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Assessing the Innovation Capacity of Manufacturing Firms in Ordu Province: A Multi-Criteria Evaluation Using CIMAS

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Abstract: Manufacturing firms face increasing pressure to enhance their competitiveness, penetrate new markets, and prioritise customer satisfaction in an increasingly dynamic global business environment. To remain competitive, these firms must adopt innovative strategies that address the evolving demands of customers. In this context, a firm's capacity to innovate is critical, as it directly influences both the development and implementation of strategic initiatives. Innovation capacity in manufacturing companies is shaped by numerous interrelated factors, each contributing to a firm's ability to respond to technological advancements, market shifts, and changing consumer expectations. This study aims to identify the key determinants of innovation capacity in manufacturing firms based in Ordu Province, Turkey, with a focus on the role of corporate identity. A multi-criteria decision-making (MCDM) approach, specifically the Criteria Importance Assessment (CIMAS) technique, is employed to determine the relative importance of these factors. The findings suggest that "clustering and international networking activities" emerge as the most significant factor influencing innovation capacity, while the "level of entrepreneurship" is found to have the least impact. These results underscore the importance of collaboration, international connections, and strategic partnerships in driving innovation, while highlighting the comparatively limited role of entrepreneurship in fostering innovation within the studied region. The findings have significant implications for manufacturing firms, particularly in terms of strategy development, resource allocation, and the identification of key areas for improvement in innovation processes. Additionally, the research provides valuable insights for policymakers seeking to enhance the innovation capacity of manufacturing sectors in emerging markets.

Keywords: Manufacturing; Innovation; Innovation capacity; multi-criteria decision-making (MCDM); Criteria Importance Assessment (CIMAS)

1 Introduction

Innovation, which is at the basis of the business and transactions between the supplier, manufacturer, distributor, and customer in the supply chain, constitutes an important field of activity in both manufacturing enterprises and service-producing enterprises. Because the level and capacity of innovation have a critical place as a function of flexibility and competitiveness in manufacturing enterprises. The capacity to create innovation, which is widely accepted, is one of the main indicators that play a critical role in customer satisfaction and business success [1].

Innovation capacity includes the skills and resources that firms can use to engage in new product development activities and explore opportunities by continuously improving their capabilities and resources. Innovation capacity is the capacity of firms to be an important strategic element to gain competitive advantage, to survive, and to grow in the market. Innovation capacity (IC) also refers to an organization's ability to innovate [2].

In this context, innovation as a concept includes the introduction of a new product or its quality, the development of a new production method or an existing one, the creation of a new market, the discovery of new sources for the supply of raw materials or semi-finished products, and the creation of a new organizational structure to create a monopoly situation or to break the monopoly structure [3]. In fact, innovation has a complex structure in the form of new market and new product creation, or process innovation and product innovation [4].

A firm's innovation capacity, in other words, its ability to innovate, is very important in the implementation of its strategies and in gaining and sustaining competitive advantage. Therefore, innovation capacity is an important and special asset that a firm possesses. Innovation capacity is an important key for competition [5]. Innovation capacity is an important factor for firms to maintain a sustainable competitive advantage. An organization with a high innovation capacity has the ability to recognize opportunities, develop new goods and services, and provide value to customers [6].

Innovation capacity is a concept that includes all the factors necessary for a firm to innovate. Therefore, measuring and quantifying innovation capacity is used as an indicator of a firm's ability to innovate. The products of a firm's innovation capacity are innovative results or outputs. Innovation capacity is a tangible indicator of the environment that enables the achievement of innovative outcomes [7].

In fact, if innovation is successful, it is possible to reduce costs, shorten the production process, and increase performance and productivity. Therefore, innovative activities are important in terms of efficient use of resources, being ahead of competitors by producing strategies in marketing, and attracting the attention of customers [8].

In particular, by innovating, businesses aim to shift the demand curve of their products by some activities (e.g., improving the quality of the product they produce, producing new products, reaching new markets and customers) or to shift the cost curve by reducing the cost of some activities (e.g., production, procurement, logistics, transaction costs) or to gain a competitive advantage and improve their performance by improving some factors that affect the firm's capacity to innovate.

In addition, the capacity to innovate is one of the main indicators of competitiveness and advantage; moreover, it has recently become important in new development approaches to consider whether the potential of regions with this capacity to withstand economic crises can catch up with the potential by increasing this capacity in other regions [9].

