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Gravitational Intelligent Decision-Making Model at the Fuzzy Front End with Extrinsic Idea Integration by the K-Means Algorithm

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Abstract: If the dynamic fuzziness of the Front End (FE) part of New Product Development (NPD) cannot be treated in a timely manner, fuzziness accumulates over other parts of NPD hence NPD can result in costly mistakes. The authors tried to remedy this strategically critical problem by implementing mainstream theoretical/methodological approaches, but they found inherent weaknesses of each. The purpose of this study is to bring an objective and intelligent decision-making model to FE so as to lessen fuzziness of it. Model quantizes ideas based on pillars, and re-clusters them with every new idea addition thanks to combining non-mainstream approaches like K-means, distance-based algorithm with gravitational theory inspiration, an accumulation of idea and an exponential function. Study showed that fuzziness of FE can be lessened by quantizing, and objectively managing. The founded core reasons of fuzziness can guide practitioners and authors for better understanding and coping with fuzziness of FE; moreover, the model can be used by companies. Introducing an objective and intelligent decision-making model working like a human brain to FE is a unique idea that has not been tried ever before.

Keywords: Fuzzy Front End (FFE); extrinsic idea integration; K-means; idea selection; intelligent decision-making; decision support

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1. Introduction

The effective and efficient development of high quality new products is a requirement when rapid evolving technologies, more demanding customers, and fast changing markets are considered [1]. However, the development of a continual stream of new products via the new product development (NPD) process requires extensive time and effort.

Moreover, dynamically changing conditions also increase the unsuccessful rate of NPD more than ever [2]. At this point, the quality of both the pre-development activities and project definition makes the greatest distinction between successful and unsuccessful companies [3–7]. These activities are covered in the Front End (FE) part of NPD. FE is generally called as Fuzzy FE (FFE), due to the lack of reliable information, proven decision rules and well-defined processes [8]. There, existing risk resources need to be early diagnosed and managed, instead of waiting for impossible total risk avoidance [9]. If risk sources are not managed well in FE, inherent fuzziness in FE accumulates through other NPD steps and causes costly mistakes.

These aforementioned findings lead us to think that lessening the fuzziness of FE is a strategic decision, however, only limited studies have been conducted to provide a remedy such as Stage-Gate System [10,11], "Alternative versus alternative" method [12], rapid, electronic, or self-managed gates [13], spiral development [14], and Agile Stage-Gate System [15].

Even though all these studies were executed under different names, their proposed models were based on similar, in other words, mainstream approaches. While these mainstream approaches are providing relatively easier and faster decision-making, they have drawbacks such as subjective assessment and elimination of ideas. In addition to these drawbacks, already proposed models provide a limited and similar remedy as a result of that they were based on similar mainstream approaches. There, rather than creating a model based on these similar approaches and waiting for different results than other proposed models, an innovative model should be created for FE. In other words, an innovative model should include mechanisms such as dynamic foresight and updating weights of multi-dimensional decision criteria.

Considering the conclusion that the critical success factors of Stage-Gate development process and FFE are not different [16], 10 generic decision criteria for FFE were designated as pillars [17], and based on them, an intelligent decision model was proposed for FFE [18].

The proposed model in [18] brought an innovative perspective to FFE, however, it had drawbacks such as lacking knowledge generation or management [19,20], unmatching the rate between the timing of information exchange, not changing in the environment [21], and not using a dynamic model to minimize the effect of time [22]. Furthermore, the FE model should be supported with a dynamic idea portfolio based on innovative idea resources such as supplier involvement [23], social media tools [24], embedded open toolkits [25], and interaction among R&D centers and universities, the public sector, industry [26], social media, patents, open innovation, and tacit knowledge. There, the motivation was the creation of an ultimate innovative model based on unique solutions never tried before for FE to cover the aforementioned drawbacks.

With this motivation at hand, the executed study identified challenges in front of these solutions, not only which solutions should be used but also how these solutions should be executed in the model. There, a unique model based on pillars presented in [17,18] was created and it was strengthened with non-mainstream approaches like an accumulation of ideas and objective decision-making. These two mainstream approaches were embodied by a uniquely combined K-means, distance-based algorithm with gravitational theory inspiration and exponential function. As a result, an enabler tool was created for innovation teams.

