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Effective Product Development Framework to Examine Enterprise Organizational Learning

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Abstract: Intelligent Product Development of Industry 4.0, systematic and thorough study in Chinese circumstances is uncommon. It is a new idea that requires study progress for precise definitions and measures. This article is conceptual research that aims to analyze and prioritize essential elements for smart product developments as a research model connected to industry 4.0 in the Indian environment. An effective product development framework (EPDF) is proposed in this article that develops a decision-making model based on the consumer and risk assessment model. Technological advances, project management, collaborative development, lean processes and environmentalism are key elements mentioned. For the arrival of the Decision Structure, specific recommendations have been taken. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique has been used to understand priority variables considered by individuals and organizations. This paper contributes to stronger 4.0 SPD, followed by agile and sustainable development in the Chinese economy. Regarding its contributions, this research's results can help users make real-time judgments by making optimal use of resources, using highly personalized goods in a shorter lead time. Decision-makers can utilize the suggested decision-making framework, gain a thorough grasp of the conception of current policy in the light of Industry 4.0 and its associated smart products deployment aspects, specifically in the Chinese scenario.

Keywords: critical factors; industry 4.0; organizational learning; product development

1 INTRODUCTION TO PRODUCT DEVELOPMENT

Industry 4.0 called the manufacturing reformation, as an implementation of complex innovations, involves the progression of cyber-physical systems (CPS) through the Internet of Things (IoT) and cloud-based production [1, 2]. Industry 4.0 is a group phrase for supply chain technology and principles. Industry 4.0 is the latest level of the development stage, the supply chain organization. Industry 4.0 descriptions have been supplied to date globally. Increased data capacity and connection, big data analysis and systems integration, human-machine interfaces, intelligent robots, and 3D print are viewed as the digital evolution of the product design and development sectors [3, 4]. Manufacturers require to continuously upgrade production systems to meet evolving market and competitive requirements.

They significantly influence the whole product development processes and value chain, enhancing the current process and adaptability from the performance measurement point of view [5]. In addition to traditional production, China is expanding towards smart factories and smart equipment, which influence goods and connect the link between digital and physical fields to produce clever goods. The production sectors to achieve sustainability and the generation of work are increasing quickest and are profitable [6, 7].

In addition, with the Ministry of China's campaign as its national goal, the production ecosystem takes a good story in this area. These innovations are thought to increase prices, production, reliability, adaptability, and bring happiness to employees. Thus, smart Product Development (SPD) must continue to play an important competitiveness role in the production process [8]. Since Industry 4.0 and smart production are in their initial point in the Chinese context, acceptance of the SPD can reinvigorate China's new industrialized automated lifestyle.

In the current environment, intelligent goods may relate to whole processes, which allow specific production phases to control autonomously [9, 10]. The smart product development defined by a high customer satisfaction might suffer from inadequate planning and installation, which leads to increased costs and time. While Industry 4.0 looks forward to changing the SPD production industries' architecture and function, there is a doubt about its acceptance, specifically from the Chinese perspective [11]. Because of the niche, the appropriate model for analyzing key factors for optimal production process related to the SPD, which must thus be adopted by businesses. The desire of the market client now is quite flexible and is changing rapidly [12, 13]. Therefore, creating new products becomes a necessary problem, not a choice in this difficult competitive environment for any company or corporation to thrive. One of New Development Products (NDP) aims to maximize client compatibility, minimize production cycle times, and reduce production costs [14].

Due to the significant unpredictability involved with the product production process, it is difficult and tough to build and manage a new item. Many hundreds of such goods arise annually, but only 10% of them are predicted to succeed in the trade. Construction managers must deal with enormous obstacles for managing big NDP initiatives since the international market lacks historical data and insecurity [15]. NDP activities are both dangerous and expensive due to the failure of the efforts of the new product. Substantial amounts of R&D funding might be spent [16].

Based on past studies, 80% of the initiatives of NDPs globally collapse before they can be finished. The goods created from the remaining 20% do not have a return on investments [17] especially in the nations where most entrepreneurial endeavours fail due to several circumstances. SPDs (smart Product Developments) adopt financial growth and employment. Therefore, what elements contribute to the failure of NDP initiatives among business people in the present study issue. In addition, several empirical investigations have shown that 50 percent of small and medium-sized businesses are closed down before they finish their fifteenth year [18, 19].

Limited funding, human capabilities, and lack of expertise in risk managing techniques usually exist in small and medium-sized companies. It indicates that SPDs are less likely than other major organizations to endanger and be subject to dangers, which is related to NPD handling.

Depending on the research topic, the purpose is to explore the elements due to the failure of NPD in SPDs or how it occurs utilizing a fuzzy logic method. This research and reasons are intended to build as follows.