In addition, human capital plays a key role in defining the innovation capacity of an organization. Because it has been said that the better innovation capacity is built and used effectively, the more efficiently businesses can carry out the innovation process and therefore the stronger the innovation performance [10].

At the same time, the factors affecting the innovation capacity of enterprises are also important in guiding the decisions of policymakers in countries and evaluating the innovation capacity and performance of firms. Because when the effects of innovation on competitiveness, development, and economic growth are examined, it is of great importance that innovation practices are realized regardless of the size of the enterprise [11].

From this point, the factors affecting the capacity of enterprises to create innovation affect vital issues such as customer satisfaction, effective process management, and cost. Because a small disruption in production processes affects the entire process up to the final consumer, the factors affecting the capacity to innovate in enterprises appear as key components that should be emphasized meticulously. Based on all these issues, the study aims to determine the factors affecting the capacity to create innovation in manufacturing enterprises with corporate identity in Ordu Province and to assess them via the CIMAS, one of the MCDM techniques.

In the following sections of the study, the literature review on the factors affecting the innovation/innovation creation capacity is emphasized, which constitutes the method of the study; explanations about CIMAS and the application of the method for Ordu Province are examined. In the last section of the study, conclusions and information about future studies are presented.

2 Literature

Some studies in the national and international literature on the factors affecting innovation and innovation creation capacity are given below.

· Jørgensen and Ulhøi [12] find that network relationships established in the early stages of the firm's life cycle play a critical role in developing the SME's capacity for continuous innovation. Furthermore, the study contributed to network theory by questioning the dichotomy of weak and strong ties, as the relationships that are critical for SMEs' innovation capacity have characteristics of both types of ties.

· Fan [13] provides micro-level insights on innovation capacity and economic development in a case study of domestic biotechnology firms in China and India.

· Tekin and Durna [14] examined the perspectives of top-level managers in innovation management activities in hotel businesses. As a result of the research, it was determined that business managers are mostly effective in making innovation decisions.

· Hassan et al. [15], in their study to determine the impact of innovation types (product, process, organizational and market) on the innovation performance of manufacturing enterprises in Pakistan, found that process innovation is more important than other types of innovation.

· Najda-Janoszka and Kopera [16] revealed the barriers to innovation in small and large tourism businesses.

· Kalay and Kızıldere [17] evaluated the factors affecting the product, process, marketing and organizational innovation performance of Turkish firms and the product, process, marketing and organizational innovation performance of Turkish firms.

· Özkul and Örün [18] examined the impact of entrepreneurship and innovation on economic growth between 2002 and 2013.

· Ávila et al. [19] investigated the link between innovation and sustainability in the context of higher education and the main barriers to innovation and sustainable development.

· Erdal and Korucuk [20] presented the determination of innovation priorities in the logistics sector as a comparative analysis.

· Chuang et al. [21] conducted a literature review-based study to identify innovation barriers in academic libraries.

· Gürtuna and Polat [22] evaluated the global innovation index data with cluster analysis.

· Radicic [23] conducted a study to analyze the effects of barriers to innovation on firms' tendencies and stated that financial, information, and competition factors are the most important barriers.

· Memiş and Korucuk [8] made firm selection by determining marketing innovation criteria in the fast-food sector.

· Yücel and Terzioğlu [24] determined the eco-innovation capacities of countries; they have also revealed the spatial interaction of macroeconomic variables and periodic (short-long) spatial interaction.

· Aytekin et al. [25] aimed to determine the importance of the barriers to smart production systems in plastics sector companies operating in Samsun and to select the best innovation management model.

· Sinatoko Djibo et al. [26] found that firms' innovation and learning capacities have a positive impact on eco-innovation.

· Salihi et al. [27] found that the more the company recognizes the importance of governance, environment, and economic governance, the higher the tendency of companies to have green innovation capacities. They also stated that more emphasis on environmental and governance dimensions increases the tendency towards green innovation capacities.

This comprehensive literature review reveals that very few studies have been conducted on the factors influencing the ability to create innovation. Given the importance of creativity in manufacturing, there is a clear need for more comprehensive studies on the subject. In addition, the use of CIMAS that considers expert evaluations will add a different perspective to the solution of similar problems. In this context, the study is expected to contribute to the literature on manufacturing businesses and innovation studies.

