00	5.00	9.09	1.00	1.00	1.00

For example, pairwise comparison calculations of the new product acceptance share variable in the market (C2) to the pass level variable standardization and requirements (C6) which is equal to (1 4.50 9) as follows. Because the experts have four different opinions with doubts about the pairwise comparisons of the two analyzed variables.

$$AHI = (7\ 9\ 9)\ , ESHI = (3\ 5\ 7)\ , WHI = (1\ 3\ 5)\ , EHI = (1\ 1\ 3)$$

So we have

$L = Min\{7\ 3\ 1\ 1\}$=1

$U = Max\{9\ 7\ 5\ 3\}$=9

To calculate M, it is necessary to calculate the community of all OWA operators.

$$M = OWA_W(a^i{}_M, a^i{}_M, a^{i+1}{}_M \dots, a^j{}_M) = \frac{1}{i}\sum_{i=1}^{i} a^i{}_M$$

$$M = \frac{9+5+3+1}{4} = 4.50$$

Based on Table 7, the geometric mean of the values in each row is calculated as Table 8.

$$L_{C4} = (\prod_{j=1}^{4} ci\,j)^{1/4}$$

$$M_{C4} = (\prod_{j=1}^{4} ci\,j)^{1/4}$$

$$U_{C4} = (\prod_{j=1}^{4} ci\,j)^{1/4}$$

Table 8
Geometric mean values of exogenous variables

Exogenous variables	L	M	U
C1: the investment certainty factor of new product	1.024	1.613	3.000
C2: New product acceptance share in the market	1.089	2.018	3.313
C3: New product development strategy	0.786	1.506	2.542
C4: Attracting funds for applied research factor	0.240	0.423	0.765
C5: funds attracting factor for Product development research	0.277	0.523	1.016
C6: Passing standards and requirements	0.481	0.923	1.815

In the next step, we calculate the weight of the criteria based on the geometric mean values on the highest number (number 9) in the fuzzy scale. The next step is de- fuzzing. De- fuzzing is the method of converting a set of fuzzy numbers into non-fuzzy values. Many of these methods have been developed in the past decades. In this research, mean value method is applied. In this method, Left and Right separation, which is not only easy but also contains membership function information has been used for de-fuzzing. The amount of de-fuzzing by the mean value method is equal to:

$$S(A) = \frac{L_{1i} + 2M_{2i} + U_{3i}}{4}$$

Table 9 shows determining the weighted importance of exogenous variables.

Table 9
Determining the weighted importance of exogenous variables

Exogenous variables	**L**	**M**	**U**	De-fuzzing	final weight
C1: the investment certainty factor of new product	0.114	0.179	0.333	0.201	0.239
C2: New product acceptance share in the market	0.121	0.224	0.368	0.234	0.278
C3: New product development strategy	0.087	0.167	0.282	0.176	0.209
C4: Attracting funds for applied research factor	0.027	0.047	0.085	0.051	0.061
C5: funds attracting factor for Product development research	0.031	0.058	0.113	0.065	0.077
C6: Passing standards and requirements	0.053	0.103	0.202	0.115	0.136
				0.843	1.000

According to compatibility rate, C.R=0.024 is less than 0.1. Therefore this analyzed matrix has completed stability and it can be the basis of the importance of exogenous variables.

Therefore, based on the analysis, exogenous variables in the state of uncertainty, which is finally approved by organizational experts were added to the basic causal model. It should be mentioned that the relationships between exogenous variables and systemic variables are hypotheses. New product development investment certainty factor variable of exogenous nature and its direct impact on research and development budget depends on product development projects. Every organization can change the risk of investment by strategic decision-making of the high-rankings managers and it does not originate from the amount of sales or competitiveness. In domestic studies, it has been shown that regardless of brisk sales of products that companies enjoy, there is no interest in research and development for new products. New product development strategy. New product development strategy, as an exogenous variable on the intensity of research and development plays a role for new product development. This strategy can originate from various factors; however, due to the complexity of the relationships affecting the formulation of the new product development strategy, it has been left out and this variable is considered as an aid in solving the system model. The absorption rate of product development research funding is considered as an exogenous variable in the creation of product innovation. Similarly, the absorption rate of applied research funding is considered as an exogenous variable in process of innovation knowledge creation. The share of new product acceptance in the market is related to various factors that this variable is only considered as an exogenous factor in the new product supply by the company. Finally, the key variable of passing the standard and requirements is also considered an external factor. Every new product that is produced to be sold in the market must meet the quality standards and legal requirements set by the government or related institutions. In Figure 3, the cause and effect model can be seen by considering exogenous variables which illustrates the closed relationship between evaluating business plans with a new product development approach. Starting with income loop, we have the factors of new product development and new product production capacity that together certifies the launching of every new single product. As was mentioned before, negative sings shows the opposite relation between factors which means as one increases the other one decreases. Loop R3 represents that, as the rate of innovation rises matching the process with product features requires more attention and clarification.