2. Relation to Existing Theories and Work

A literature review was executed in two steps to create an innovative FE model. In the first step, studies including innovation, NPD, and FE keywords were searched. In the second step, studies including both NPD keyword and also Management Control Systems (MCS), Diagnostic Controls, Decision Support Systems (DSS), Artificial Intelligence, Knowledge Management, Integrative Models, Idea Assessment, Open Innovation, Social Media, Analogical Thinking in Invention, Innovation Typology, Nature of Online Ideas, and Uncertainty Reduction keywords were searched. As a result, 111 articles, 13 books, and 5 book chapters were found and studied. The executed literature review not only revealed different proposed methods by authors to lessen fuzziness in NPD, but also identified challenges in front of creating an innovative FE model. Consequently, methods to lessen fuzziness in NPD will be explained under the three following main groups.

When should fuzziness or uncertainty in NPD be lessened? Uncertainty is the distinction between the amount of information required and its already gathered part [27]. Changing environmental conditions should be seen as an opportunity rather than as a threat [28]. In this manner, the authors suggested lessening uncertainty in strategic planning [29], in FE [7,30,31], and not in the development stage [4].

How should fuzziness in NPD be reduced? Authors proposed to reduce fuzziness by implementing mainstream/legacy methods such as customer and competitor analysis, fusing customer needs into products, integrating upper management, studying rivals and their products [32], customer participation [33], and customer relationship [34,35], regular direct contact with customers [6], the knowledge about competitors and likely competitive moves [36], integrating the customer regarding the company's products, services, and technologies, and the firm's employees [37–42], competitors' and technologies' limits and keeping the value of crucial variables within predetermined limits [21], firms' in-house capability and expertise [43], matching the customer needs with a firm's fabricating potential [44], using a diverse assessment group [45], experiments and corporate entrepreneurship [46], and collective identity [47].

How should gathered ideas in NPD be processed? Specific words or expressions are used to relay ideas among people [48], but they are partly structured or unstructured [49]. Ideas' complex nature hinders both being found and to be used for innovation [50,51]. This causes difficulty while defining the requirements of future products [52,53]. Moreover, idea assessment is a multi-dimensional process including strategy, finance, technology, manufacture, market, and customer dimensions [54]. Probably because of these reasons, idea assessment was executed by 54% of individuals-groups and by 46% of interdisciplinary teams [32] or automatic idea detection systems at initial screening [55].

The aforementioned findings prove that the process of lessening fuzziness should be begun in FE and that this process should be managed by a specifically designed FE model; otherwise, FE fuzziness relays through other NPD steps and causes more costly mistakes. In the following paragraphs, five challenges confronted while creating an FE model will be identified.

The first challenge was to answer whether project management types depend on the innovation level of the project or not. Projects were classified as low, medium, high, and super-tech [56,57]. In these projects, fewer features are common [57,58], high and low uncertainty projects have to be managed differently [33], radical and incremental NPD projects' FE are different [59–61], and there is no universalistic theory [56,62–64]. Oppositely, radical and incremental projects' FE has no dramatic differences [7]. There, the balance should be secured among conflicting requirements of different project types [65–69] by the usage of ambidexterity and punctuated equilibrium strategies [70,71].

The second challenge was to answer what is expected from FE MCS. Out of 3000 ideas, 125 were selected for development and just 1 gained commercial success [72]. The probable reason for mistakenly chosen ideas can be seeing the early stages of an innovation system as a trial-error phase [72,73], lacking key technical features, meeting buyer needs and adequate marketing support [74], poor constrained information flow [4], and no shared knowledge [75]. There, a remedy can be provided by the sharing of information [76,77], coordination and common database usage [78], decentralization of planning activities [4], no elimination of opportunities at strategic and project-level screening processes [79], knowledge exchange via conferences, research forums, seminars, and technology exchange meetings, etc. [80], and preserving of not selected but valued ideas [81].

Moreover, MCS should also have other capabilities such as goal alignment [82–84], integration [82,85–87], adaptability [82,84,88], providing dynamic equilibrium with the environment [89], fast idea screening [31], rapid risk elimination of ideas [16], securing balance between generality and particularity while comparing rival concepts in detail [90], accessing the diverse information [91], exploring discontinuity [92], and selecting original product concepts [8]. At that point, the definition of the original idea should be made.

