E-ISSN: 2676-6167 | P-ISSN: 2538-5100

Journal of Applied Research on Industrial Engineering

www.journal-aprie.com

J. Appl. Res. Ind. Eng. Vol. 8, Spec. Issue. (2021) 1–23.

Paper Type: Research Paper

# Improvement Solutions for Production and Service Functions in the Innovation System: Prioritizing Solutions Using FMADM Approach

**Adel Azami[1], Hanif Kazerooni [1,*], Hossein Mohammadkhani Ghiasvand[1]**

[1] Supreme National Defense University, Tehran, Iran; a_aazami@ind.iust.ac.ir; hanif.kazerooni@gmail.com; hosein.mohammadkhani7@gmail.com.

**Citation:**

Azami, A., Kazerooni, H., & Mohammadkhani Ghiasvand, H. (2021). Improvement solutions for production and service functions in the innovation system: prioritizing solutions using FMADM approach. *Journal of applied research on industrial engineering, 8* (Spec. Issue), 1-23.

Received: 24/02/2021 Reviewed: 27/03/2021 Revised: 06/05/2021 Accepted: 20/05/2021

## Abstract

The production and service functions in the innovation system emphasize producing new products. As any innovation system's final output must ultimately produce new products and deliver new services, the considered function is essential in the innovation system. This study seeks to extract the challenges and give solutions to improve the production and deliver services in the innovation system. Producing and delivering services does not occur in a vacuum and should occur in a context called the Supply Chain (SC). In this paper, qualified experts were interviewed to discover the challenges and solutions to improve production. Fifteen elite researchers in the innovation field then discussed the results in focus sessions and refined practical solutions after an in-depth review of the extracted information. The role of responsible institutions was determined, and the necessary indicators were extracted to evaluate the factors of innovative production after providing the required infrastructure to achieve production promotion. One of the Fuzzy Multi-Attribute Decision Making (FMADM) techniques is also used to prioritize the discovered solutions based on the importance of influencing the producing promotion. Finally, a model is presented for improving the production and service functions in the innovation system. The results showed the main solution is to collaborate and create efficient integration at different SC levels.

**Keywords:** Innovation system, Production and service functions, Improving production capability, Multi-attribute decision-making, Fuzzy theory.

## 1 | Introduction



Innovation is the process of developing creative theories and turning them into goods, services, or practical methods and models. In other words, it is a multi-step process of generating an idea to implementing it [1]. Innovation is also implementing a new or highly upgraded product or service or a new organization's approach in business relations [2]. Innovation is mainly the result of contributing many people who produce critique and then improve many of the ideas [3] and [4].

Innovation is generating, accepting, and implementing ideas, then creating new processes to develop products or services [5]. The emergence of a global movement for the trend towards innovation and the growing desire of the world's largest production companies for innovation can alone convince

Corresponding Author: hanif.kazerooni@gmail.com

http://dx.doi.org/10.22105/jarie.2021.274952.1260

any company to take serious action in the field of innovation. The production and service sectors need innovation to upgrade their capabilities, despite being costly, time-consuming, complex, and challenging [6].



*Fig. 1* shows the innovation process as an innovation pipeline. In fact, a few ideas turn into products, of which only some of them enter the market successfully [1]. Therefore, innovation is a multi-step process of generating an idea to implementing it.

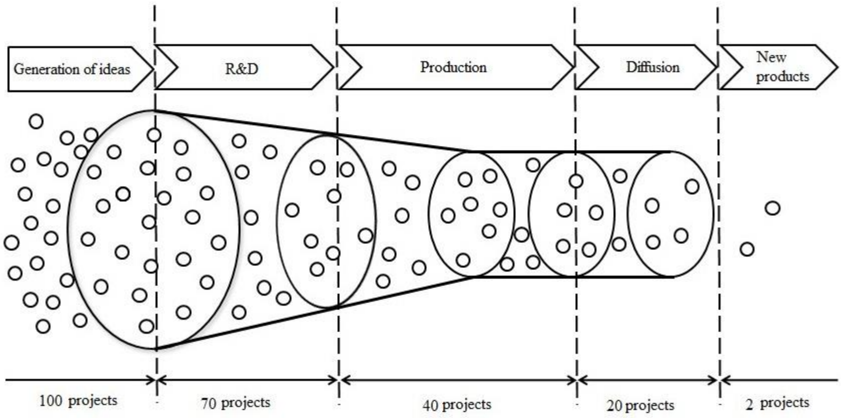


**Fig. 1. The overall process of innovation [1].**

The innovation system provides a framework for managing innovation processes' complexity and understanding the measures needed for innovation success [7]. Innovation systems focus on dynamism and economic changes and are defined as a systemic approach. Innovation involves complex interactions between the foundation and the environment in the systemic approach [8] and [9]. According to the innovation system, the interaction between the factors influencing the innovation process is essential to succeed in the innovation event. Innovation never occurs in an isolated foundation [9]. Innovation is exploring innovative sources of knowledge and technology and using them for producing new products. This is because the foundations' competitive ability depends strongly on the capability to apply new knowledge in creating innovative products [10]-[12]. Many approaches to the innovation system have emerged in the last 20 years, pointing to different areas of the innovation system. The innovation system approaches include national innovation system, regional innovation system, technological innovation system, and sectoral innovation system. The innovation system has seven essential functions, which are [13]: 1) Policy-Making, 2) Funding, 3) Research and Development, 4) Entrepreneurship, 5) Technology Transfer and Expansion, 6) Human Resource Development, and 7) Producing Goods and Delivering Services.



This research mainly aims to provide a model and solutions to improve the innovation system's production and service functions. First, it is necessary to point out the role of production and service functions in the innovation system. Different combinations of actors and institutions interact with each other in the innovation system to produce, develop and expand innovation to make the innovation occurrence possible by promoting these functions [10]. The final output of any innovation system must ultimately lead to producing new goods and services. In fact, any innovation system is incomplete without realization the production and service functions. Therefore, the production and service functions are one of the most important functions of the innovation system in terms of its final role in the innovation system; and it should be the place for producing innovative products.

Innovation in the production and service functions is strongly related to change as organizations use innovation as a tool to change the environment [14]. However, product innovation can involve a wide range of different types of change in proportion to the organization's resources, capabilities, and strategies. Different types of innovation in the production and service functions can be related to the broad nature of new products, materials, new processes, and the supply of new services [15]. Innovation is a multi-step process in terms of production and service functions by which organizations produce new or improved products and services to compete in the market. One of the main goals of organizations is to improve production capabilities through improving production and service functions. The production's success and promotion at any company require, undoubtedly, to set up efficient communication, interaction, and collaboration with successful organizations in producing products in a competitive market.

The production and service functions coincide. In fact, the production step and the step of supplying more services are inseparable. Producing and services are two primary outputs of specialized business in organizations, and they create value for them [16]. The producing and delivering services are not formed in a vacuum, and they must occur in a vital context, which is the SC. The SC is a network of interconnected tasks from the transfer among raw materials to production, transportation and distribution, material, financial, and information flows to prepare products and services and deliver them to final customers [17] and [18]. It should be noted that the producer is only one of the SC links, and therefore producing innovative goods depends on other levels of the chain. Thus, the relationships and the interaction degree between different levels of the SC become important.

The production and service functions require solutions that can realize and accelerate innovation in this function. This research tries to provide a model and solutions to realize and promote the production and service functions in the innovation system as a consequential function of this system and its most important outputs. The order of solutions is also determined using the FMADM techniques [19] because the importance of each solution's effective in promoting new products and services is different. Therefore, the purpose or contributions of this paper are to answer the following questions:

- *What is the proper model for realizing the production and service functions in the innovation system?*
- *What are the main challenges in achieving the production and service functions?*
- *What are facilitating infrastructures and solutions necessary for the success of production and service functions?*
- *What are the indicators for measuring innovation under the production and service functions?*
- *What are the priority and order of the proposed solutions?*

The paper proceeds as follows. Section 2 is a literature review on innovation, innovation system, and production and service functions. In Section 3, the methodology of the study is provided. Section 4 is dedicated to the results of this paper and their analysis in separate sub-sections. In Section 5, the proposed solutions are prioritized using the FMADM technique. Finally, Section 6 concludes the article.

## 2 | Literature Review

The literature review is presented from the perspective of both theoretical and experimental approaches. In fact, from a theoretical point of view, theoretical scope and, consequently, the literature is theoretical in nature, and articles and books are used to discuss the subject in a purely theoretical manner. However, in the experimental literature, concepts are given that cover the practical and experimental field. In a way, articles and books have been used to discuss the subject more in the form of practical and executive implementation. Therefore, the reason for the separation of theoretical and experimental literature has been for better theoretical saturation and a better understanding of the subject from an experimental and theoretical perspective.

### 2.1 | A Theoretical Perspective on the Production and Service Functions in the Innovation System

The concept of production and service functions is related to three organizational levels, which generally include three types of organizational communication: a) It relates to national borders and informal organizations and formal institutions in a country, which plays a decisive role in the production function, such as the scientific centers [8], [9], [20]. b) Regional systems focus on the region and are mostly related to a specific geographical region or a limited range of production tools [21]. And c) Technology systems in which the main focus is on the factors of production, release, and utilizing networks of technology [22]-[24].