- A recommended decision-making system for a particular industry 4.0 is proposed.
- A decision-making system is proposed to examine enterprise organizational learning.
- Risk-based evaluation of the product development framework is designed.

The rest of the research is as follows. Section 2 deals with the background of the product development models. The proposed effective product development framework (EPDF) is designed and implemented in section 3. The software analysis and performance evaluation are discussed in section 4. Section 5 deals with the conclusion and findings of the proposed model.

2 BACKGROUND TO THE PRODUCT DEVELOPMENT MODELS

Changing industrial trends emphasizes considering key elements for digital production and the organization's profitability. Designing SPD-related industry 4.0 implies great dimensions in sophistication. Moreover, this new model encompasses various possibilities connected to industrial environments to improve productivity and organizational effectiveness via SPD. The most crucial impacts of SPD are as stated below.

2.1 Integration of the System

It is an automated technique of links between physical items and technology that allows multiple modules to share excellent information [20]. Concerning the CPS, it is predicated in computing capacity on a connected structure comprising physical inputs for service provision. The study of Hafezi et al. is the subject of debate on the interplay of human equipment with CPS [21]. Intelligence system topology upon industry 4.0 viewpoints is an important part of interoperability.

2.2 Building Collaborative Systems

It enables clients to value the cooperation using cable platforms. Collaboration is important for executing tasks or operations from the manufacturing aspect, from human interaction, resulting in quality creation, including distributing partners [22]. This partnership refers to the integrated strategy of bringing together technologies and processes that help the coaching team increase productivity and efficiency. It offers a non-solution pathway, where teams begin preparing, reporting and product development stages.

Developing a business model that would produce new methods of offering value to clients is conceivable based on a strategic alliance [23]. Zhang et al. point out the cross-linking of participants, goods and equipment throughout the product cycles from the stage of raw materials procurement to the location of end life from the perspective of general environment end-to-end architecture [24]. The interconnected public cloud, procurement, expansion, restructuring, recycling, handling, and reusing raw materials between all stages can serve as collaborative architecture.

2.3 Creativity and Innovation

It refers to the supply of services that may easily be achieved using web innovations and IoT techniques that give a unique manner of bringing value to manufacture. As new technological innovation regarding manufacturing techniques, IoT combines intelligence machinery, enhanced data analytics, and machine-human cooperation [25]. To promote remote production, it delivers a real-time capacity for quick data capture sensing. The social media network links web-based innovations to encourage open innovation through a group of organizations. It also helps to harmonize the flow of products and data [26]. Therefore, big data analysis for actionable information is essential for industrial businesses.

2.4 Lean Systems of Operation

In industry 4.0, Lean Manufacture (LM) is a precondition for three features, i.e., systematic, accessible and reproducible procedures making this unbroken and unambiguous. The lean deployment of CPS, which reduces waste with maximization of output, is launched by deploying automation machines at the manufacturing level [27]. It offers adaptability to manufacturing processes that minimize optimum time after time to marketing throughout the operational cycle. Subramanian et al. state that leaner and industry 4.0 are linked and mutually reinforcing, although few others reject any reduction [28].

2.5 Sustainable Development

Research with a specific focus on economic, ecological, or prescribed treatment has been carried out [28, 29]. Considering the financial element, Industry 4.0 speeds up production cost reductions resulting in added value, adaptability and product or service personalization. The important effects include decreased waste, resources, and power use concerning ecological and environmental viewpoints. With the development of industry 4.0, greenhouse gases are alleviated through data-centered carbon emissions assessments. On the other hand, the social side focuses on health, pay in the evaluation, human education, and work satisfaction.

It is not simple, as it seems, to start the goods and firm. It is a complicated and difficult procedure. It has to take a great risk of investing the money and effort to produce fresh new products without ensuring that it is recognized. Reche et al. say more than 30000 new goods are manufactured each year, and three quarters failed based on Harvard Expert Clayton Christensen [29]. On the other hand, as shown in previous studies, 5 percent or more are nevertheless successful. Some scholars stated that a lack of economic scale study would lead to a failure in the endeavour [30]. Others say it is more important to ignore changes in client behaviour. Some of the scientists suggested these, and several others lead to product creation failures.

Cooper said that around 40% of new goods might fail at the introduction [31]. Furthermore, he said that out of 7 to 10 ideas for new products, just one is a successful business. Just13% of enterprises acknowledged achieving their yearly profit targets with their overall future product efforts. The success elements can be limitless based on the preceding section, but no study can employ an indefinite number, so the important success elements are specified and assessed. In other terms, the crucial success elements in business dictionary.com shall be calculated as the number of qualities, circumstances or variables having a direct and severe influence on an organization, program or project's performance, productivity and sustainability [32]. The actions linked with CPS should be carried out to the greatest possible standard of excellence to fulfil the overall goals. Important successful factors or key outcome regions are named.