6. Conclusion and Discussion

This research has been carried out with the purpose of proposing an organization's business evaluation approach by linking different dynamic processes in the development of new products for a manufacturing company. The dynamic new product development model considered in this research is based on the theory of (Globocnik et al., 2020) which is itself about Gunn's product and process innovation along with the chain model (Gann et al, 2020). This model is used to assess the dynamic flow of innovation, where the tendency towards a complex aspect of innovation is achieved through mutual internal exchange. Feedback in each department of a business can help develop innovation in product development. Since the relationship between different types of innovation with research and development and production is important, the feedback loops that exist in the dynamic system method are generally connected and closed loops of mutual causes and effects. The sign or pole of each link shows how the variables affect each other. Therefore, a causal loop diagram can be viewed as a simplified map of connections in a closed system of cause and effect. The shift in variable of labor productivity is not in the same line with the variable of funding and average production cost. It means that the more the average productivity increases the more the average production cost decreases. Similarly, the results of the change between the two variables of labor productivity and capital and pressure to change the production process are not in the same direction. This issue is also true for the two variables of distinguishing product features and the need for a new feature of the production line. After analysis of 6 cause and effect loops, we have integrated the variables of the dynamic model of new product development to be used for business development. Besides, following the footsteps of past researchers, process connection between dynamic loops was designed. To determine the exogenous variables in the dynamic system of product development based on research literature 41, first, the identification was done and then according to fuzzy Delphi methodology, the required data was collected. The results show that 6 exogenous variables were selected as key variables in the selection and development of a new product in the organization.