The production structure has features such as complexity and hierarchical structure that can combine elements creating a product line [25]. It is determined how the specialization or industrial diversity degree in the production line affects a particular industry's creative output [23] and [26]. The widespread complexity in producing innovative products has sometimes led to the fact that the production's influencing factors hinder each other or negatively affect the product innovation [27] and [28]. Therefore, an integrated system with interoperability, trust, security, and maintaining the innovative feature of production should be provided [29]-[31]. Research on producing and delivering services is critical because they link technological innovations to them [32].

The concept of production and service function should ultimately lead to producing a specific product [33]. Marginal factors are related to which are not as effective as the central factors. However, their presence affects producing or delivering the product, and their absence changes the product quality. Central factors play a fundamental role in the production; because their absence disrupts the production. The production function cannot be understood properly; if the role of central and marginal factors is not considered in the production process. Four issues should be considered in identifying the central and marginal elements [34]: First, Innovative activities are essential, and the main focus is on the evolving part of the production. Second, the linkers, converters, and their role in producing and creating the proper interaction among the institutions involved in the production should be considered. Third, the relationship between innovation systems and organizational frameworks for production is also important. And fourth, the flow of local and global knowledge and developing communications is finally essential to help innovative production.

The theoretical approach to the innovation system's production function is based on four basic traditions and, ultimately, evolutionary theory. These traditions focus on dynamism as the core of product innovation. They make sense about networks and key elements of the innovation and production process [35]. Those four traditions are as follows: 1) The first tradition emphasizes changes and evolution in the sectors. Sectors change over time; therefore, much attention must be paid to their development to produce innovative products [36]-[38]. 2) The second one emphasizes the links, interdependencies, and boundaries of production and service sectors. These concepts concentrate on the infrastructures that cover the sector boundaries [39]. 3) The third one is the comprehensive innovation program, which considers innovation as an interactive process among different actors [7], [9], [23]. And 4) The last one is an evolutionary theory that provides a general theoretical framework for the innovation and production sector [40]-[42].

## 2.2 | An Experimental Perspective on the Production and Service Functions in the Innovation System

Understanding production and service functions background in innovation systems practically and empirically is useful. The concept of innovation systems is a combination of ideas derived from the analysis of the following, which practically forms the production and service functions:

- *Concepts related to economic policies of producing a product in terms of production value.*
- *Economic interaction in producing a product with other domestic and even foreign production organizations.*
- *Economic and political changes in the production of industrial products.*

No one practically expected the innovation system to be used as widely as today when the idea of creating it was first discussed in the mid-1980s. The institutions, such as the Organization for Economic Cooperation and Development (OECD), the European commission, and the United Nations Conference on Trade and Development (UNCTAD), are absorbing and expanding this concept as an integrated part of their analytical perspective. The World Bank and international monetary funds have been reluctant to use this concept in the past. These reasons pushed the organizations toward the innovation system based on their economic value added by paying attention to innovation in production.

In a specific context, the focus on national systems, such as production, extends to a wider range of globalization because today's products can not produce innovation without using the abroad capacity, whether in knowledge, technology, or materials. It is necessary to provide some marginalized parts of the innovation requirements from abroad, and the central core of the innovation is formed within the country [43]-[45]. The most obvious starting point for the production and service functions is analyzing Smith's labor division [46]. This analysis involves not only developing knowledge about robust production activities but also providing specialized services. But ignoring their systematic nature, Smith assumed the innovation and ability to build new products as an independent concept. The national production and learning systems include a lot of national institutions, including education and infrastructure such as the public and goods transport network. In other words, structures that emerge by collaboration and interaction of innovation are not independently [47] and [48].

In general, we have to look for the main production context in the policymakers and innovation students' requirements to find its roots in the innovation system. The activities of national governments and international organizations such as the OECD led to financial benefits in the 1960s and 1970s. Therefore, the national growth rate is different; and the economic growth rate in innovative products is one of the reasons for the differences in the research systems of different countries. Most of the new knowledge required for innovation comes directly from national concepts and technical research, and it even comes through empirical research and development in many industries. It also comes from other sources such as product manufacturers, customers, and marketers. Consequently, the idea of an innovation system for production was formed in the Ike group in Aalborg in the first half of 1980 [49].

Some researchers developed the technological systems concept, which deals with production [50], while some others developed the innovative systems concept that emphasizes more on product innovation [51]. Innovation must inevitably benefit from and interact with abroad structure, and on the other hand, it must ultimately lead to innovative products. Some researchers have emphasized similar concepts, but with a trans-regional scope having a special focus on innovation production [52].

## 3 | Methodology

Using an appropriate research method that depends on the objectives, the nature of the subject, and the facilities is the scientific study's characteristic. In summary, exploratory, inductive, qualitative research was conducted in this study to explain a model for the production and service functions in the innovation system. The sampling method, interviews with qualified experts, and data analysis was performed using thematic analysis. It was necessary to use the thematic analysis method regarding the literature review, refining information, as well as based on the concepts derived from the interviews with experts. The thematic analysis can be well used to formulate and analyze a theme network [53]. The thematic analysis is a method for identifying, analyzing, and reporting models and themes in the data [54].

The present study is applied-exploratory research in terms of the purpose according to the categories; because it seeks to answer a real problem through discovering the reality. On the other hand, it is qualitative research in terms of the method with an inductive approach. Because we use the qualitative research method with an inductive approach in a situation where there is rich experimental data, and the existing theories don't explain the research question sufficiently and in detail. We need an in-depth study of the experimental data. Therefore, it is almost impossible to understand the details in quantitative research or review of archival data.

Our research method was based on library studies, including books, research, and related thesis in this paper. Library studies were used to receive the basic concepts according to the objectives of the research.

Semi-structured interviews were also conducted with experts to extract practical industrial experiences and refine the literature concepts to examine the compatibility with the existing conditions. In fact, qualified experts were interviewed to match what exists in the field of innovation in production. Interviews were conducted with university lecturers and experts active in large manufacturing companies specialized in production, innovation, and SC. Experienced experts in the field of production, therefore, confirmed the obtained concepts. Finally, a team of elite researchers in the field of innovation reviewed the interviews' results to exchange views and analyze them, based on the focus group in several stages. The most important production obstacles were detected, and the necessary solutions were obtained to improve the performance of the production and service functions after analyzing the interviews and considering the literature summary.



A focus group is a group discussion that concentrates on a specific topic. The focus groups can be formed to explore the perspectives' depths of those who have different characteristics so that a situation for free expression of information and views becomes more available [55]. Focus groups deal with a wide range of information that other methods can not study. A focus group is a group interview involving a small number of demographically similar people. Their reactions to specific researcher-posed questions are studied [56]. This study's statistical population consisted of specialized and experienced experts, including managers, officials, decision-makers, and academic researchers. Since the researcher uses the inclusion criterion for the interviewed experts, the sampling method was purposeful, strategic, and based on criteria. This sampling and interviewing method continue until the concept extraction leads to a theoretical saturation. Therefore, the twelve experts experienced in the fields of the production industry, innovation system, and SC were interviewed in this study. We had our focus group meetings with these experts to obtain their real valuable experiences, especially in the industry. *Fig. 2* shows the steps performed in the methodology of this paper schematically.

Azami et al.| J. Appl. Res. Ind. Eng. 8(Spec. Issue) (2021) 1-23

## 4 | Results and Analysis

This section analyzes and refines information obtained from the literature, interviews with qualified experts, and a focus group consisted of innovation elites. Some of the most important challenges in improving the innovation system's production and service functions are identified using MAXQDA software. Besides, some essential operational solutions are proposed. The following sub-sections identify the infrastructures and give a role to the institutions responsible for implementing the solutions and the indicators. Finally, a model is also presented for realizing and promoting the production and service functions in the innovation system.

### 4.1 | The Identified Challenges

The main identified challenges are:

I. Lack of collaboration and proper integration at different levels of the SC in the production industries:

Many studies have shown that the lack of collaboration between different SC levels leads to a significant reduction in production efficiency. Most experts have also stated that there was not any proper collaboration and communication between different SC levels. Therefore, information sharing and collaboration at different levels of the SC highly affect innovative products' success. Many coordination and data flow between different departments are not established and integrated well in production organizations, reducing productivity and preventing improvement in the production and services. In fact, it is very difficult to innovate in the SC, which faces the lack of integration at its levels and stages.