From this background study, this study proposes an effective product development framework (EPDF), a decision-making model based on the consumer and risk assessment model. The following section elaborates the design methodology with significant mathematical explanations.

3 PROPOSED EFFECTIVE PRODUCT DEVELOPMENT FRAMEWORK (EPDF)

Two steps are taken in the research approach. First, the framework is developed to guide the development of a new product in start-ups. Second, a fuzzy logical strategy to elucidate the results is decided by the investigator. The high level of uncertainty in NPD programs in small and medium-sized enterprises, especially, is a failure. Small businesses employ the management version of fuzzy logic to cope with uncertainty, fuzzy control to handle inaccurate, unclear, imperfect, untrustworthy, vaguely or happening in one or more ways. In addition, the investigators opted to employ one of the delicate calculation processes to establish the most important variables in the performance of start-up goods because of the considerable fluctuation in the primary success variables and the subjective nature of evaluating such elements.

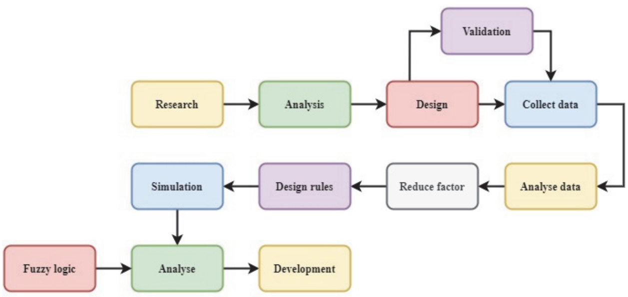

Figure 1 The work process of the enterprise organizational learning

Fig. 1 shows the work process of enterprise organizational learning. The research articles are collected and analyzed. Based on the design, the collected data is validated and analyzed. The received factor is reduced based on the design rules and simulation tools. The categorized articles are analyzed using a software model, and then based on the best model, the proposed framework is designed and implemented.

3.1 Conceptual Framework

The development of a theoretical framework is a consequence of contemporary literary works and the interrogator for similar and specialized start-up firms. The frame sees the marketplace and the consumers as a first step and then seeks to establish a financially sound business proposition.

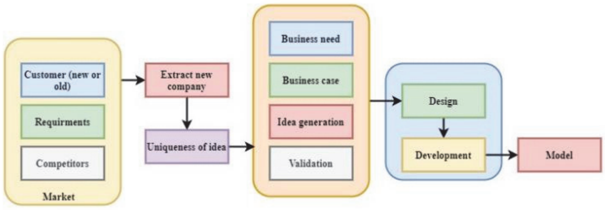

Figure 2 The theoretical framework of the end-to-end product design

Fig. 2 shows the theoretical framework of the end-to-end product design, offers the overall actions and the sequencing taken by any organization to decrease uncertainty and raise the chance of the new product being successful. The customer requirement is analyzed from the marketplace, and features are extracted. Then, based on the uniqueness of the data business model is designed, developed, validated. Based on the idea, a model or template of the proposed product development system is manufactured. A loop response to minimize ambiguity and help bridge the difference is one main idea in this procedure. The figure also shows that the major crucial nodes and terminals are: the distinctiveness of the concept. This economic case required the development and further stages of a concrete business system. It provided and eventually the development of the prototype reflecting the market characterized by a large marketing strategy.

Numerous studies have sought to identify and evaluate the most beneficial aspects of new product innovation performance in start-up organizations. The originality is the commercial potential, costs, expert opinion, the sustainability and future impacts of the existing and future factors, the accessibility and future attractiveness. Transportation and launch scheduling play a crucial part in subsequent development. Managers should focus their attention on launching the schedule to boost their likelihood of succeeding. A product innovation procedure had achieved around 16 important variables in five fields: senior management engagement, organizational structure and systems, appealing new product conceptions, adequate personnel, and project management groups.

The preceding demonstrates the variables important to producing the new product creation in the new start-up firms. But the key variables may be inferred by this investigation and by examining all the raw materials: originality of the concept, company model and advertising strategy. Thus, the inquiry can focus on understanding the most efficient success elements using the Fuzzy logic method for those three components.

3.2 Fuzzy Logic Application

In this study, the principle of the Fuzzy set was utilized to express uncertainties and mathematical concepts. Fuzzy logic is a blend of ideas and arithmetic. In code, not all propositions are to some extent true or incorrect. In most circumstances, however, the grey region should be examined, particularly in the opinion of qualified persons and specialists. Furthermore, many academics employed Fuzzy collections to study and analyze various knowledge domains in multiple applications in the business.

The NPD failure might be triggered because of numerous variables based on fuzzy logic analysis. A recommended role based on demographic results for the current investigation. The Unusual Idea, financial model, and advertising have therefore been discovered to have an important connection, affecting each NPD performance component.

