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Examining the Factors Driving Military Innovation Using the Fuzzy DEMATEL Method: A Case Study of Türkiye

Bulanık DEMATEL Yöntemi Kullanılarak Askeri İnovasyona Yön Veren Faktörlerin İncelenmesi: Türkiye'de Bir Vaka Çalışması

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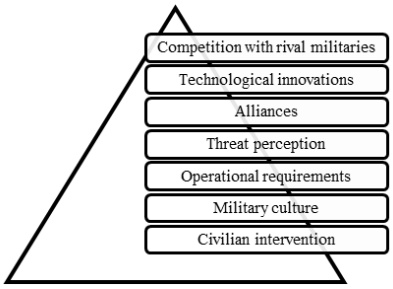
Highlights

The discourse surrounding military innovation has garnered considerable attention, revealing its significance for experts in Türkiye and the nation at large. Despite this vital engagement, the current body of literature addressing military innovation within the context of Türkiye remains notably scarce. This gap highlights the necessity for further scholarly inquiry and analysis in this critical area.

Graphical Abstract



Abstract

The study explores the perception of military innovation in Türkiye with the primary objective of defining this perception and prioritizing the factors that drive military innovation. While the existing literature on military innovation is limited, there is a noticeable absence of prioritization studies among them. Broadly, civilian influence, evolving threat perception, military and economic alliances, technological innovation, military culture, competition with rival armies, and operational requirements are identified as key factors within discussions on military innovation. The Fuzzy DEMATEL method was chosen in line with the research's objectives. A total of 7 participants, including civilian and military experts, as well as academics with expertise in military innovation and operating in Türkiye took part in the study. The research findings highlight the most crucial criteria driving military innovation, with competition with rival armies, technological innovation, military and economic alliances, changing threat perception, operational requirements, military culture, and civilian influence emerging as the most crucial. These findings have significant implications, as they underscore the need for increased awareness of the components of military innovation and call for further research in this area. Moreover, they have the potential to significantly influence and shape future strategies and policies in the field of military innovation.

Özet

Araştırma Türkiye'deki askeri yenilik algısını konu edinmekte ve askeri yenilik algısını tanımlamak ve askeri yeniliği tetikleyen unsurların önceliklendirilmesini amaçlamaktadır. Literatürde askeri yeniliği yönelik çalışmalar sınırlı olmakla birlikte unsurlar arasında bir önceliklendirme yapılan çalışmanın olmadığı görülmüştür. Askeri yenilik tartışmaları kapsamında sivil etkisi, değişen tehdit algısı, askeri ve ekonomik ittifaklar, teknolojik yenilik, askerî kültür, rakip ordularla rekabet, operasyonel gereklilikler ana unsurlar olarak belirlenmiştir. Bulanık DEMATEL yöntem araştırmanın amacına uygun olarak tercih edilmiştir. Türkiye'de görev yapan ve askeri yenilik konusunda uzmanlığa sahip olan sivil ve askeri uzmanlar ile akademisyenlerden oluşan toplam 7 katılımcı araştırmada yer almıştır. Araştırma bulgularına göre askeri yeniliği tetikleyen en önemli kriterler sırasıyla; rakip ordularla rekabet, teknolojik yenilik, askeri ve ekonomik ittifaklar, değişen tehdit algısı, operasyonel gereklilikler, askeri kültür ve sivil etkisi şeklinde sıralandığı belirlenmiştir. Kriterlerin birbirleri üzerine etkisi analiz edildiğinde ise değişen tehdit algısı, sivil etkisi ve askeri kültür unsurlarının diğer askeri yenilik unsurlarını etkilediği sonucuna ulaşılmıştır. Bu bulgular, askeri inovasyonun bileşenlerine ilişkin farkındalığın artırılması ihtiyacının altını çizdiği ve bu alanda daha fazla araştırma yapılması çağrısında bulunduğu ve potansiyel olarak gelecekteki stratejileri ve politikaları şekillendirdiği için önemli çıkarımlara sahiptir.