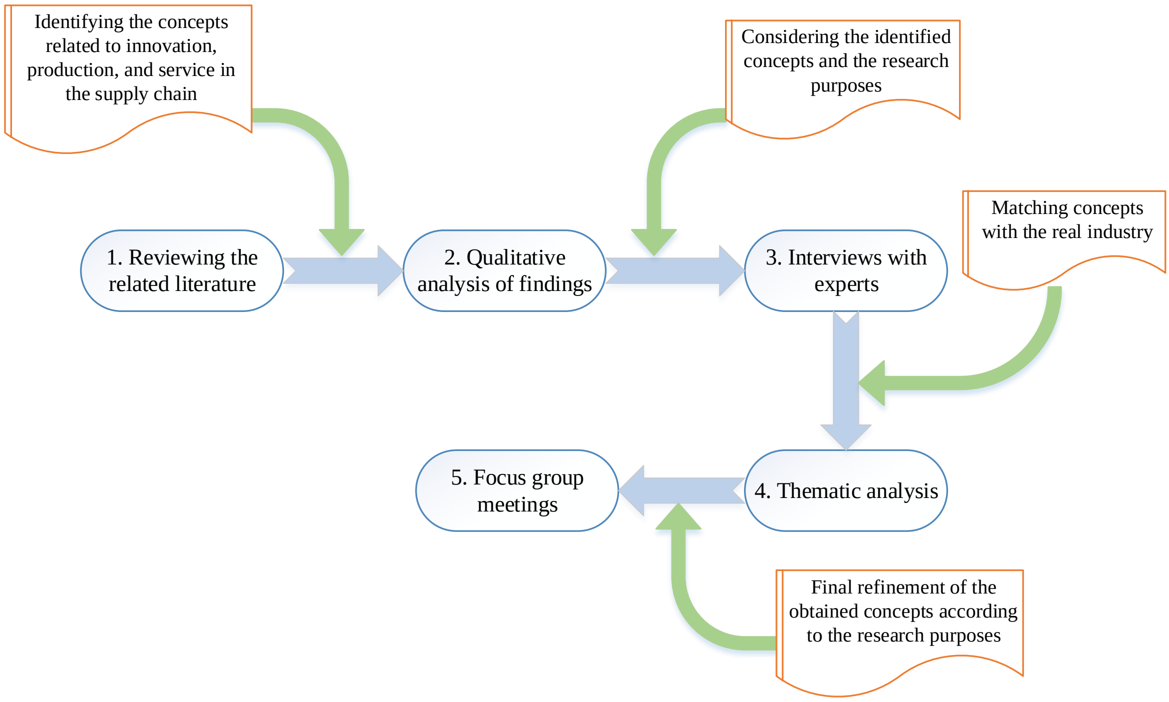


**Fig. 2. The methodology of this research.**

II. Lack of communication and knowledge sharing between industry and university, and lack of absorption of elite ideas in the field of new productions:

People emerge and are reinforce new ideas in the university. The weak connection between industries and universities, and the lack of sufficient attention to the valuable opinions of the elites, according to the experts' opinion, has led to losing opportunities for flourishing of the ideas to produce more efficient products. Interest confliction and diversity in industrial and academic experts' goals have had an adverse effect on the effective relationship between industry and academia. It seems that industries and universities have not yet achieved the desired co-evolution, intra-action, and synergy. Factors such as lack of industry trust in the university, an ideological perspective to the university environments, lack of industry managers' awareness of the universities' potential, and lack of policy makers' long-term view have affected the relationship between and academia in regards to the industry. On the other hand, the strict rules for communicating with the industry, insufficient attention to solving industry problems, the lack of a strategic view, and the unfamiliarity of professors with the industry problems have prevented the university-industry relationship regarding the university. The lack of elite institutes in industrial project heads has also led to a lack of product innovation.

III. Lack of allocating the budget on time and lack of sufficient financial support for production industries:

Studying the interviews reveals that the cost performance and high investment in production occur during the development of successful industries. Therefore, the lack of allocating sufficient funds is one of the main reasons for the failure and abandonment of many projects of producing new products. An unstable economy causes destructive effects in producing new products, but the funding must be such strong for production that no interruption would occur at any stage of the project.

IV. Ignoring strengthening the information exchange between products consumers and researchers:

According to interviews, one of the major obstacles which prevent producing and improving new products fully is the lack of proper communication between product consumers and researchers to address the shortages of products made in research centers through feedback. Therefore, researchers cannot take an important step to improve the next products; when they do not know the defects of producing the particular proposed product in full detail. The researchers' effective communication with the product users can certainly enhance all shortages of a new product.

V. Lack of empowering human resources and lack of encouraging and motivating people in the organization:

Human resources are one of the significant factors in the organization, affecting the organizational culture and is affected by it. Lack of empowering human resources of the organization is one of the challenges that every production industry faces to collaborate between staff and innovation in the production. The production staff doesn't have enough energy to produce new and efficient products if they don't have sufficient capability and motivation at different stages. The most critical issues that cause insufficient attention to human resource empowerment and reduce staff morale toward their useful idea are reported. They include lack of meritocracy, lack of strong supervision, lack of knowledge about the basic needs of staffs, discrimination, insufficient attention to staff welfare issues, lack of informing teams about their performance results, lack of fair payment, rapid changes in strategies, lack of matching between the individuals' field of study and their role in the organization, and the lack of purposeful education.

VI. Prolongation of the process of designing and producing new products due to ignoring the essential role of the SC in supplying the materials on-time:

Paying attention to supply raw materials on-time is one of the fundamental issues to perform various production stages, especially to new products associated with more challenges. Measurements to supply and deliver materials needed for production are not on-time and in a good position, and less attention has been paid to the essential role of the SC. Both technical and systematical inadequate measurements to provide the required materials on-time caused some delays in the projects. This problem extends the life cycle of the project in the operating environment and slows down the design and production process.

VII. The existence of significant differences in different levels of power and conflict in personal and organizational interests:

Conflict of interest is a set of conditions that cause secondary self-interest to influence professional decisions and measurements. Turning to personal interests and the abuse of power and position by people is another obstacle to production progress, which unfortunately leads them away from the ideal path of producing a product. Thus, conflicts between different personal and organizational interests, which delay paying special attention to innovation, should not be ignored. This issue has led to considerations in the solutions used.

VIII. Lack of attention to useful production strategies such as lean production, agility, and flexibility:

According to the interviews, important production strategy concepts, such as lean production, agility, and flexibility, are not well considered in producing new products due to limited resources in terms of time and cost. In contrast, several institutes pay more attention to these production techniques in the leading countries in producing new products.

IX. Changing officials of production organizations frequently and discontinuing previous innovative projects:

The frequent change of officials is another problem in production organizations that prevents the previous innovative projects from being properly pursued until that project is partially completed or fails. Different people are responsible for the essential parts in a cross-sectional manner, and there are differences of taste, which creates an atmosphere for organizational instability because people change periodically. Therefore, there is no integration in making decisions and implementing them until the desired result is achieved.

X. Hasty decision-making due to fear of lack of time and enough experience regardless of past documentation:

Enough attention is not paid to proper timing in developing technologies and the emergence of efficient problem-solving innovations. It is not also possible to use the experiences obtained from earlier causes of success or failure without correct and enough documentation.


Azami et al. | J. Appl. Res. Ind. Eng. 8(Spec. Issue) (2021) 1-23

XI. Organizational inertia despite the incredible intensity of changes in the need for new products and rejecting changes in traditional processes by officials:

Failing to adapt to rapid changes, and to analyze them deeply, surprises those who don't have the necessary knowledge about the sources of the changes. An organizational inertia problem prevents changing the structure or emerging any improvement ideas in any organization. Inertia in an organization is a pest that prevents dramatic changes in producing a new product. Steps must be taken vigorously to create dynamism within organizations. Some traditional processes don't need to exist in production organizations, and their complexity should be reviewed seriously.

## 4.2 | Suggesting Solutions to Address the Challenges

A summary of the main solutions proposed to overcome the challenges and improve production are as follows. We discovered the challenges and some of the solutions from the interviews. The other solutions were proposed based on our in-depth studies, and some practical inspections.

I. Forming collaboration and creating appropriate and efficient integration at different SC levels:

It is important to pay attention to the SC's conceptual model, based on moving towards collaboration. The first important point is to define the coordinating team for each SC [57]. The collaboration protocols should also be defined based on the overall needs. Developing better communication between different levels of the SC should be considered. It is necessary to consider improving the performance and occurring innovation within different SC levels to tackle the challenges in the SC and innovate the production. Each department should have a strong manager with relevant expertise who monitors the collaboration and integration between all sectors. In summary, the integrated SC's loops in producing a product should work together to innovate in producing goods. Significant production innovations can only be achieved in a collaborative environment. It is recommended to follow the model in *Fig. 3* to start and strengthen the collaboration. This figure described that the collaboration should be created between all levels of a specific SC.

II. Strengthening efficient communication and knowledge sharing between industry and university:

Universities and industries are islands that are sometimes bridged together with small projects. The relationship between industry and academia should be strong to prevent implementing projects in the industry without consulting academic professors. This should be a two-way relationship, and academia should try to solve industries' problems. Managers should trust science in any place, and academia should know that its life depends on solving real-world problems. There are suggestions for strengthening collaboration between academia and industry, including hiring academic graduates by industry, holding conferences in participation with both parties, establishing companies by academic professors, holding meetings and informal communication, transfer of researchers between academia and industry, consulting contracts.

III. Allocating the budget at the right time and providing adequate financial support for the production:

Proper investing in producing any new product that passes the design and scientific feasibility evaluation stages always solves many key production problems. The wise investment has been one of the reasons for developing some production industries. Adequate and on-time financial support is certainly needed to meet and promote producing any new product success.