3.2.1 The Single Thought Model

Before production, the initial element generates the concept and evaluates it until the best component is found. The problem, though, is this: is your offering unique? In addition, is your offering actual value to a product that already exists? Therefore, to handle the issue of individuals or complete what consumers desire, the aims of making the product must be clear. In addition, the creation idea requires responding to the goals and challenges the company needs to fix and how the concept reaches its target client.

3.2.2 Specific Corporate Model

In developing a growth framework aligning with start-up goals, the marketing strategy usually plays a defining role. The business model includes people who persuade investors to invest. The demographic segmentation, product proposal, incomes and costs must be very well defined in this company model. The recent concept is that the marketing strategy must be extremely strong and extremely concrete to maximize profit. In most situations, funds buy in the products which yield large returns instead of steady businesses. The marketing strategy, therefore, is vital to help product innovation succeed.

3.2.3 Process of Marketing Model

When the products are manufactured, marketing is highly crucial. The date of the product's debut is significant for the potential lender. Although the company has a beautiful idea, a real business strategy, skilled workers and enough cash, yet nobody would purchase the items when the item was introduced. For example, during summers, umbrellas are sold. No customers buy the merchandise in this situation since, at this period, the umbrellas are not essential. Nevertheless, if the parachute is sold during the wet season, the profits can be increased. In product design, the approach to promote the product is vital.

3.3 Methodology and Results

This study employs an order-preference technology with an ideal solutions similarity (TOPSIS) methodology to prioritize critical factors (CF) as a multi-criteria decision-making methodology. A three-stage technique for discovering and selecting appropriate CFs that combine qualitative methods is adopted. At first, an extensive search is done via certain pairs of journal articles based on SPD and Industrie 4.0 content, which discovers specific CF indications. Since the research focussed on the Indonesian market, the situational variables/indicators should be identified. The opinion of specialists is thus crucial to investigate SPD situational CFs by creating an open inquiry. Ten responders, including CEOs, executives and business people with a wealth of experience in production, R&D in the creation of products and growth of reputable businesses, were chosen. Questions have been answered to coincide with the aim of the research to discover SPD CFs further.

Answers in a verbal form that are examined line by line are documented. Data points were collected from a qualitative standpoint and studied extensively to generate indications. The determined indicators/variables are also modified into three different dimensions: education systems, cooperative engineering, science and innovative technologies, lean software platforms, and sustainable development, which are dependent on the description in the indigenous environment, based on their significance and relationship issues. Alternatives (called crucial aspects) can be prioritized against parameters in the following step of research. Cost, efficiency, reliability, adaptability and staff happiness are parameters of the criterion. These elements can be fully reviewed and explained by interviewees as a criterion.

It produced and emailed a questionnaire method to the 25 participants chosen. However, five questions were not completed, and fifteen answers were obtained. For evaluation, a total of ten surveys were therefore evaluated. The sample size considered for the TOPSIS technique ranking is 10. The answers were obtained with the 5-point Likert scale from "1 (extremely low) to 5 (extremely high)" following its attributive relevance. The weighting of each criterion element is measured based on a further standardized expert judgment. Here are some of the benefits of TOPSIS: i) a solid logic which is concerned with the weighted sum, which concurrently describes the best and worst possibilities. ii) it evaluates each alternate of polyhedron characteristic for any size at least. (iii) being a utility-based methodology, it immediately ties each choice to measurement matrix and weight information (iv) it has only the smallest possible reverse among different category techniques. TOPSIS is therefore selected to prioritize the measurements.

3.4 Decision-Making Algorithm

Step 1: A decision problem is produced and stated as a matrix where the options are S_i, $i = 1, 2, \ldots, m$; C_j is a j-th characteristic or criteria, $j = 1, 2, \ldots, n$ is associated with the option. The preferrable matrix P of decision is denoted in Eq. (1).

$$P = \begin{bmatrix} \varphi_{11} & \varphi_{12} & \cdots & \varphi_{1n} \\ \varphi_{21} & \varphi_{22} & \cdots & \varphi_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \varphi_{m1} & \varphi_{m2} & \cdots & \varphi_{mn} \end{bmatrix} \tag{1}$$

φ_{ij} denotes each candidate solution S_i ranking concerning each criterion C_i. Here the variables i and j vary as $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$.

Step 2: Compute the standardized $D = \left[d_{ij} \right]$ decision model. d_{ij} is determined as normalized value in Eq. (2).

$$d_{ij} = \frac{\varphi_{ij}}{\sqrt{\sum_{i=1}^{m} \sum_{j=1}^{n} \varphi_{ij}^{2}}} \tag{2}$$

The ranking of the solution is denoted as φ_{ij}. Based on the ranking, the decision element is calculated.