When the distance between the old and the new idea is small, it falls into the class of "literal similarity" [93] and is considered less original [94]. In contrast, when the distance is far, the relationship of ideas is viewed as a far analogy and called as "mental leaps" [94,95]. There, information delivered from near analogy is different than from far analogy [8].

The third challenge was to answer what kind of control techniques MCS should have. Control techniques should provide the balance between the control and the operational context [96,97], more regulatory variety [21], conventional contingency analyses [98], diagnostic controls [99,100], product comparison [54], a bypass instead of excessive process control [101], no ad hoc collections of control techniques [102–105], and an avoidance of over-emphasizing diagnostic mechanisms [106]. These findings revealed that there is no consensus on control techniques even if their usage is required to maintain competitiveness in the market [107].

The fourth challenge was to answer which types of a Decision Support System (DSS) should be used by companies. The authors suggested using a business strategy document [108], Multi-Attribute Utility Theory (MAUT) [109], MAUT with Cumulative Prospect Theory (CPT) [110], Expert Decision Support Systems (EDSS) combined with a knowledge-based expert system (ES) and DSS [54,111], NEWPRODEX [112], Integrative Model of NPD Process [36], the combination of fuzzy neural network and constraint programming methods [113], and deep learning [114].

The fifth challenge was to answer how extrinsic ideas should be integrated into already existing ones. Actually, this challenge was a derived need for the FE model when other challenges were considered but there was no direct study about it. Just a few indirect studies were found, such as defining the mathematical relationship between product and customer as a nonlinear pattern [114–116], exponential curve [90], and rectified linear unit and exponential linear unit [117]. Other studies concluded that quantitative functions generally are not known [118]; even if known, they are not shared because of the competition among partners [119]. All these aforementioned challenges have no hierarchy against each other and are not to be solved respectively, but the FE model has to be designed to answer all of these challenges at the same time. Founded challenges were summarized in Figure 1.

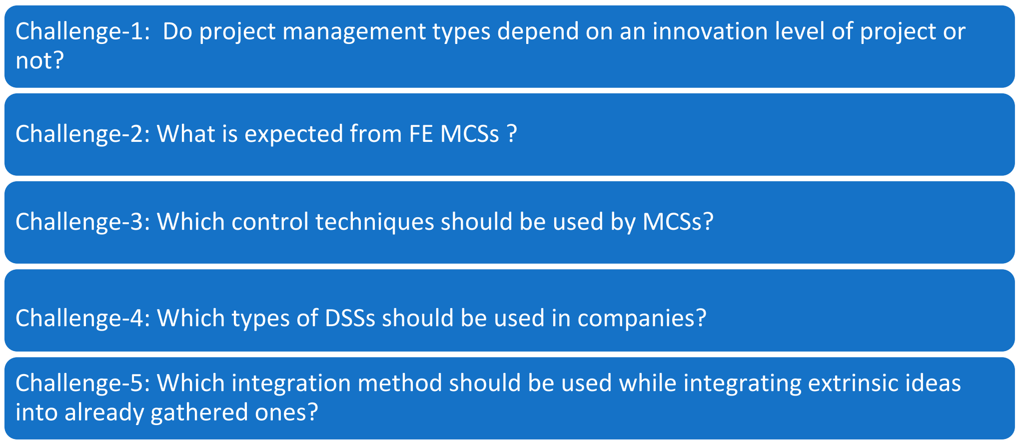

Figure 1. Challenges in front of creating an FE model.

The complexity of defining a mathematical relationship in FE guides managements to use non-analytic "gut feel" in their decision-making process and to treat ideas as if they are independent of each other. There, rather than executing the same techniques used by other authors and waiting for different results than their studies, ideas should be integrated into each other by using joint attributes (here called as pillars) to reach an objectively defined total memory of the market. Then, an objective decision-making process should be executed among founded total memory. How this uniquely created FE model works will be explained in the next section.

3. Innovative FFE Model Approach-Methodology

Existing FE models could not select promising ideas due to their inherent drawbacks of them. One drawback was the elimination of ideas by which valuable knowledge was discharged. Another was the usage of a subjective assessment process limiting the success of it with an individual or group's pure tacit knowledge. Actually, FE fuzziness can only be dealt with by creating an innovative FE model based on non-mainstream approaches like no idea elimination and an objective assessment of ideas.