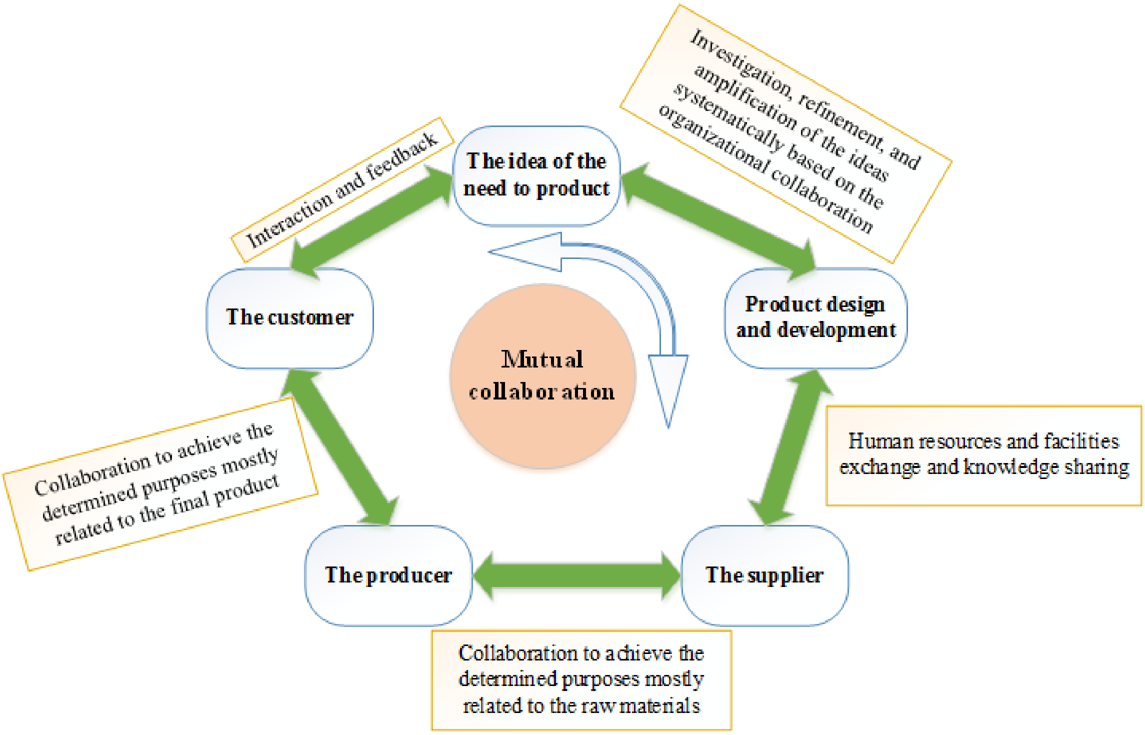


Fig. 3. The collaboration model in the SC.

IV. Strengthening communication and effective information sharing between customers and researchers:

Producing a product can be enhanced when academic researchers know the defects of a product made during its use. Establishing the proper connection through the effective information sharing between the user and the designer informs how a new product works. Therefore, efficient communication should be established between the researcher and the customer to improve a new product in future productions.

V. Empowering human resources, as well as applying proper encouraging and motivating:

Empowerment enables the organization to react more appropriately to the competitive production environment's dynamics by training motivated and capable people to present their practical ideas. Empowerment helps to collaborate for a new production at different SC levels through a super-motivated, psycho-political, psycho-symbolic, and relational perspective. The production organization should consider rewards for those who make efficient suggestions. Practical measurements for human resource empowerment include: 1) Demonstrating leadership commitment, 2) Considering staff benefits, 3) Training staff, and 4) participating staff in planning and sharing performance information.

VI. Using the most efficient experiences to supply the required materials on time and design a strong SC:

Attention should be paid to the supplier of raw materials in producing new products, and their performance promotion should also be affected by proper collaboration via designing an appropriate SC [58] and [59]. Using production methods that are less dependent on the supplier is one way to reduce the dependency of an organization's output on its suppliers. Buying management activity identifies their basic needs by establishing proper communication with different parts of the organization. The manager then selects the best ones in terms of price, delivery time, and quality using selected suppliers.

VII. Paying more attention to the staff needs to increase their organizational interests and loyalty:

Undoubtedly, human abilities can be used to advance the organization's goals. This requires providing the necessary prerequisites for employees and requires investment and comprehensive attention to human resources. People work in an organization to meet personal needs through income. Paying enough salary to

Azami et al. | J. Appl. Res. Ind. Eng. 8(Spec. Issue) (2021) 1-23

meet the person's needs, on the one hand, and having a fair system to pay rewards, on the other hand, are the factors that affect employee loyalty.

VIII. Changing managers' view on production strategies, including lean production, agility, and flexibility:

Efficient production strategies cannot be ignored to improve production. Therefore, it is necessary to pay attention to useful concepts, such as lean production, agile production, and flexibility. Flexibility in production enables transferring production technology and knowledge from the external environment. A negative role is considered for the unfinished goods stuck in storages, in lean production. Lean production uses the philosophy of continuous improvement. Besides, Agile production is a production system with tremendous capabilities to respond quickly to demand changes [60] and [61].

IX. Efforts to strengthen the stability in completing past innovative projects, even changing managers:

In many cases, when the director of a department or the head of an organization change, they leave many previous projects entirely and start new projects. Changing the person's place in different parts of the production organization should not abandon previous innovative projects.

X. Being patient to avoid ineffective immediate decisions without considering past experiences:

Both enough specialization and avoiding rushing are essential in deciding to produce new products to meet appropriate results by referring to previous experiences.

XI. Changing officials' opinion to turn into up-to-date processes and deal with organizational inertia:

The organization's managers and senior officials are the most important force at the evolution forefront in the transformation route towards improvement. Because accepting evolution in the first stage depends on the senior managers' opinion. Many managers do not accept changes easily and resist change. The organization managers have to look for ways to manage employee resistance to new processes. The organizational culture should be reformed to reduce organizational inertia.

XII. Reducing the complexity of the process structure in production companies:

Various processes in production companies need to be reviewed, controlled, and improved. Some long approval processes and complex structures reduce the efficiency and productivity of the organization. Thus, the relevant structures should be improved by focusing on creating innovation and change in the organization.

XIII. Avoid the traditional bureaucracy systems and move to some automatic systems:

Unfortunately, some of the old paper-work approaches prevent on-time progress. Sometimes, traditional bureaucratic systems have to be avoided and structures to be broken down to allow innovative ideas to produce new products. All managers should make an effort to use some automatic systems [62].

XIV. Paying attention to prioritizing to produce new products based on needs:

SC operations should focus on the operator needs strategy and prioritize producing new products to meet customer needs. The successful and innovative production industry is always aware of priority in producing goods.

## 4.3 | The Infrastructure for Realizing Production and Service Functions

In this section, the necessary infrastructures for realizing and promoting the production and services through implementing the proposed solutions are presented with the aim of innovation. To improve production, it is essential to draw attention to the existence of infrastructure. Paying attention to the infrastructures that have led to the significant success of some production industries can be an approach to reinforce the infrastructure to innovate producing other products. The provided infrastructures are one of the key prerequisites, which are: 1) financial infrastructure, 2) scientific infrastructure, 3) technology infrastructure, and 4) human resource collaboration and SC collaboration infrastructures.

The first and most important step considered in progress in various cases is strengthening the financial infrastructure. A strong financial infrastructure is needed for doing something from the beginning to the end without wasting time and energy. A planned financial infrastructure for producing new products can be considered necessary because progress in some production industries has required financial infrastructure. Finding loyal suppliers to supply the needed raw materials requires strong financial resources to deliver the best parts without financial worries when a shortage occurs. Providing the most advanced technologies and computer systems as well as hiring the best specialists need financial resources.

You must also have an advanced scientific foundation to have a successful production [63]. University is the first scientific center in the country. The relationship between the university and industry should, therefore, be tight. The production industries should attract academic elites and hold periodic meetings with university professors to share information. A special focus on scientific infrastructure flourishes efficient ideas, innovations, and up-to-date technologies.

On the other hand, technology infrastructure provides the basis for connecting all infrastructures. Technical knowledge is one of the main prerequisites for any project, including information about the technical design process. Failing to produce and commercialize a technology or product means the innovation and technology cycle remains incomplete [64]. Therefore, the technical knowledge transfer model is a document that defines the path of transferring technical knowledge of a project to the industry and determines the tasks of all departments. The sharing technical knowledge model leads the results of research carried out by researchers for several years to achieve the desired output and avoid wasting huge research costs. Undoubtedly, the progress on producing new production becomes possible by using a strong technology and promoting it.

Finally, the key to meet significant production success in any production industry is its human resources. Indeed, other infrastructures will not also work efficiently if the human resources are not motivated and can not collaborate and interact effectively. Specialists and elite, who have efficient ideas and proper interactions, are necessary for different parts of the production.

## 4.4 | Giving A Role to the Institutions Responsible For Implementing the Solutions

A map showing the main actors and their interactions can clarify gaps and structural barriers. This giving role helps to identify inconsistencies and shortcomings in support programs. Thus, studying institutions can explain many of the obstacles in the occurrence of innovation. The role of each of the active actors in the innovation system becomes clear using giving a role to institutions. Institutions that work together to innovate in producing new products and services are

**Policy-making institutions.** These institutions are, in fact, the shapers of macro-policies and innovation development programs. Planning organizations are formed to create SC loops in producing new products, integrate relevant tasks, and dividing tasks between those in charge of the production, directing, and controlling the tasks of different parts of the production. It is responsible for formulating policies, implementing and evaluating them, and allocating budgets. Human resource and funding organizations are associated with this institution.

**Academic and research institutions.** These institutions, along with industrial centers, are involved in creating and publications new knowledge and give the conditions for cultivating the human resources needed for innovation.  A close connection should be between production industries and universities as the centers for nurturing elites in producing new products. In fact, the university is considered as the production and publication institution of science, and the spunk of the innovation and innovative products starts from the university. Industrial companies, on the other hand, receive advances in science and technology from the university.

**Industrial institutions.** Industrial production institutions have a duty of producing new products, along with universities, and with integrated collaboration. These institutions play a key role in innovating and exploiting knowledge. One of the industrial organizations involved in producing new products is the design office. One of the key activities in the design offices is preparing and formulating the production documentation and product supplies on the production line. This issue comes from the proper interaction between designers and manufacturing engineers.