Step 3: By combining the normalized decision model by its corresponding weights, create a weighted normalized decision model. Standardized weighting quantity B_{ij} is expressed in Eq. (3):

$$B_{ij} = B_j x d_{ij}; i = 1, 2, \cdots, m, j = 1, 2, \cdots, n; \tag{3}$$

where the j-th property or criteria is represented by B_j.

Step 4: Favourable and unfavourable options are expressed in Eqs. (4) and (5).

$$\begin{aligned} S^{+} &= \left\{ B_1^{+}, B_2^{+}, \cdots, B_n^{+} \right\} = \\ &= \left\{ (\max B_{ij} \left| j = K, \min B_{ij} \right| j = K'); i = 1, 2, \cdots, m \right\} \end{aligned} \tag{4}$$

$$\begin{aligned} S^{-} &= \left\{ B_1^{-}, B_2^{-}, \cdots, B_n^{-} \right\} = \\ &= \left\{ (\min B_{ij} \left| i = K, \max B_{ij} \right| i = K'); j = 1, 2, \cdots, n \right\} \end{aligned} \tag{5}$$

When K is linked to benefit criterion, K' is linked to the cost criterion. The favorable decision and unfavorable decision are denoted as S^{+} and S^{-}. The weight of the solution is denoted as B_{ij}. The favorable and unfavorable weights are denoted as B_1^{+} and B_1^{-}.

Step 5: Calculate Euclidian range from ideal favorable and ideal unfavorable solutions for each choice. For each option, two dispersions are determined. The favorable distance and unfavorable distance are denoted in Eq. (6) and Eq. (7).

$$L_i^{+} = \sqrt{\sum_{i=1}^{m} \left(B_{ij} + B_i^{+} \right)^{2}}; i = 1, 2, \cdots, m, j = 1, 2, \cdots, n \tag{6}$$

$$L_i^{-} = \sqrt{\sum_{i=1}^{m} \left(B_{ij} - B_i^{-} \right)^{2}}; i = 1, 2, \cdots, m, j = 1, 2, \cdots, n \tag{7}$$

The normalized weight of the fuzzy logic decision model. The favorable and unfavorable decision weight of the fuzzy set is expressed as B_i^{+} and B_i^{-}.

Step 6: Compute a positive-ideal suggestion relative proximity. The positive solutions are quite proximate to the results. The real closeness of the decision is expressed in Eq. (8).

$$RC_i = \frac{L_i^{-}}{L_i^{-} + L_i^{+}}; i = 1, 2, \cdots, m \tag{8}$$

The favorable and unfavorable length of the proposed model is denoted as L_i^{+} and L_i^{-}. The final closeness of the decision of the ith ranking is denoted as RC_i. The closeness value should be varied from 0 to 1. The condition of the closeness is expressed in Eq. (9).

$$0 \le RC_i \le 1 \tag{9}$$

The closeness of the actual decision to the predicted decision is expressed as RC_i.

3.5 Risk Management Model

Hazard identification, method of evaluation and modeling are the essential computer elements in the risk management process. Due to the unpredictable, flexible and dynamic structure of hazards in sophisticated product design, the process may be viewed as a typically grey process. Therefore, the behavioural data may be studied to investigate the connection between hazard and level of risk and the data which discover and evaluate the risk variables using the grey correlation and the grey linear regression model.

3.5.1 Risk Assessment Based on the Analysis of Grey Correlations

The conventional grey correlation coefficient approach employs grey correlation levels to illustrate the link between multiple factors that affect risks using distinct factor data. In cases where the two components are generally consistent, as shown in the sample data series, the similarity of both factors is considered high. Rather, they are considered low. It can answer the average values of identifying components to identify and classify risk using Equation, the correlation matrices of the most effective indicator. The influences of risks may be detected and classified according to the strength of the scale by estimating the risk level of a single element with grey correlations.

3.5.2 Risk Evaluation Based on the Hierarchical Gray Analytics

Grey's hierarchy analytical covers two components: element weight determination and a complete indexing theory assessment. Initially, weight is computed according to the information provided by the surveys of specialists. Next, it must determine the grey association grade of the ideal index set and the planned indexing set as a level of risk.

3.5.3 Risk Forecasting Based on the Analysis

In the risk factors, both the topology predictions and sequence previews in grey theories can be employed. The sequencing forecast is generally utilized to assess index growth potential. These metrics are used directly to indicate risk managing systems features in the project component. A topology prediction must be implemented for the whole risk administration system in the project's sinusoidal emerging trends.

3.6 Product Design Framework

A whole approach from project presentation should be followed in risk assessment of complicated product design. R&D risk needs to evaluate and adjust at every level. During the review process, the personnel requires the data they provide for the management platform, and the results confirm the employees' judgment. Therefore, the entire process is interactive with the administration platform: the Risk Managing Team system, specialists and engineers during this procedure. R&D risk assessment is a collective decision-making process dependent on many facts and many individuals. Based on the features indicated above, the networked, automated administration system for complicated product design is advantageous to R&D risk assessment. The effective transportation system is built on data storage technologies in the online environment.