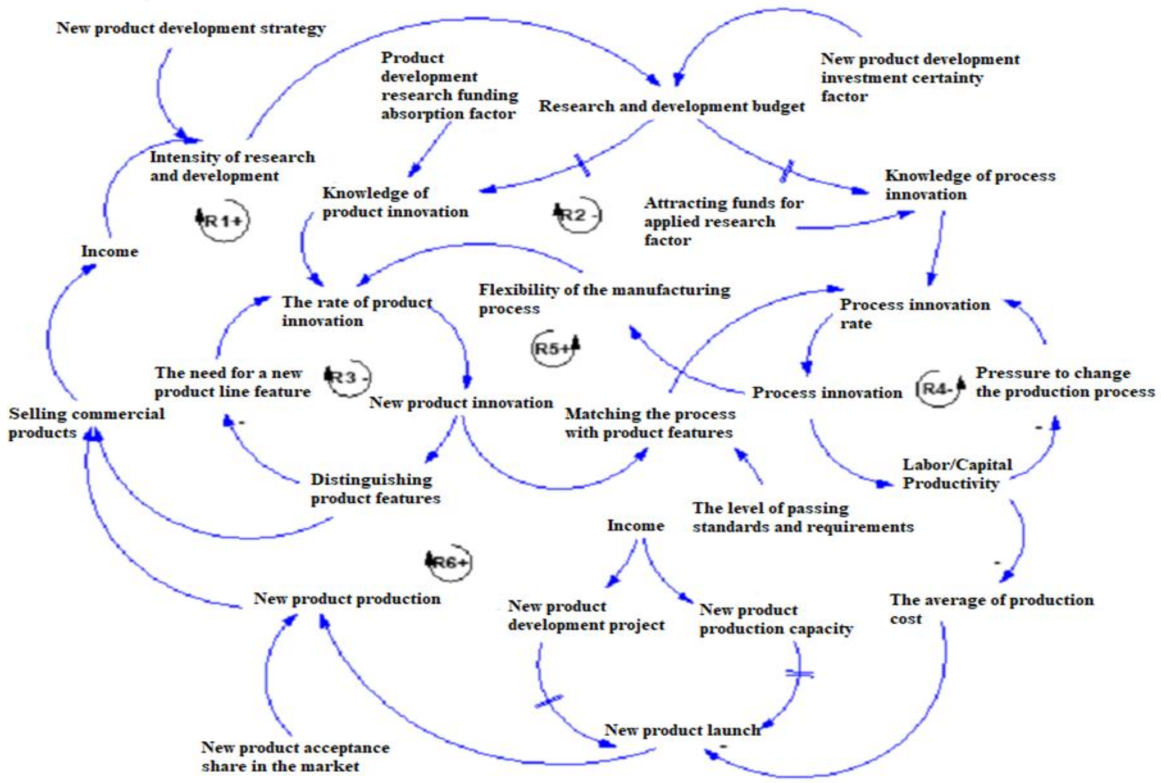

Fig. 3. The final causal model for evaluating business plans with a new product development approach

In this research, to determine the importance of the exogenous variables that experts have difficulty in determining their importance, the fuzzy hierarchical analysis technique has been used. To perform the analysis, first, the exogenous variables are compared in pairs based on the goal. The weighted importance of exogenous variables according to the use of fuzzy method in decision making is:
certainty of investment in product development (0.239), new product acceptance share in the market (0.275), new product development strategy (0.209), attracting funds for applied research factor (0.077), passing standards and requirements (0.136), and funding for product development research (0.061) therefore, based on the analysis, exogenous variables in the state of uncertainty, which were finally approved by organizational experts, were added to the basic causal model. New product development investment certainty factor variable of exogenous nature and its direct impact on research and development budget depends on product development projects. Every organization can lower the risk of investment by strategic decision-making of experts and it does not originate from the amount of sales or competitiveness. In domestic studies, it has been shown that regardless of brisk sales of products that companies enjoy, there is no interest in research and development for new products.
New product development strategy is also an exogenous variable on the intensity of research and development for new product development. Based on the results of this research, there is a close relationship between the technical knowledge of new product manufacturing and process innovation. Management in business development should be dynamic interactions between new product development and design processes and also should consider the limitations caused by the implementation of different types of innovation. The dynamic product development model, which is based on the cause and effect relationship, needs to test the simulation of the present and future decision-making performance. For this reason, as it was shown in the causal diagram, this model can be simulated by changing the coefficients of decision and exogenous variables. The degree of reliability and intensity of research and development is influential in research and development investment. The level of technological capabilities is influential on the investment of new product development projects. In addition to this capability, the intensity of competitiveness in the market and the importance factor in investing in the production of new products can be obtained from the flow of profit from the sale of commercialized products. Therefore, these five key factors can be effective in the organization's decision-making in selecting and developing new products. Therefore, the analysis of exogenous variables based on different scenarios can provide a more appropriate approach in analyzing the behavior of the studied system. Based on its business strategies, the organization can focus on the process innovation of its current products to reduce production

costs, increase quality, reduce waste and increase production speed. All of them are mentioned under the title of organizational productivity. But according to this research, regardless of the required capital and resource limitations in the development of new products, increasing investment in product innovation is more effective in strengthening the profitability of the organization than investing in process innovation. Therefore, it can be suggested that the organization should increase the share of investment in product innovation in order to develop a new product. Until now, companies have consistently done their best with short-term product innovation. However, this research shows that a firm's investment policy relies on product innovation to maximize short-term profits. In the case of innovation, both product innovation and process innovation are critical policy parameters. Therefore, this research proposes a mechanism for making investment decisions according to the state of the companies and the market structure. These decisions are in the dimension of medium and long-term dynamics. According to the results of the current research, suggestions for future research can be recommended as follows:

- Since the dynamic model defines the time interval conventionally, an arbitrary time interval may make it difficult to accurately measure each parameter. There may be errors in the simulation sensitivity settings. Therefore, objective and more accurate analysis of data is needed in order to check the validity of the model for every company.
- It should be noted that the model presented in this research may provide different results when applied to other industries or different processes. Therefore, future research should prepare another approach for other industries based on this issue.
- This research should combine data on consumer behavior in the process, from launching a new product to customer purchase of this product to reinvesting in research and development.
- Although innovation makes the product superior and cheaper than existing products in terms of performance and quality, the process of introducing a new product from the customer's point of view provides another research topic. Therefore, future research should include consumer behavior regarding new products in the market.

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