3 CIMAS

Criteria are one of the main components of decision problems. Understanding the decision maker's preferences, priorities, or approach in the context of criteria is extremely important for solving the decision problem [28]. An important issue regarding the criteria is weighting.

Weighting is the process of regulating the impact of criteria on problem solving. Decision-makers can assign values directly or use techniques developed for this purpose. Weighting techniques refer to algorithms developed using scientific tools to determine the weights of criteria [29]. There are many techniques developed for weighting purposes. The problem addressed in this study requires a weighting process based on expert evaluations.

Evaluations of experts or decision-makers whose opinions are requested in group decision-making problems are rarely of equal importance. In such decision-making problems, the experts' evaluations should be weighted and reflected in the solutions. Bošković et al. [30] developed the CIMAS technique to achieve this goal, which provides weighting based on experts' years of experience. The CIMAS process steps are outlined below.

Step 1. A set of criteria is defined. For this purpose, the studies in the literature or experts' opinions can be used. In this study, $C_1, \ldots, C_n$ denotes criteria.

Step 2. Experts are determined. $E_1, \ldots, E_r$ denote experts in this study.

Step 3. The weight of each expert's evaluations is computed using Eq. (1), where t_k is the k-th expert's experience duration in years.

$$\lambda_k = \frac{t_k}{\sum_{k=1}^{r} t_k} \tag{1}$$

Step 4. Experts evaluate criteria in the context of importance. For this purpose, 1-10 importance scale can be employed. The lowest degree in this scale is 1, while the highest one is 10. The input data matrix $A = [a_{kj}]_{r\times n}$ is constructed. In this matrix, a_{kj} denotes the k-th expert's evaluation for the j-th criterion, where $k = 1, \ldots, r$ and $j = 1, \ldots, n$.

Step 5. The normalized data matrix $G = [g_{kj}]_{r\times n}$ is obtained via Eq. (2).

$$g_{kj} = \frac{a_{kj}}{\sum_{k=1}^{r} a_{kj}} \tag{2}$$

Step 6. Multiplication of each value in the normalized input data matrix by each expert's importance (expert-weighted matrix) is applied via Eq. (3).

$$v_{kj} = \lambda_k g_{kj} \tag{3}$$

Step 7. The maximum value ($V_{j_{max}}$) and the minimum value ($V_{j_{min}}$) of each criterion are determined using Eqs. (4)-(5). Also, the difference between $V_{j_{max}}$ and $V_{j_{min}}$ is computed by applying Eq. (6).

$$V_{j_{max}} = \underset{k}{max}\ v_{kj} \tag{4}$$

$$V_{j_{min}} = \underset{k}{min}\ v_{kj} \tag{5}$$

$$b_j = V_{j_{max}} - V_{j_{min}} \tag{6}$$

Step 8. The weight coefficients of criteria are determined by applying Eq. (7), where $\sum_{j=1}^{n} w_j = 1$, and $0 \leq w_j \leq 1$.

$$w_j = \frac{b_j}{\sum_{j=1}^{n} b_j} \tag{7}$$

4 Results

This study investigated the factors affecting the key determinants of innovation management. CIMAS is employed to determine weight coefficients for criteria. Table 1 presents the list of criteria.

Table 1. The list of criteria

Codes	Criteria	Source(s)
C1	Level of access to information	[8, 31]
C2	R&D expenditures and international cooperation on R&D	[16, 20]
C3	Ability to transform information into products and services	[8]
C4	Innovative activities	[15]
C5	Incentive structures	[20]
C6	Collaboration between private sector and academia	[8, 24]
C7	Clustering and international networking activities	[11]
C8	Level and composition of foreign trade	[1, 8]
C9	Level of entrepreneurship	[1, 32–34]

In this study, three experts' opinions were sought to solve the problem under consideration. They work as customs consultants (two years of experience), operations managers (eleven years of experience), and process managers (13 years of experience). Table 2 presents the expert evaluations of the criteria. Also, the weight coefficients of experts are given in Table 2.

Table 2. The evaluations of criteria provided by experts and the weights of experts

	C1	C2	C3	C4	C5	C6	C7	C8	C9	t_k	λ_k
Expert 1	7	8	9	8	8	7	7	8	8	2	0.0769
Expert 2	7	6	7	8	7	7	5	6	7	11	0.4231
Expert 3	6	7	7	8	8	7	7	6	6	13	0.5000

The normalized data matrix is presented in Table 3.