3.6.1 The fundamental structure

The networked intelligent administration system is supported by data storage facilities based on the 4-level Browser/Server (BS) paradigm.

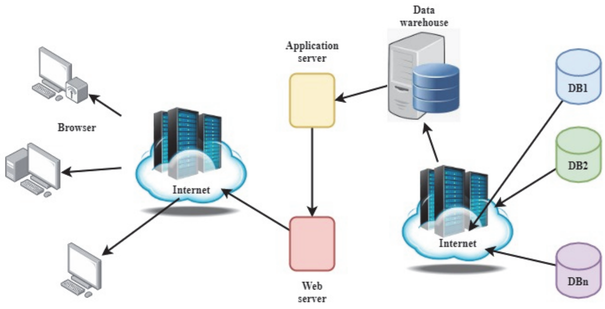

Figure 3 The proposed browser/server model architecture

Fig. 3 shows the proposed Browser/Server model architecture. The collected information from the users is stored in the database in the close through the internet. The data warehouses are used to access the required information via the application server and the web server. The received information is visually presented to users via browsers. The web application is the implementation phase, a connection between the consumer and the Web servers, in the above management platform. As the web server may interface with Browser immediately, a unique browser is the only way for customer service to perform numerous duties. For instance, when an expert chooses, he needs to click the smart question icon to send a proposal to a web application. The decision-making system can change the data format into an HTML or XMLE application and then forward it to the webserver that delivers it to the customer service user.

3.6.2 Data Storage Platform

The administration system is built as an accessible judgment support tool instead of the product R&D method rigidly. In such a system, personnel control the risk by the decision-making support network following the requirements of product R&D, so that the scheme is much more adaptable. The conventional decision-making system normally constructs and creates the databases, model basis and knowledge base, resulting in a lack of inner homogeneity. This research suggests employing online analysis data and management mining based on information warehousing as a novel technique to overcome this challenge. The storage system based on information storage contains two parts: one is a standard decision-making system, while the other is an information storage facility. Rather than functioning individually, both sections are integrated via the body of knowledge.

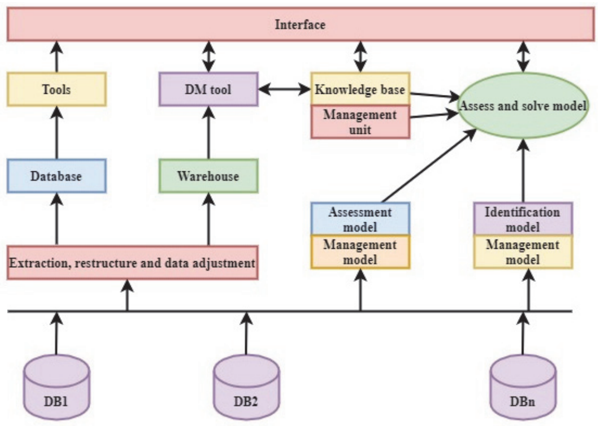

Figure 4 User interface model of the proposed architecture

Fig. 4 shows the interface model of the proposed architecture. The user requirements are stored in several databases in the cloud. The information is accessed via a warehouse or database interface module. The user information is classified into management model and identification model. This information is sent to the manufactures through the interface: the main responsibility of the sequential decision aid system, the provision of information processing, statistical techniques and extensive risk analysis, monitoring and evaluation tool by the model foundation. Method information for the correlating decision - making of this risk evaluation procedure is in the graph described above the main goal for the implementation of this conventional decision support tool. In the meantime, the smart core is part of the information warehouses, which uses data extraction tools to collect the relevant data from a data distribution center and provide support and relationships. These help modes and relationships are analyzed and evaluated, and some of them can be delivered via a human-machine interaction to decision-makers by specified guidelines. Meanwhile, some conclusions might be transmitted to the base of information to investigate and evaluate new information.

4 SOFTWARE ANALYSIS AND PERFORMANCE EVALUATION

The simulator was modeled with the Vensim SD tool by vision 3.13.4 (VENTANA Systems Inc.). The modeling has been modeled for various values providing simulation results that show the whole descriptive method of the trials with selected factors, each with three different levels. 6851 individual simulations and findings were examined by asset utilization and a plot of relationships. The information of the simulations depicting the 2-level factors design was utilized to simulate the modeling with selected factors with two levels apiece: the Pareto graph showing the effects and the interconnections of each variable on the NPD advanced notice.