In detail, each idea has the knowledge and can affect other ideas. As a result, total memory occurs similarly to how the human brain works. The brain gathers knowledge independent of time and situation, creates links among them, and then accumulated knowledge is used to reach correct decisions. Here, this inherently unique feature of humans is transferred into our model by creating an accumulation idea approach. This approach depends on dissipating quantized knowledge of one idea into others in an idea pool with considering the related idea's importance. While in quantization, pillars defined in [17,18] are used. Thus, decision-making can be executed considering both the idea itself and the history of all accumulated ideas to explore market trends objectively.

There among total memory, promising quantized ideas are chosen by a uniquely created decision model combining K-means, the distance-based algorithm with gravitational theory inspiration, and the exponential function methods. In the model, the objective selection of ideas was secured by using both the idea quantization and the objective decision model. In addition, the idea pool should be dynamically supplied with not only previously mentioned legacy methods but also modern idea resources such as social media, patents, open innovation, etc. How this proposed model overcomes the aforementioned challenges of creating an FE model will be explained next.

The first challenge is the separation of radical and incremental projects since there is no global optimization method for FE due to the many different economics of the specific situation [31]. Thus, not only the selection of promising ideas in its related innovation group but also the comparing and then eliminating ideas from different innovation groups are secured.

The second challenge has two aspects. First, the accumulation of idea approach secures effective information flow. Second, the need for decentralization of activities is provided by attaining relative weights to pillars with respect to a distance-based algorithm. Furthermore, idea assessment is executed in both micro- and macro-level market perspectives by calculating local and global values of ideas, respectively. Hence, outlier ideas are included in the decision-making process.

The third challenge is the dynamic updating of weights of pillars according to ideas' changing importance, hence promising idea selection can be provided.

The fourth challenge is the hybrid usage of the best sides of humans and machine algorithms. The idea assessment team has tacit knowledge but their decision made is subjective. Algorithms and machines are good at objective decision-making, but they have problems dissolving ideas into pillars because of the inherently complex nature of ideas. These facts led us to think that the decision-making process should be executed by an algorithm. However, other supplementary processes such as dissolving ideas into pillars, finding and completing missing information in an idea, creating new ideas, or updating already supplied ones by studying previous ideas should be executed by an interdisciplinary team.

The fifth challenge is to secure promising ideas by effective usage of the accumulation of idea approach and the exponential function. Thus, all ideas are secured not only to be considered later but also to provide total memory of the market. Moreover, in the model, each idea addition dynamically and exponentially affects other ideas' importance, which is explained next.

4. K-Means Algorithm with Extrinsic Idea Approach Model

4.1. Step-1: Find Each Pillar Scale

The size of each pillar scale is not limited, however, 10 choices are equilibrium between clarity and specificity [120]. The scale should be in quantitative form, however, if the scale is in qualitative form, it should be converted into the quantitative form by the firm's executives regarding the market and product innovativeness.

4.2. Step-2 Find the Level of "K"

K-means algorithm is used to classify ideas into "K" groups or clusters. While "K" value is generally chosen with an intuition base, it should be in balance with the size of related pillar scales, otherwise, trend knowledge is lost.

4.3. Step-3 Assign Each Pillar to a Weight

Initial pillar weights presented in Pillar Weight Vector (w_s) are assigned by a firm's executives regarding the market and product innovativeness. Thanks to this perspective, pillars' importance is converted into a quantitative form thus an objective comparison of pillars is secured.

4.4. Step-4 Create a New Idea Value Vector

An idea's qualitative data are mapped or dissolved into the quantitative form regarding each pillar scale by an interdisciplinary team and called here as Idea Value Vector (v_t).

4.5. Step-5 Calculation of Clusters' Centroids by Using K-Means Algorithm

K-means algorithm considers, at the same time, both minimizing distances within clusters and maximizing distances among clusters' centroids. With every new idea addition, K-means algorithm re-clusters ideas regarding the new state. Clusters' centroids are presented in the Center of Gravity Value Vector (CoG).