Table 3. The normalized data matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
E1	0.3500	0.3810	0.3913	0.3333	0.3478	0.3333	0.3684	0.4000	0.3810
E2	0.3500	0.2857	0.3043	0.3333	0.3043	0.3333	0.2632	0.3000	0.3333
E3	0.3000	0.3333	0.3043	0.3333	0.3478	0.3333	0.3684	0.3000	0.2857

The weighted normalized data matrix, ranking comparison matrix, $V_{j_{max}}$, $V_{j_{min}}$, b_j, and weight coefficients for criteria are presented in Table 4.

Table 4. The weighting findings for criteria

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
E1	0.0269	0.0293	0.0301	0.0256	0.0268	0.0256	0.0283	0.0308	0.0293
E2	0.1481	0.1209	0.1288	0.1410	0.1288	0.1410	0.1113	0.1269	0.1410
E3	0.1500	0.1667	0.1522	0.1667	0.1739	0.1667	0.1842	0.1500	0.1429
$V_{j_{max}}$	0.1500	0.1667	0.1522	0.1667	0.1739	0.1667	0.1842	0.1500	0.1429
$V_{j_{min}}$	0.0269	0.0293	0.0301	0.0256	0.0268	0.0256	0.0283	0.0308	0.0293
b_j	0.1231	0.1374	0.1221	0.1410	0.1472	0.1410	0.1559	0.1192	0.1136
w_j	0.1025	0.1144	0.1017	0.1175	0.1226	0.1175	0.1299	0.0993	0.0946
Ranking	6	5	7	3	2	3	1	8	9

As seen in Table 4, the most important criterion is C7 (clustering and international networking activities). The second most important criterion is C5 (incentive structures). The importance ranking order of the criteria is obtained as $\mathrm{C7} > \mathrm{C5} > \mathrm{C4} \sim \mathrm{C6} > \mathrm{C2} > \mathrm{C1} > \mathrm{C3} > \mathrm{C8} > \mathrm{C9}$.

5 Conclusions

Today, one of the ways to provide competitiveness and cost advantage in manufacturing enterprises is undoubtedly through innovation and innovation management practices. In particular, effective innovation management practices provide businesses with efficiency and productivity and offer a market advantage. However, it is important that the factors affecting the capacity to create innovation in enterprises are at the desired level and coordination in terms of performance in business processes. Therefore, this situation is one of the issues that should be emphasized in enterprises and pushes managers to think from this perspective.

By combining the organization's innovative capabilities, resources, and processes, businesses can contribute to achieving the organization's strategic goals and building a sustainable future. Therefore, developing the innovation capacity of businesses is of vital importance for firms. Innovation capacity is an important organizational and management tool. The initiative to support innovation processes in businesses is vital and needs to be emphasized. Despite the increasing emphasis on designing and implementing innovation capacity, there is still a lack of comprehensive understanding in enterprises. What innovation capacity is and to what extent it can support the development of effectiveness and efficiency should be presented as an organizational culture to all public and private sector institutions. Focusing on long-term strategic goals and planning for the future in businesses depends on the success of their innovation capacity. Plans and processes to foster innovation capacity should be part of these strategic plans. Firms should follow innovative technologies that will increase innovation capacity and make investments in line with customer needs. Encouraging innovation and innovative practices and supporting employees' skills in this direction are important for increasing efficiency and capacity.

In this context, the study investigated the factors affecting the basic determinants of innovation capacity in manufacturing enterprises with corporate identity in Ordu Province. According to the research results, the most important factors affecting the basic determinants of innovation capacity were determined as "clustering and international networking activities," "incentive structures," "innovative activities," "collaboration between the private sector and academia," "R&D expenditures and international cooperation on R&D," and "level of access to information." The factors "level of entrepreneurship" and "level and composition of foreign trade" were determined as the least important elements regarding the basic determinants of innovation capacity.

The results of the study reveal the basic determinants of innovation capacity in manufacturing enterprises and offer various ideas and strategies to business managers within the framework of technological transformation. At this point, the results of the study provide a roadmap for the factors mentioned above and can also be considered as a guide in filling an important gap. The studied subject can be evaluated with other MCDM or other parametric or non-parametric methods in the future. Furthermore, CIMAS can be used to identify the weights or important levels of factors in similar problems in various fields.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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