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1. INTRODUCTION

The topic of military innovation has sparked extensive debate among scholars and experts in various fields. Disagreements stem from differing perspectives on the reasons behind and the methods through which militaries adapt and evolve. A review of the literature reveals that the triggering factors encompass civilian influence, evolving threat perceptions, military and economic alliances, technological innovation, military culture, competition with rival militaries, and operational requirements [1]. While these concepts will be further explored in detail, they are interconnected in dynamic and complex ways. There is no widely accepted understanding of the interplay and prioritization of factors that drive military innovation. Additionally, the literature indicates that these concepts are not consistently prioritized in the context of military innovation, and there is minimal research on the mutual influence of these concepts.

The debate surrounding the precipitating factors of military innovation remains pertinent within the context of Türkiye as well. For example, [2] emphasizes the significant role of the needs of the Turkish Armed Forces in the development of the Turkish defense industry. He asserts that the decline in Türkiye's domestic defense industry occurred following the accession to NATO. However, he posits that various embargoes have brought military innovation and the development of the defense industry to the fore. Another group of experts argues that political and military changes in the international system have triggered the military change. They also emphasize that the overt and covert embargoes experienced by Türkiye have contributed to military innovation and the development of defense industry [3].

Kurç and Neuman's study examined the defense industries of developing countries. The obstacles to the development and self-sufficiency of Türkiye defense industry are listed as inefficient use of military capabilities/lack of planning, competition and confrontation in civil-military relations, overdependence on foreign technology and external pressures on autonomy [4]. In addition to these studies, which specifically focus on the development of the defense industry, other studies emphasize the impacts of Turkish military innovation in various areas. An edited volume draws on the authors' field experience [5]. Consequently, it is argued that changing threat perceptions and operational needs are the main driving forces behind military innovation. However, none of the above-mentioned studies focused on the relationship between the factors that trigger Turkish military innovation.

Contrary to previous studies, this article aims to contribute to the literature by examining the relationship between the factors that trigger military innovation with the DEMATEL method in line with expert opinions. The fact that this contribution is from an under-studied country such as Türkiye increases the value of the article. The first part of the study delves into the debate on military innovation, summarizing existing discussions in the literature. The subsequent section details the research methodology, specifically the use of the Fuzzy DEMATEL method within the context of the Turkish sample, along with information about the research process

and analysis. The findings section describes the results obtained after analysis, focusing on prioritizing the factors driving military innovation and creating a corresponding ranking, as presented in Table 7. Additionally, Figure 2 depicts an impact diagram illustrating the relationships between identified concepts.

2. MILITARY INNOVATION DEBATE

Since the 1980s, military innovation has become a subject of academic research, drawing contributions from various disciplines and sparking debates. Scholars have discussed the factors that drive military innovation, and this section summarizes those views, with more detailed information to follow. Barry Posen, who initiated the innovation studies in the 1980s, utilized organizational theory and balance of power theories to elucidate the factors instigating military innovation. Posen highlights the significance of civilian intervention in achieving military innovation [6]. Rosen, who has a contrasting perspective to Posen, argues that implementing promotion strategies is the most crucial method for a military to change during periods of peace. To foster innovation, esteemed senior military officials must acknowledge substantial structural shifts in the global security landscape and develop a new strategy after that. Subsequently, it is imperative to enhance the promotional prospects for young officers who can effectively adjust to this novel technique. Contrary to commonly held beliefs, the crucial factor for bringing about change is not financial resources but rather highly trained military men, sufficient time, and extensive information. Civilian intervention can be beneficial in safeguarding these leaders. Terriff and Farrell, however, contend that the factors that initiate or impede military innovation originate from institutional culture and military culture [7]. Kimberly Marten highlights the significance of organizational resistance in military innovation. She argues that the catalyst for innovation is the implementation of innovative measures that guarantee the independence of the military framework. Furthermore, he underscores that advancements in the armed forces of competing nations stimulate military progress [8].

Deborah Avant highlights that the key factors that facilitate military innovation are the ability of institutions to adapt and be flexible, as well as the level of transparency within these institutions [9]. King highlights the significance of alliances and foreign intervention in stimulating military innovation, particularly in relation to economic and defense requirements [10]. Blanton and Kegley assert that globalization serves as the catalyst for military innovation. Authors argue that globalization fosters military innovation through competition and imitation [11]. However, Sloan argues that the real trigger for military innovation is the change in threat perception [12]. Contrarily, Malesic asserts that the catalyst for military innovation is broadening the obligations and roles of armies following the conclusion of the Cold War [13].