4.6. Step-6 Update Pillar Value Vector

Newton's Theory of Gravitation states that a mass attracts another mass in the universe, and the gravitational force appearing between them is not only proportional to the product of these masses but also inversely proportional to the square of the distance between them. Concisely, the more distance means less attraction. This fact can be used in our case since an original idea emerges when there is no resemblance to previous ones. Thus, to discover original or promising ideas, Distance Weighted Algorithm based on measuring the biggest difference between an idea and its related centroid and finding its weight counterpart in w_s was created. While this algorithm exponentially upgrades the promising pillar's weight counterpart, it also downgrades others. Then, Updated Pillar Weight Vector (w_{se}) is created. There, the r value represents the growth/decay rate, and q represents the maximum value in the pillars' value vector:

$$d_t = |CoG - v_t| \tag{1}$$

$$w_e = \frac{[w_e]}{(q)} \tag{2}$$

$$[w_e, l] = find(d_t == \max(d_t(:))) \tag{3}$$

$$r = \frac{\sum_{t=1}^{l} (d_t == \max(d_t(:)))}{l} \tag{4}$$

$$y = a(1+r)^{1/l} \tag{5}$$

$$[w_{se}, l] = [w_e + y, l] \tag{6}$$

$$z = \frac{y * l}{(10 - l)} \tag{7}$$

$$[w_{se}, 10 - l] = [w_e - z, 10 - l] \tag{8}$$

$$[[w_{se}] = [[w_{se}, l] + [w_{se}, 10 - l]]] \tag{9}$$

4.7. Step-7 Calculate Global Point (PG) for Each Idea

PG_t value for each idea is recalculated by using Distance Vector (d_t) and Updated Pillar Weight Vector (w_{se}) at every new idea addition. Here, it should be noted that when a new idea is added to an idea pool, CoG vector and w_{se} change, thus PG_t also changes:

$$PG_t = \frac{w_{se} d_t}{\sum_{s=1}^{n} w_{se}} \tag{10}$$

4.8. Step-8 Calculate Local Point (PL) for Each Idea

PL_t calculation starts with finding the biggest absolute distance value(s) (k = # of biggest absolute values) in d_t. Then, values in w_{se} corresponding to the biggest absolute value(s) in d_t are found. The product of the biggest absolute value(s) and its corresponding value(s) gives PL_t. PL_t recalculation is executed for each idea with every new idea addition:

$$[m_t, k] = find(d_t == \max(d_t(:))) \tag{11}$$

$$w'_{se} = [w_{se}|k] \tag{12}$$

$$PL_t = \frac{m_t w'_{se}}{\sum_{t=1}^{k} w'_{se}} \tag{13}$$

4.9. Step-9 Calculate Average Value of Updated Pillar Weight Vector

Values in w_{se} are averaged and then the found vector is called as ap_t. This step provides adaptively following pillar importance. For instance, even if an idea's PL_t or PG_t is high, this idea's Total Point can decrease as a result of the idea's improper weight distribution, or vice versa:

$$ap_t = \frac{\sum_{t=1}^{l} w_{se}}{k} \tag{14}$$

4.10. Step-10 Calculate Total Point (P) for Each Idea

P_t value for each idea is recalculated by multiplying PL_t, PG_t, and ap_t with every new idea addition.

$$P_t = PG_t x PL_t x ap_t \tag{15}$$

4.11. Step-11 Increase Index

This step assigns each idea to a unique index number called here as t:

$$t = t + 1 \tag{16}$$

4.12. Step-12 Return to Step-4

Thanks to this step, Step-4 through Step-11 is executed consecutively.

5. How the Model Works Is Exemplified in a Simple Case

The proposed model quantizes ideas regarding 10 pillars. In other words, qualitative ideas are turned into quantitative form in 10 dimensions by using pillars. Thanks to this quantization process, not only can ideas be accumulated, but also market trends can be visualized at 10 dimensional planes. There, rather than visualization of quantized ideas at 10 dimensions, the visualization in 2 dimensions was preferred for easier representation.

For this presentation, the limited section of the development of a multipurpose wrist-based watch through the light of different product ideas was selected, since a multipurpose wrist-based watch is one of the most desired wearable technologies nowadays. It can include tools such as health measurement, navigation, music player, contactless payment etc., for making life easier. For this case, 2 pillars out of 10, namely, technology and market, and also the scale of 4 and 7 in these pillars were selected respectively. In Table 1, the dissolving process of product ideas under the related scales in technology and market pillars are shown, and in Figure 2, the figure of quantized and clustered ideas under 4 scales in the technology pillar and 7 scales in the market pillar were presented.