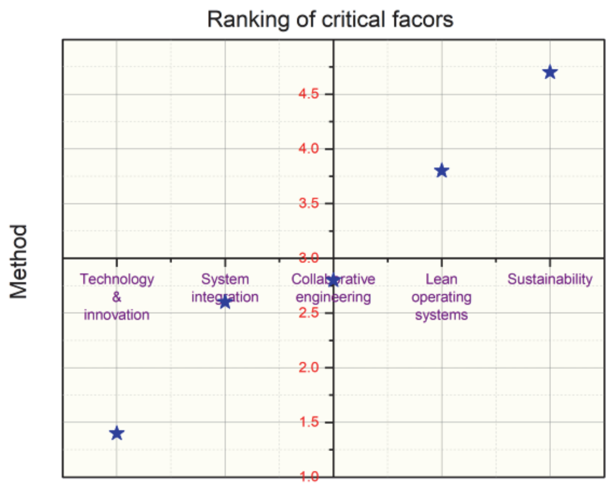

Figure 5 (a) Ranking analysis of the existing CPS model

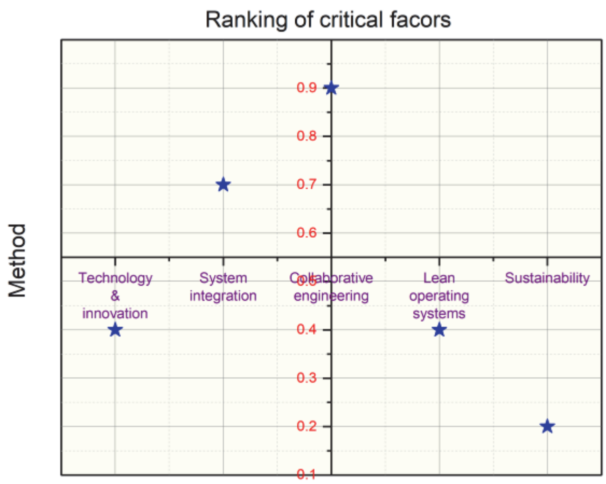

Figure 5 (b) Ranking analysis of the proposed EPDF

Figs. 5a and 5b show the ranking analysis of the existing CPS model and proposed EPDF, respectively. The critical factors for the ranking include technology and innovation, system integration, collaborative engineering, lean operating systems and sustainability of the product design and development model. The critical factors are ranking on the scale of five for the five. The maximum value indicates the highest likeliness, and the lowest ranking results in unfavorable decisions. The proposed EPDF has the highest accuracy in all the factors.

Table 1 Performance analysis of the proposed EPDF

Type	New product innovativeness	Speed to market	New product financial performance
Customer type			
Business customer	0.074	0.345	0.372
Consumer	0.372	0.075	0.224
Country type			
Emerging	−1.42	0.51	0.421
Developed	0.294	0.186	0.234

Tab. 1 shows the performance analysis of the proposed model. Based on the customer type and country type, the outcomes are varied. The simulation outcomes such as New product innovativeness, Speed to market, and New product financial performance are considered for the simulation analysis. The customer is categorized into business customer and end-user. The country requirement is categorized into developing country and developed country. The respective product design and development are calculated and tabulated in the above table.

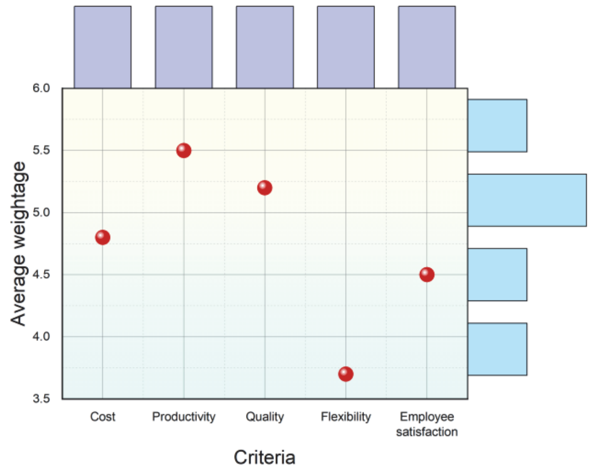

Figure 6 (a) Average weight analysis of the proposed EPDF

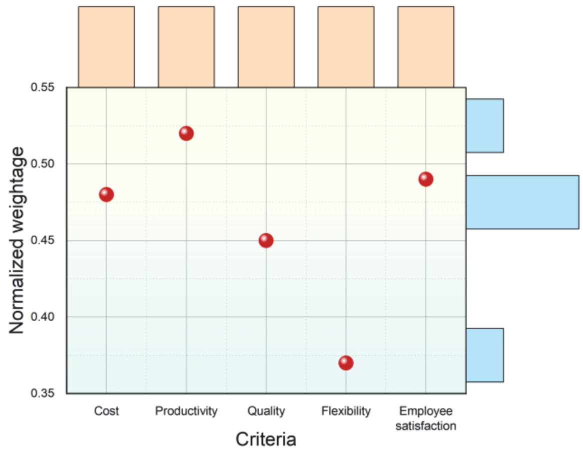

Figure 6 (b) Normalized weight analysis of the proposed EPDF

Figs. 6a and 6b show the average weight and normalized weight analysis of the proposed EPDF, respectively. The simulation is carried out by analyzing the proposed model and existing model with the simulation criteria such as cost, productivity, quality, flexibility and employee satisfaction. The weight of each decision is calculated, and the weight is adjusted based on the consumer requirement. The proposed EPDF produces the higher accuracy than the existing CPS model.