**Intermediary institutions.** Intermediary institutions established to integrate all innovative production activities and transfer knowledge and technology to production companies. In particular, some institutions facilitate the innovation process and the conditions for the necessary interactions. Some of the most important roles of these institutions are: helping to create research and industrial networks, creating databases, supporting the technology transfer centers, developing the international collaboration, developing the interaction between scientific and industrial sectors, a research evaluation system, a researchers' recruitment system, developing funds for supporting the innovation, holding conferences. In fact, intermediary institutions are SC loops that help facilitate the production process.

The role of institutions related to the production and service functions and their relationships in the innovation system is given in *Table 1*. The first column shows the five kinds of activities influencing the production and service functions. The second one describes the roles of the related institutions for realizing the considered functions. Finally, the last column determines the institutions which play a critical role in those functions.

## 4.5 | The Production and Service Functions Evaluation Indicators

The main indicators for evaluating the results of innovative products are identified in this section. There are several indicators for evaluating the production and service functions in the innovation system. Evaluating these indicators shows the level of capability and the performance of each system in the field of innovative production [65]. The final results of the innovation system indicate the produced innovative products and their effectiveness level. The degree and the application of the innovation can be a reason to compare organizations that produce new products.

Indicators for evaluating the results of innovative products are as follows: 1) The number of product innovations, 2) The number of process innovations, 3) The number of new products that have developed the knowledge frontiers, 4) The degree of novelty and evolutionary of innovative products compared to the current situation, 5) The level of effectiveness of innovative products from a strategic point of view, 6) The importance of the needs met by innovative products, and 7) The degree of alignment of producing new products with the demands.

Azami et al. | J. Appl. Res. Ind. Eng. 8(Spec. Issue) (2021) 1-23

**Table 1. The role of institutions in the field of the production and service functions in the innovation system.**

| Type of the Activity | The Roles in Realizing the Considered Function | Relevant Institutions in Realizing the Considered Function |
|---|---|---|
| 1- Policy-making, leading, and organizing the production, and service delivery with innovation. | Developing and approving policies. | Through the board of trustees in the production industries. |
| | Implementing the policies. | Implementing in all production industries. |
| | Evaluating and monitoring the policies. | Members of the decision-making board of the production industries. |
| 2- Providing and facilitating financing, and developing product production infrastructures, and providing innovative services in the production industries. | Allocating the production budgets and providing innovative services. | Accounting department, and decision-making board of trustees board, as well as the production industries planning department. |
| | Supporting the innovation. | Section of supporting the innovation in the production industries. |
| | Supporting the innovation in the production industries. | Developing the production infrastructures and providing innovative services in the production industries. |
| | Developing standards for new products. | Standard center in the production industries board of trustees. |
| | Reinforcing intellectual property protection. | Section of registering the innovation and the invention in the board of trustees. |
| 3- Developing human resources to produce products and provide services. | Modifying and reinforcing production programs and developing human resource. | The deputy of human resources, with the assistance of the deputy of industrial affairs and the production industries board of trustees. |
| | Re-engineering and modifying the composition of the human resources. | The deputy of human resources, with the assistance of the deputy of planning & programming as well as the production industries board of trustees. |
| | Reinforcing the postgraduate courses according to the needs. | The universities and the research centers in collaboration with the production industries board of trustees. |
| | Developing technical and vocational training and training skilled technologists. | Production industries in collaboration with the universities and the research centers. |
| | Developing specialized and technical training. | The deputy of human resources in collaboration with the industries, the universities, and the research centers. |
| | Attracting and employing the elites. | The industrial organizations, along with the production industries board of trustees. |

### 4.6 | The Model of Realizing and Promoting the Production and Service Functions

According to the research purpose and based on the identified challenges and proposed solutions, the model of realizing and promoting the production is presented. The complexity of producing innovative products is emphasized before presenting the model, which needs improving the fundamental abilities.

According to the specific innovative products' characteristics, some factors complicate producing the innovative products as the output of the industry's innovation. The innovative products are considered the capital products which are expensive and have advanced technologies. They are produced in small and customized projects and batches. These products are produced to meet the specific customers' needs, and they differ from those standard consumer products made by a mass production strategy. Undoubtedly, the production of complex products has a significant impact on developing innovative technology and industrial and economic development. The more attention is paid to the production of complex products, the better point is expected for the industry and the economy. Therefore, we need to improve critical capabilities closer to the current and future technological production capabilities for complex products. Indeed, paying attention to enhance these capabilities significantly affects the innovation system's main output, namely producing and delivering innovative products and services. Key capabilities to be upgraded to facilitate the occurrence of the innovation and promote the innovative production of the most sophisticated products; are:

1) Technological capabilities, 2) Testing, manufacturing, and production capabilities, 3) Capabilities to create integration, 4) Capabilities to reinforce communication and collaboration, 5) Capability to manage and plan large-scale projects, 6) Capability to manage and control the knowledge flow, and 7) Capability to manage the market and communicate with the customer.

According to this study results, *Fig. 4* presents the model of realizing and promoting the innovation system's production and service functions. In this model, the key factor for achieving and promoting the production of innovative products is to pay attention to the effective central institutions and reinforce their interactions. It was necessary to point out the main features and roles of these institutions promoting and improving the production industry's relevant capabilities to identify them better. Solutions to complex challenges were also presented. This model's overall goal is to move beyond the current state of production to improve and enhance it.

## 5 | Prioritizing the Solutions by the FMADM

In this section, the proposed solutions are prioritized based on the total obtained score of each solution. For this purpose, each expert is first asked to rate each of the 14 solutions. The rating given to each solution is based on how much that solution can increase the key capabilities mentioned in the previous section. Therefore, each solution's scoring criterion is how much the solution's desired effect has had on increasing the key capabilities needed to improve producing and delivering new services. A weight value is also applied to each key ability (as a criterion), which is effective in calculating each solution's score from each expert's perspective.

The weight given to each criterion is obtained using the pairwise comparisons matrix. In this paper, the verbal expressions and the fuzzy triangular numbers in *Table 2* are used to calculate weight in the pairwise comparisons.

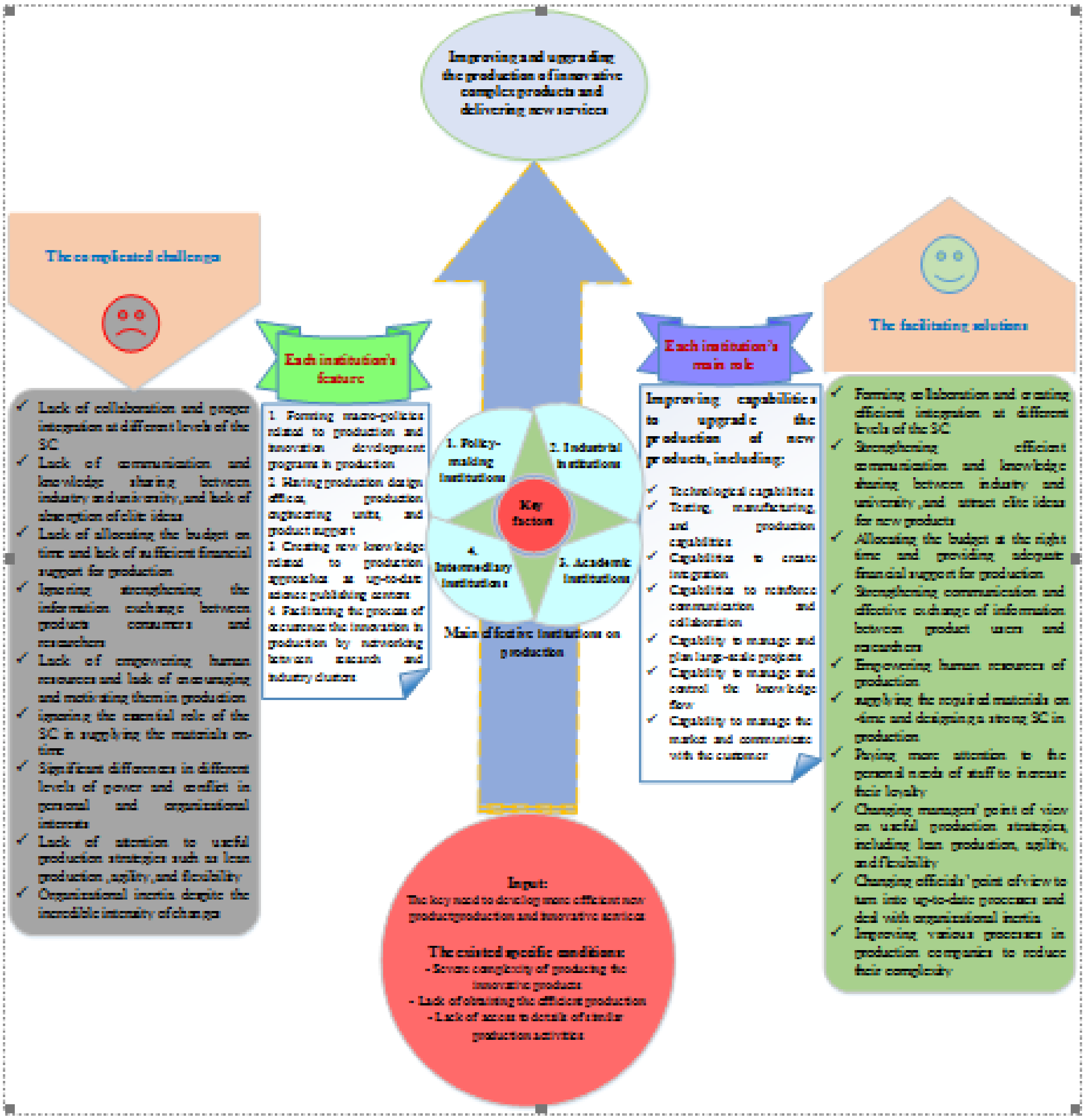


**Fig. 4. The model of realizing and promoting the innovative production and services.**

**Table 2. The verbal expressions and the fuzzy numbers.**

| Code | The Verbal Expression | The Fuzzy Number |
|---|---|---|
| 1 | Equal preference | (1,1,1) |
| 2 | Low to medium preference | (1,1.5,1.5) |
| 3 | Medium preference | (1,2,2) |
| 4 | Medium to high preference | (3,3.5,4) |
| 5 | High preference | (3,4,4.5) |
| 6 | High to very high preference | (3,4.5,5) |
| 7 | Very high preference | (5,5.5,6) |
| 8 | Very high to quite extremely high preference | (5,6,7) |
| 9 | Quite extremely high preference | (5,7,9) |

According to the expert opinions' aggregation, the pairwise comparisons' integrated matrix is as shown in *Table 3*.