Table 1. Dissolving ideas into pillars.

Product	Product Idea	Technology-Level Scale	Market Needs Scale
1.	Analog Pocket Compass	Analog Sensor (AS)	Mechanic
2.	Analog Vehicle Compass	AS	Mechanic
3.	Analog Thermometer	AS	Mechanic
4.	Analog Barometer	AS	Mechanic
5.	Digital Vehicle Compass	Digital Sensor (DS)	Electronic
6.	Navigation System	DS	Electronic
7.	Digital Compass (DC)	DS	Micro-Electronic
8.	Navigation (NAV)	DS	Micro-Electronic
9.	DC + NAV	DS	Micro-Electronic Integration (MEI)
10.	DC + NAV+ Thermometer (TER)	DS	MEI
11.	DC + NAV + TER + Barometer (BAR)	DS	MEI
12.	Multi-Sport Wrist Watch (MSWW)	DS	MEI + Application Production (AP)
13.	MSWW + Heart Rate Monitor (HRM)	DS	Digital Health Measurement (DHM) + Multi-Sensor (MS) + AP + MEI
14.	MSWW + HRM + Pulse Oximeter (PO)	DS	DHM + MS + AP + MEI
15.	MSWW + HRM + PO + Contactless Payment (CP)	DS + DP	DHM + MS + AP + Digital Payment (DP) + MEI
16.	MSWW + HRM + PO + CP + Smart Notifications from Cell Phone (SN)	DS + DP + DCom	DHM + MS + AP + DP + Digital Communication (DCom) + MEI
17.	MSWW + HRM + PO + CP + SN + Wireless Music	DS + DP + DCom	DHM + MS + AP + DP + DCom + MEI

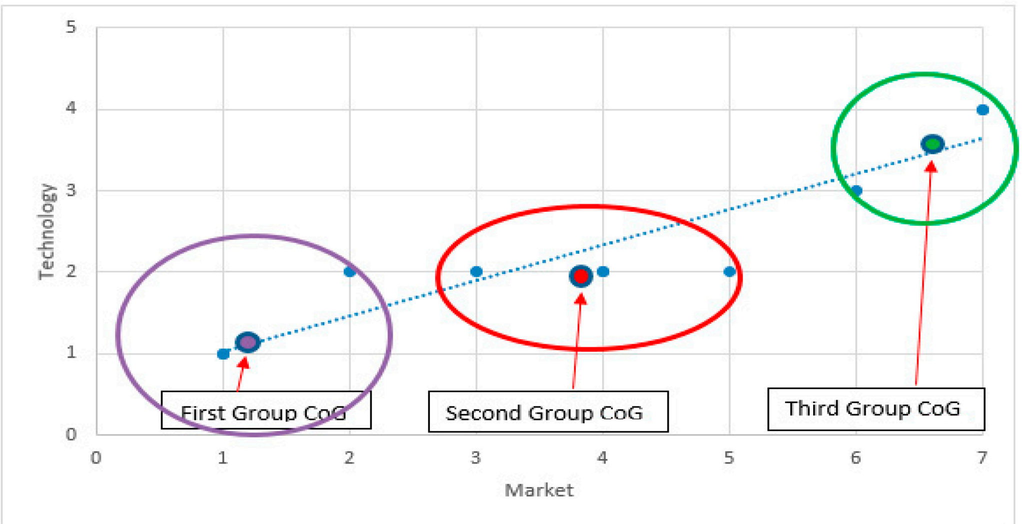

Figure 2. Clustering of quantized ideas into 3 groups.

6. Discussion

An unparalleled structure with previously proposed models brings unique advantages to FE such as the accumulation of historical data to explore market trend knowledge objectively, and then, among them, choosing the promising ones by the objective decision-making algorithm. The proposed model adapts itself to the changing environment unlike other proposed models. While aforementioned areas show advantageous sides of the model against others, it still has some disadvantages and limitations.