Table 2 NPD stage performance analysis of the proposed EPDF

Type	New product innovativeness	Speed to market	New product financial performance
Ideation	0.245	0.154	0.306
Development	0.267	0.097	0.254
Launch	0.372	0.186	0.298

Tab. 2 shows the NPD stage performance analysis of the proposed EPDF. The NPD stages such as creativity, development, and launch are considered for the simulation analysis. The product design and development outcomes such as New product innovativeness, Speed to market, and New product financial performance are evaluated. The weight of each performance is calculated and tabulated in Table 2. The proposed EPDF has the highest efficiency in adjusting and finding the decision of the outcomes.

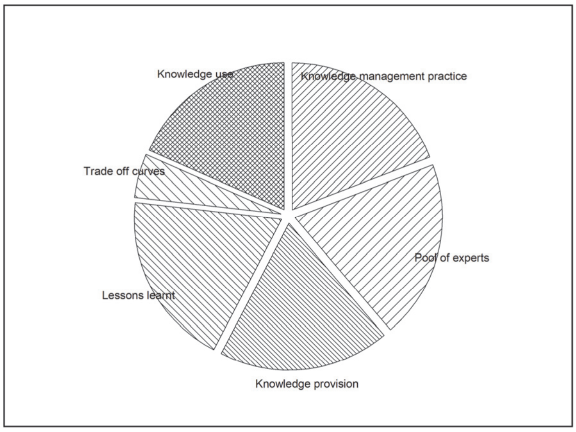

Figure 7 (a) Knowledge base analysis of the existing CPS model

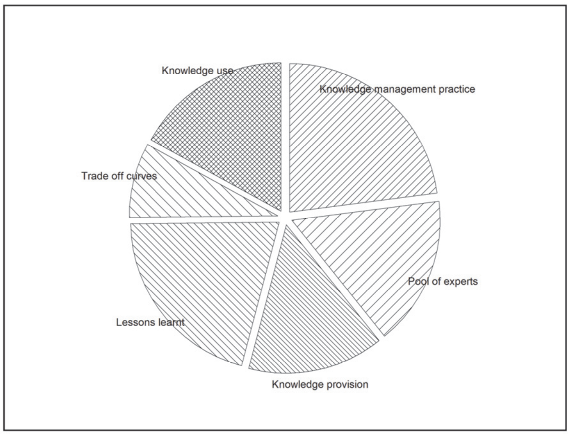

Figure 7 (b) Knowledge base analysis of the proposed EPDF

Fig. 7a and Fig. 7b show the knowledge base analysis of the existing CPS model and the proposed EPDF, respectively. The knowledge base outcomes such as knowledge use, knowledge management practice, the pool of experts, knowledge provision, lessons learned, trade-off curves are considered for the simulation analysis. The proposed EPDF and the existing CPS model are analyzed, and the results are plotted in the above figures. The results indicate that the proposed EPDF has the higher utilization of the knowledge base than the existing CPS model.

The proposed EPDF is designed, implemented. Their performance is analyzed in this section. The simulation outcomes such as knowledge base analysis, weight analysis, NPD stages analysis, ranking analysis of the proposed and existing system are analyzed, and the performance is compared. The results indicate that the proposed EPDF has the higher accuracy and efficiency than the current CPS model.

5 CONCLUSION AND FINDINGS

This article analyzes the proposed model and existing models, as well as simulation standards such as cost, productivity, quality, flexibility, and employee satisfaction. This article calculates the weight of each decision and adjusts the weight according to consumer requirements. Compared with existing CPS models, the proposed EPDF has the highest accuracy, which is its advantage. This research develops a framework for recommendations by the TOPSIS technique to decide which elements must be prioritized throughout development. This strategy was designed as "something" rather than "what" is the strategy. An effective product development framework (EPDF) is proposed in this article. The results reveal that 'technologies and invention', 'system integration and 'cooperative architecture' are CFs, where appropriate implementation may contribute to stronger 4.0 SPD, followed by agile and sustainable development in the Chinese economy. This research can include additional people and comparison with other methodologies. Future studies can potentially address questions related to the viewpoint of product design. The empirical research should be carried out based on a comprehensive field study to corroborate the opinion-focused conceptual frameworks cross-Country research, determination of variables, and determinants of reliance.

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