Table 3. The integrated matrix of the pairwise comparisons.

| Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | (1,1,1) | (1/2,3/4,1) | (1/2,3/4,1) | (1/4,3/10,1) | (3/4,5/4,5/2) | (3/4,5/4,5/2) | (1,5/4,9/4) |
| 2 | (1,4/3,2) | (1,1,1) | (1/4,3/4,2) | (1/4,1/2,5/4) | (1,7/4,13/4) | (5/4,7/4,3) | (1,2,3) |
| 3 | (1,4/3,2) | (1/2,4/3,4) | (1,1,1) | (1/4,3/4,1) | (5/4,7/4,3) | (3/2,7/4,11/4) | (1,9/4,11/4) |
| 4 | (1,10/3,4) | (4/5,2,4) | (1,4/3,4) | (1,1,1) | (9/4,3,15/4) | (2,13/4,15/4) | (5/2,3,7/2) |
| 5 | (2/5,4/5,4/3) | (4/13,4/7,1) | (1/3,4/7,4/5) | (4/15,1/3,4/9) | (1,1,1) | (1/4,3/4,2) | (1/2,1,3/2) |
| 6 | (2/5,4/5,4/3) | (1/3,4/7,4/5) | (4/11,4/7,2/3) | (4/15,4/13,1/2) | (1/2,4/3,4) | (1,1,1) | (3/4,1,5/4) |
| 7 | (4/9,4/5,1) | (1/3,1/2,1) | (4/11,4/9,1) | (2/7,1/3,2/5) | (2/3,1,2) | (4/5,1,4/3) | (1,1,1) |

We use the extent analysis method proposed by Chang [19] to calculate this table's weight. This method was employed due to its distinguished applicability in such kinds of evaluations, and also it is the most common fuzzy prioritization approach among researchers. It is almost a more accessible method when compared to other approaches on FMADM, and it applies linguistic variables to consider the comparative observations made by respondents. The technique requires lower calculation complexity than other techniques when executing. Moreover, it was confirmed to be a suitable method in undertaking practical MADM problems. It showed the benefit of capturing human thinking's ambiguity and solving the problem by a structured and straightforward process. This method's results are reported below according to the method presented by Chang, which is also explained in detail and used by Hassanzadeh and Asghari [66] and Shafi Salimi and Edalatpanah [67].

$$s_1 = \left(4.75, 6.55, 11.25\right) \otimes \left(\frac{1}{92.61}, \frac{1}{58.4}, \frac{1}{38.12}\right) = \left(0.05, 0.11, 0.3\right). \tag{1}$$

The other $s$ values will be calculated in the same way. To calculate V values,

$$s_2 = \left(5.75, 9.08, 15.5\right) \otimes \left(\frac{1}{92.61}, \frac{1}{58.4}, \frac{1}{38.12}\right) = \left(0.06, 0.16, 0.41\right). \tag{2}$$

$$s_3 = \left(6.5, 10.2, 16.5\right) \otimes \left(\frac{1}{92.61}, \frac{1}{58.4}, \frac{1}{38.12}\right) = \left(0.07, 0.17, 0.43\right). \tag{3}$$

$$V\ (s_1 \geq s_2) = \frac{0.06 - 0.3}{\left(0.11 - 0.3\right) - \left(0.16 - 0.06\right)} = 0.843. \tag{4}$$

$$V\ (s_1 \geq s_3) = \frac{0.07 - 0.3}{\left(0.11 - 0.3\right) - \left(0.17 - 0.07\right)} = 0.793. \tag{5}$$

All of the V values are reported in *Table 4*.

Table 4. The calculated V values.

| V | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 0.843 | 0.793 | 0.505 | 1 | 1 | 1 |
| 2 | 1 | 1 | 0.948 | 0.686 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 0.734 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 0.860 | 0.683 | 0.617 | 0.325 | 1 | 0.948 | 0.995 |
| 6 | 0.923 | 0.759 | 0.697 | 0.413 | 1 | 1 | 1 |
| 7 | 0.857 | 0.672 | 0.604 | 0.305 | 1 | 0.950 | 1 |

$$d'(Criteria\ 1) = V\ (s_1 \geq s_2, s_3, s_4, s_5, s_6, s_7) = \min(0.843, 0.793, 0.505, 1, 1, 1) = 0.505. \quad (6)$$

$$d'(Criteria\ 2) = V\ (s_2 \geq s_1, s_3, s_4, s_5, s_6, s_7) = \min(1, 0.948, 0.686, 1, 1, 1) = 0.686. \quad (7)$$

$$d'(Criteria\ 3) = V\ (s_3 \geq s_1, s_2, s_4, s_5, s_6, s_7) = \min(1, 1, 0.734, 1, 1, 1) = 0.734. \quad (8)$$

The other $d'$ values will be obtained in the same way. Therefore,

$$W' = (0.505, 0.686, 0.734, 1, 0.325, 0.413, 0.305). \quad (9)$$

via normalization, the final weight vector for each criterion will be obtained as follows:

$$W = (0.13, 0.17, 0.19, 0.25, 0.08, 0.1, 0.08). \quad (10)$$

*Table 5* shows the scores that the first expert has given to the 14 proposed solutions.

**Table 5. The first expert scores for the proposed solutions.**

| Solutions | Criteria (Capilities) with Their Weights | | | | | | | Scores |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| | 0.13 | 0.17 | 0.19 | 0.25 | 0.08 | 0.1 | 0.08 | |
| S1 | 5 | 7 | 9 | 9 | 5 | 5 | 5 | 7.09 |
| S2 | 7 | 5 | 5 | 9 | 3 | 3 | 3 | 5.74 |
| S3 | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 5.60 |
| S4 | 3 | 9 | 7 | 9 | 3 | 3 | 9 | 6.75 |
| S5 | 5 | 5 | 3 | 5 | 7 | 5 | 7 | 4.95 |
| S6 | 3 | 9 | 5 | 5 | 5 | 3 | 1 | 4.92 |
| S7 | 3 | 3 | 3 | 5 | 7 | 5 | 5 | 4.19 |
| S8 | 7 | 5 | 9 | 9 | 5 | 5 | 5 | 7.00 |
| S9 | 5 | 3 | 5 | 7 | 7 | 3 | 5 | 5.11 |
| S10 | 5 | 9 | 5 | 5 | 5 | 3 | 3 | 5.33 |
| S11 | 5 | 5 | 3 | 5 | 5 | 3 | 3 | 4.27 |
| S12 | 3 | 5 | 5 | 5 | 5 | 3 | 3 | 4.38 |
| S13 | 3 | 3 | 5 | 5 | 3 | 3 | 5 | 4.03 |
| S14 | 1 | 5 | 5 | 5 | 5 | 3 | 3 | 4.13 |

Each solution's final score is calculated when all experts' scores for each solution were obtained based on the effect of each solution on increasing key capabilities. According to the weighted aggregation of experts' scores, each solution's final score is reported in *Table 6*. The weight given to the scores obtained from each expert in the previous step is calculated by the projection method.