Complex decision-making needs for different purposes lead people to rely more on artificial neural networks (artificial intelligence) providing more efficient solutions than other algorithms when they are trained with a large amount of exact and objective information. However, in the FE case, exact successfulness knowledge, in other words, successfulness label of ideas cannot be known prior to the production and sending of it to market. K-means, one of the unsupervised learning algorithms, can overcome this problem due to the usage of unlabeled projects. As a result of using unlabeled projects, exact successfulness level of the model cannot be known, and this situation can create a disadvantage for our model.

Therefore, system validation is the satisfaction level of the model's stated purpose/ requirements [121,122], and the history of old NPD projects cannot be effectively used to assess truly new and revolutionary projects [78]. Thus, our model's validity check is constrained to the existing history of old projects. Due to this limitation, the model's purpose of usage can be seen as a decision-making aid for managers while selecting promising ideas considering calculated market trend knowledge. The calculation of market trend knowledge is important since the product's launch quality is positively affected by market orientation [123]. Thus, even though the proposed model has disadvantages and limitations, the usage of this model can lessen the burden as a result of a decision process based on managers' gut feelings and intuition.

Furthermore, the present study has two implications, both for the research on the FE model and for the managerial point of view. First, the objective idea assessment can be achieved with an effective combination of the quantization of ideas, the accumulation of ideas, and the intelligent decision-making algorithm, respectively. Second, to achieve as much effectiveness as possible in objective decision-making, the best sides of human and machine (algorithm) should be effectively combined in the FE model. Third, calculated market trend knowledge should be visualized to give situational awareness to managers especially.

7. Conclusions

When the most dynamic fuzziness part of NPD, namely, FE, is not managed well, decision failure occurs and FE fuzziness is relayed through other parts of NPD, thus costly mistakes occur. The remedy of FE fuzziness is not provided by an implementation of similar mainstream approaches but the creation of the innovative FE model based on non-mainstream approaches such as no elimination of ideas, called here as the accumulation of ideas and the objective assessment. There, the accumulation of idea approach dissipates each idea's knowledge into others in the idea pool to produce combined idea knowledge, and this process is similar to how the human brain works. Then, among combined idea knowledge, in other words, total memory, promising ideas can be selected with the uniquely created objective assessment model combining K-means, the distance-based algorithm with the gravitational theory inspiration, and the exponential function.

Since discovering knowledge fragments in user-generated content depends on the success of text mining methods [124], the proposed model translates ideas' unstructured, fuzzy, and qualitative knowledge to a quantitative form by using pillars to provide an objective comparison of ideas. In the model, weights are attained to pillars regarding tacit knowledge of employees, then, an algorithm dynamically and objectively not only fine-tunes these weights but also calculates each idea's value from local and global perspectives by considering related ideas' importance among combined idea knowledge. This process loop repeats with every new idea addition and ideas' recalculated places in the idea pool can be visualized to create market awareness for managers or innovation teams.

This study's main contributions to the literature are how to cope with fuzziness in FE, the confronted challenges while creating an FE model, and how to define tips of creating the innovative decision model for FE.

We believe that the proposed study merits further research on four issues. First, collaboration should be executed with the industry to test the effectiveness of the model by using relevant industry data. This collaborative work can be organized under three main titles such as finding the scale for each pillar, quantization issues of ideas under these scales, and the determination of weights for each pillar. Additionally, testing the model's plasticity while adapting itself to different industry-specific needs remains a subject for future research.

The importance of success factors changes depending on the situation [125]. Considering this fact, the proposed model was based on generic design principles and can be applied to different industries by changing its parameters. There, as a second further research, this plasticity of model should be tested by applying it to different types of industries and their projects.

The performance of cross-functional innovation teams is moderated by the organizational context [126]. This problem is remedied by assigning an interdisciplinary team to a range of unique tasks such as dissolving ideas, finding and completing lack of information in an idea, creating new ideas, considering old ones or updating already supplied ones. However, as a third further research, accomplishment levels of these tasks should be tested.

Finding the selection criteria for interdisciplinary team members is another important topic. At this point, the authors concluded that not all people are efficient [127], and the usage of a non-company-based external team is at least equivalent or surpasses the usage of an internal-based team [128]. In addition, more benefits are uncovered when socially oriented people (who use social media effectively) are employed. The foresight and sense-making via cross-fertilization provide collective discovery and formal diffusion of user foresight [129]. In this manner, exploring the selection criteria of interdisciplinary team members remains a subject for a fourth further research study.

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