Azami et al.| J. Appl. Res. Ind. Eng. 8(Spec. Issue) (2021) 1-23

Table 6. The final score for each solution calculated by the weighted summation of all experts' scores.

| Solutions | Experts with Their Weights | | | | | | | | | | | | Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| | 0.04 | 0.13 | 0.09 | 0.09 | 0.04 | 0.09 | 0.13 | 0.09 | 0.09 | 0.13 | 0.04 | 0.04 | |
| S1 | 7.09 | 7.54 | 6.83 | 7.32 | 7.16 | 7.23 | 6.92 | 6.86 | 7.18 | 7.08 | 6.79 | 7.84 | 7.145 |
| S2 | 5.74 | 6.39 | 5.76 | 5.89 | 5.75 | 5.86 | 5.62 | 5.55 | 5.81 | 5.83 | 5.28 | 6.32 | 5.841 |
| S3 | 5.60 | 5.94 | 5.37 | 5.76 | 5.59 | 5.68 | 5.4 | 5.39 | 5.69 | 5.61 | 5.09 | 6.22 | 5.614 |
| S4 | 6.75 | 7.28 | 6.6 | 6.91 | 6.78 | 6.82 | 6.54 | 6.55 | 6.88 | 6.93 | 6.27 | 7.44 | 6.827 |
| S5 | 4.95 | 5.23 | 4.71 | 5.2 | 5.1 | 5.09 | 4.85 | 4.76 | 5.02 | 5.08 | 4.59 | 5.57 | 5.011 |
| S6 | 4.92 | 5.36 | 4.84 | 5.08 | 4.95 | 5 | 4.79 | 4.77 | 5.03 | 4.99 | 4.61 | 5.43 | 4.990 |
| S7 | 4.19 | 4.48 | 4.05 | 4.37 | 4.28 | 4.28 | 4.1 | 4.09 | 4.23 | 4.29 | 3.88 | 4.62 | 4.245 |
| S8 | 7 | 7.51 | 6.75 | 7.24 | 7.04 | 7.1 | 6.82 | 6.71 | 7.06 | 7.1 | 6.39 | 7.73 | 7.051 |
| S9 | 5.11 | 5.44 | 4.91 | 5.28 | 5.16 | 5.22 | 5 | 4.98 | 5.22 | 5.22 | 4.72 | 5.66 | 5.168 |
| S10 | 5.33 | 5.68 | 5.15 | 5.51 | 5.41 | 5.44 | 5.23 | 5.16 | 5.45 | 5.49 | 4.91 | 5.98 | 5.402 |
| S11 | 4.27 | 4.52 | 4.1 | 4.42 | 4.29 | 4.33 | 4.16 | 4.14 | 4.36 | 4.38 | 3.94 | 4.64 | 4.305 |
| S12 | 4.38 | 4.52 | 4.15 | 4.53 | 4.41 | 4.41 | 4.28 | 4.21 | 4.42 | 4.42 | 4.03 | 4.83 | 4.381 |
| S13 | 4.03 | 4.31 | 3.91 | 4.14 | 4.05 | 4.11 | 3.92 | 3.93 | 4.13 | 4.09 | 3.87 | 4.41 | 4.076 |
| S14 | 4.13 | 4.48 | 4.09 | 4.24 | 4.16 | 4.19 | 4.09 | 3.99 | 4.22 | 4.15 | 3.77 | 4.58 | 4.185 |

Finally, the solutions' prioritization is as shown in *Table 7* according to their scores.

Table 7. The final priority for the proposed solutions.

| Priority | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solutions | S1 | S8 | S4 | S2 | S3 | S10 | S9 | S5 | S6 | S12 | S11 | S7 | S14 | S13 |
| Scores | 7.14 | 7.05 | 6.83 | 5.84 | 5.61 | 5.4 | 5.17 | 5.01 | 4.99 | 4.38 | 4.3 | 4.24 | 4.18 | 4.08 |

*Table 7* described that the most effective solution to improve production and service delivery in the innovation system is the first presented solution. Solution 1 emphasizes forming collaboration and creating appropriate and efficient integration at different SC levels. This solution has the highest priority and should be employed more than ever. The second priority is Solution 8, which its score based on the experts' opinion is close to the first priority. Based on Solution 8, managers should change their view on production strategies, including lean production, agility, and flexibility. Via the extent analysis method proposed by Chang, the third priority has been obtained implementing Solution 4. This suggested solution points out that communication and effective information sharing between customers and researchers should be strengthened. The other priorities for the proposed solutions can be seen in *Table 7*. It may be interesting if we glance at the last priorities, which have less impact on improving production and service delivery in the innovation system compared to the other solutions. The last priorities are Solutions 14 and 13, respectively. Solution 14 is paying attention to ranking new products to produce based on needs. Besides, Solution 13 confirms the effect of the traditional bureaucracy systems and recommends moving to some automatic systems to improve production and service delivery. Experts believe that these two proposed solutions can have less impact on production and service delivery improvement.

## 6 | Conclusion

In this paper, we attempted to extract challenges and propose solutions to improve production and service delivery in the innovation system. For this purpose, twelve interviews were conducted with qualified experts. Besides, fifteen elite researchers in the innovation field discussed the results in focus sessions and refined practical solutions after an in-depth review of the extracted information. Therefore, a qualitative-exploratory study was conducted. The responsible institutions' role was determined to identify inconsistencies and shortcomings in support programs. The necessary indicators were mentioned to evaluate the innovative production factors after providing the required infrastructures to meet the production promotion.



Moreover, the FMADM technique was also used to prioritize the discovered and suggested solutions based on the importance of influencing the production promotion. The results show that the main solution is to form the collaboration and create an efficient integration at different levels of the related SC. Finally, a model was presented for improving the production and service functions in the innovation system. In this model, the key factor for achieving and promoting innovative products is paying attention to the effective central institutions and strengthening their interactions. This model's overall goal is to move beyond the current production state to improve and enhance it. There are some suggestions to develop this paper. A significant successful product can be studied to extract insights into its development. It is also good to conduct more interviews with experienced and senior operational officials in the production industry.

# References


[1] Belliveau, P., Griffin, A., & Somermeyer, S. (Eds.). (2004). *The PDMA toolbook 1 for new product development*. John Wiley & Sons.

[2] Machado, C. F., & Miranda, R. M. M. (2020). About competencies, creativity, and innovation in the Portuguese textile and clothing sector. In *Entrepreneurship and organizational innovation* (pp. 93-112). Springer, Cham. https://doi.org/10.1007/978-3-030-19289-1_6

[3] Damanpour, F. (1996). Organizational complexity and innovation: developing and testing multiple contingency models. *Management science*, *42*(5), 693-716.

[4] Shariatmadari Serkani, E. (2015). Using DEMATEL–ANP hybrid algorithm approach to select the most effective dimensions of CRM on innovation capabilities. *Journal of applied research on industrial engineering*, *2*(2), 120-138.

[5] Thompson, V. A. (1965). Bureaucracy and innovation. *Administrative science quarterly*, 1-20. https://doi.org/10.2307/2391646

[6] Aazami, A., & Saidi-Mehrabad, M. (2021). A production and distribution planning of perishable products with a fixed lifetime under vertical competition in the seller-buyer systems: a real-world application. *Journal of manufacturing systems*, *58*, 223-247. https://doi.org/10.1016/j.jmsy.2020.12.001

[7] Edquist, C. (2013). *Systems of innovation: technologies, institutions and organizations*. Routledge. https://www.routledge.com/Systems-of-Innovation-Technologies-Institutions-and-Organizations/Edquist/p/book/9780415516112

[8] Nelson, R. R. (Ed.). (1993). *National innovation systems: a comparative analysis*. Oxford University Press on Demand.

[9] Lundvall, B. Å., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research policy*, *31*(2), 213-231. https://doi.org/10.1016/S0048-7333(01)00137-8

[10] Ormala, E. (1999). *Managing national innovation systems*. OECD

[11] DeBresson, C. (1996). *Economic interdependence and innovative activity*. Books, Edward Elgar Publishing.

[12] Wohlmuth, K., & IGC, G. C. (2013). *Nationale innovationssysteme, megatrends und globaler wettbewerb* [pdf]. Retrieved from http://www.iwim.uni-bremen.de/files/dateien/1670_nationaleinnovationssysteme.pdf

[13] Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). Functions of innovation systems: a new approach for analysing technological change. *Technological forecasting and social change*, *74*(4), 413-432. https://doi.org/10.1016/j.techfore.2006.03.002

[14] Damanpour, F. (1991). Organizational innovation: a meta-analysis of effects of determinants and moderators. *Academy of management journal*, *34*(3), 555-590. https://doi.org/10.5465/256406

[15] Ettlie, J. E., Bridges, W. P., & O'keefe, R. D. (1984). Organization strategy and structural differences for radical versus incremental innovation. *Management science*, *30*(6), 682-695. https://doi.org/10.1287/mnsc.30.6.682

[16] Stevenson, W. J., Hojati, M., & Cao, J. (2014). *Operations management* (p. 182). Chicago-USA: McGraw-Hill Education.

[17] Harrison, A., Skipworth, H., van Hoek, R. I., & Aitken, J. (2019). Logistics management and strategy: competing through the supply chain. Pearson UK.

[18] Saeedi Mehrabad, M., Aazami, A., & Goli, A. (2017). A location-allocation model in the multi-level supply chain with multi-objective evolutionary approach. *Journal of industrial and systems engineering*, *10*(3), 140-160. http://www.jise.ir/article_44936.html

[19] Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European journal of operational research*, *95*(3), 649-655. https://doi.org/10.1016/0377-2217(95)00300-2

[20] Funaba, M. (1988). [Review of the the book *Technology policy and economic performance: lessons from Japan by christopher freeman and evaluating applied research: lessons from Japan by John Irvine*]. *Japan quarterly*, *35*(3), 326.

[21] Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: institutional and organisational dimensions. *Research policy*, *26*(4-5), 475-491. https://doi.org/10.1016/S0048-7333(97)00025-5

[22] Callon, M. (1992). The dynamics of techno-economic networks. *Technological change and company strategies*, *72*, 102-119.

[23] Carlsson, B., & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of evolutionary economics*, *1*(2), 93-118. https://doi.org/10.1007/BF01224915

[24] Hughes, T. P. (2012). The evolution of large technological systems. In E. Bijker, T. P. Highes, T. Pinch (Eds.) *The social construction of technological systems: New directions in the sociology and history of technology* (pp. 45-76). MIT Press.

[25] Sanchez, C., Arribart, H., & Giraud Guille, M. M. (2005). Biomimetism and bioinspiration as tools for the design of innovative materials and systems. *Nature materials*, *4*(4), 277-288. https://doi.org/10.1038/nmat1339

[26] Paci, R., & Usai, S. (2000). The role of specialisation and diversity externalities in the agglomeration of innovative activities. *Rivista italiana degli economisti*, (2), 237-268.

[27] Makui, A., Heydari, M., Aazami, A., & Dehghani, E. (2016). Accelerating Benders decomposition approach for robust aggregate production planning of products with a very limited expiration date. *Computers & industrial engineering*, *100*, 34-51. https://doi.org/10.1016/j.cie.2016.08.005

[28] Aazami, A., & Saidi-Mehrabad, M. (2019). Benders decomposition algorithm for robust aggregate production planning considering pricing decisions in competitive environment: a case study. *Scientia Iranica*, *26*(5), 3007-3031. DOI: 10.24200/sci.2018.5563.1346

[29] Mekid, S., Schlegel, T., Aspragathos, N., & Teti, R. (2007). Foresight formulation in innovative production, automation and control systems. *Foresight*, 9(5), 35-47. https://doi.org/10.1108/14636680710821089

[30] Go Jefferies, J., Bishop, S., & Hibbert, S. (2021). Service innovation through resource integration: an empirical examination of co-created value using telehealth services. *Public policy and administration*, *36*(1), 69-88.

[31] Andreassi, L., Ciminelli, M. V., Feola, M., & Ubertini, S. (2009). Innovative method for energy management: modelling and optimal operation of energy systems. *Energy and buildings*, *41*(4), 436-444. https://doi.org/10.1016/j.enbuild.2008.11.010

[32] Avgerou, C. (2001). The significance of context in information systems and organizational change. *Information systems journal*, *11*(1), 43-63. https://doi.org/10.1046/j.1365-2575.2001.00095.x

[33] Vaezi, E., Najafi, S. E., Hajimolana, S. M., Hosseinzadeh Lotfi, F., & Ahadzadeh Namin, M. (2020). Production planning and efficiency evaluation of a three-stage network. *Journal of industrial and systems engineering*, *13*(2), 155-178. http://www.jise.ir/article_118487.html

[34] Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: regional innovation systems. In *The Oxford handbook of innovation*. DOI: 10.1093/oxfordhb/9780199286805.003.0011

[35] Gregersen, B., & Johnson, B. (1997). Learning economies, innovation systems and European integration. *Regional studies*, *31*(5), 479-490. https://doi.org/10.1080/00343409750132270

[36] Schumpeter, J. (1934). *The theory of economic development*. Harvard University Press. Cambridge, MA.

[37] Utterback, J. M. (1996). *Mastering the dynamics of innovation*. Harvard Business School Press.

[38] Klepper, S. (1996). Entry, exit, growth, and innovation over the product life cycle. *The American economic review*, *86*(3)562-583.

[39] Dahmén, E. (1988). ‘Development blocks’ in industrial economics. *Scandinavian economic history review*, *36*(1), 3-14. https://doi.org/10.1080/03585522.1988.10408102
[40] Nelson, R. R. (1995). Recent evolutionary theorizing about economic change. *Journal of economic literature*, *33*(1), 48-90. https://www.jstor.org/stable/2728910
[41] Dosi, G. (1997). Opportunities, incentives and the collective patterns of technological change. *The economic journal*, *107*(444), 1530-1547. https://doi.org/10.1111/j.1468-0297.1997.tb00064.x
[42] Metcalfe, J. S. (1998). *Evolutionary economics and creative destruction* (Vol. 1).Routledge. https://www.amazon.com/Evolutionary-Economics-Creative-Destruction-Schumpeter/dp/041540648X
[43] Archibugi, D., & Michie, J. (1995). The globalisation of technology: a new taxonomy. *Cambridge journal of Economics*, *19*(1), 121-140. https://doi.org/10.1093/oxfordjournals.cje.a035299
[44] Cantwell, J. (1995). The globalisation of technology: what remains of the product cycle model? *Cambridge journal of economics*, *19*, 155-155. https://doi.org/10.1093/oxfordjournals.cje.a035301
[45] Patel, P. (1995). Localised production of technology for global markets. *Cambridge journal of economics*, *19*(1), 141-153. https://doi.org/10.1093/oxfordjournals.cje.a035300
[46] Smith, A. (1937). *The wealth of nations*. Modern Library, New York.
[47] Freeman, C. (1995). The ‘national system of innovation’in historical perspective. *Cambridge journal of economics*, *19*(1), 5-24. https://doi.org/10.1093/oxfordjournals.cje.a035309
[48] Freeman, C., & Freeman, C. (2019). History, co-evolution and economic growth. *Industrial and corporate change*, *28*(1), 1-44. https://doi.org/10.1093/icc/dty075
[49] Dosi, G., Freeman, C., Nelson, R., Silverberg, G., & Soete, L. (1988). *Technical change and economic theory*. LEM Book Series, Laboratory of Economics and Management (LEM). sant'anna school of advanced studies, Pisa, Italy. Available at https://econpapers.repec.org/bookchap/ssalembks/dosietal-1988.htm
[50] Carlsson, B., & Jacobsson, S. (1997). In search of useful public policies—key lessons and issues for policy makers. In *Technological systems and industrial dynamics* (pp. 299-315). Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-6133-0_11
[51] Breschi, S., & Malerba, F. (1997). Sectoral innovation systems: technological regimes, Schumpeterian dynamics, and spatial boundaries. *Systems of innovation: technologies, institutions and organizations*, *1*, 130-156.
[52] Weil, K. E. (1985). PORTER, Competitive advantage, creating and sustaining superior performance. *Revista de administração de empresas, 25*(2), 82-84.
[53] Attride-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. *Qualitative research*, *1*(3), 385-405.
[54] Boyatzis, R. E. (1998). *Transforming qualitative information: thematic analysis and code development*. Sage.
[55] Barbour, R. S. (1999). The case for combining qualitative and quantitative approaches in health services research. *Journal of health services research & policy*, *4*(1), 39-43.
[56] Wilkinson, S. (2004). Focus group research. In D. Silverman (Ed.) *Qualitative research: Theory, method, and practice* (pp. 177-199). SAGE Publication.
[57] Zhang, Y., Duan, D., & Du, D. (2021). Coordinated Development of Innovation System in China’s Yangtze River Economic Belt, a Demand and Supply Perspective. *Sustainability*, *13*(1), 178. https://doi.org/10.3390/su13010178
[58] Alavi, S. H., & Jabbarzadeh, A. (2018). Supply chain network design using trade credit and bank credit: a robust optimization model with real world application. *Computers & industrial engineering*, *125*, 69-86. https://doi.org/10.1016/j.cie.2018.08.005
[59] Pahlevan, S. M., Hosseini, S. M. S., & Goli, A. (2021). Sustainable supply chain network design using products’ life cycle in the aluminum industry. *Environmental science and pollution research*, 1-25. https://doi.org/10.1007/s11356-020-12150-8
[60] Goli, A., Zare, H. K., Moghaddam, R., & Sadeghieh, A. (2018). A comprehensive model of demand prediction based on hybrid artificial intelligence and metaheuristic algorithms: a case study in dairy industry. *Journal of industrial and systems engineering, 11*, 190-203.
[61] Goli, A., Khademi-Zare, H., Tavakkoli-Moghaddam, R., Sadeghieh, A., Sasanian, M., & Malekalipour Kordestanizadeh, R. (2021). An integrated approach based on artificial intelligence and novel meta-heuristic algorithms to predict demand for dairy products: a case study. *Network: computation in neural systems*, *32*(1), 1-35. https://doi.org/10.1080/0954898X.2020.1849841

[62] Goli, A., Tirkolaee, E. B., & Aydın, N. S. (2021). Fuzzy integrated cell formation and production scheduling considering automated guided vehicles and human factors. *IEEE transactions on fuzzy systems*, *29*(12), 3686-3695. DOI: 10.1109/TFUZZ.2021.3053838

[63] Zhang, L., Hao, X., Zhang, Y., & Wang, Y. (2021). Research on the industrial economic development driving by scientific and technological service system innovation. *E3S Web of conferences* (Vol. 235, p. 02008). EDP Sciences. https://doi.org/10.1051/e3sconf/202123502008

[64] Vendrell-Herrero, F., Bustinza, O. F., & Opazo-Basaez, M. (2021). Information technologies and product-service innovation: the moderating role of service R&D team structure. *Journal of business research*, *128*, 673-687. https://doi.org/10.1016/j.jbusres.2020.01.047

[65] Taques, F. H., López, M. G., Basso, L. F., & Areal, N. (2021). Indicators used to measure service innovation and manufacturing innovation. *Journal of innovation & knowledge*, *6*(1), 11-26. https://doi.org/10.1016/j.jik.2019.12.001

[66] Hassanzadeh, R., & Asghari, H. (2020). Identification and ranking of affecting factors on sales and operations planning (S&OP) process implementation by using fuzzy AHP and fuzzy TOPSIS approach (case study: dairy industry). *Journal of applied research on industrial engineering*, *7*(1), 57-78. DOI: 10.22105/jarie.2020.222680.1142

[67] Shafi Salimi, P., & Edalatpanah, S. A. (2020). Supplier selection using fuzzy AHP method and D-Numbers. *Journal of fuzzy extension and applications*, *1*(1), 1-14. DOI: 10.22105/jfea.2020.248437.1007