Farrell, Rynning, and Terriff, demonstrate that military innovation is stimulated by factors such as the operational requirements and the subsequent feedback received [14]. Russell's paper (2010) examines the impact of operational requirements on military innovation during the American military's operations in Iraq from 2005 to 2007 [15]. According to Avant, change will be

prompted by the attitude of military and civilian leaders, the disparity between military doctrine and civilian policy objectives, and institutional competition [16]. Alexander and Putnam highlight the significance of the influence of the private sector and foreign countries in stimulating innovation. They contend that engaging in military-to-military engagement through foreign military training can stimulate military innovation by presenting different thoughts and methods of military organization. Furthermore, it is asserted that academic institutions and individuals engaging with foreign nations will promote military innovation and lay the foundation for change. The primary catalysts for military innovation in this setting are the militaristic military, private sector, foreign countries, foreign military training programs, and university research [17]. According to John A. Lynn, military change can be prompted by factors such as military culture, institutional characteristics, evolving procedures, and the effects of technology, as well as economic and commercial progress. Within this framework, military innovation can be conceptualized as being triggered by several causes such as the army model, evolving fighting tactics, economic and commercial advancements, and changes in governance systems [18].

Consequently, there is a lack of agreement on the factors that initiate military innovation. Nevertheless, it is possible to establish a generic categorization despite the absence of agreement. Upon evaluating the data derived from the literature, the primary catalysts for military innovation can be identified as follows: a) civilian influence, b) evolving threat perception, c) military and economic alliances, d) technological advancement, e) military culture, f) competition with opposing armies, and g) operational necessities. Below are the significance of the criteria in relation to military innovation and their impact.

Civilian intervention refers to the actions taken by the political leaders to enforce their judgments in the military domain within the framework of civil-military interactions [19]. The analysis of threat perception can be contextualized within global events while also being influenced by regional developments. During the modern period (1900-1945), the main concern was the possibility of enemy occupation. In the late modern period (1945-1990), the focus shifted to the fear of nuclear war. In the post-modern period (1990-...), the primary concerns include ethnic and religious conflicts, terrorism, and other related issues [20]. This scenario exemplifies the shift in the perception of danger. Today, we will address the concept of multidimensional threat perception, which is commonly analyzed within the framework of hybrid warfare. Sloan examines the initiation of innovation in the US military by analyzing its occurrence during the Gulf War, the September 11 attacks, and the counterterrorism operations in Iraq and Afghanistan. The primary inference is that the alteration in the perception of danger instigates the modification in the military [21]. Hence, the evolving threat assessments of nations must prompt military adaptations. Türkiye has a multifaceted threat perception because of its close proximity to conflict zones and the potential for both conventional and irregular wars.

The alliances encompass political and military international organizations such as NATO and the UN. Türkiye provides assistance to multiple military operations sanctioned by both NATO and the UN. Military and economic alliances are global organizations that facilitate the achievement of shared objectives and tasks. In this particular situation, the phenomenon of isomorphism among organization members becomes apparent. For instance, the United States has had a significant influence on the design of NATO, a military organization, and holds a prominent and impactful role inside the organization. To secure the organization's rules and effectiveness, it is believed that other members should undergo a transformation that aligns with the structure. The homogeneity of the personnel inside the organization is regarded as a catalyst for military innovation [22].

Technological innovation refers to developing and implementing novel or enhanced technologies, techniques, systems, and processes that lead to notable advancements or breakthroughs in different domains [23]. Marshall McLuhan posits that technological determinism is the dominant force behind societal and cultural transformation, asserting that technical advancements are the fundamental catalysts of change [24]. When assessing military innovation through the lens of technological determinism, it may be concluded that technological innovation is the primary catalyst for military advancement.

Rosen, however, assesses the influence of technological advancement on military innovation by integrating the aspects of combat, peacetime, and technology. According to his perspective, not all technological advancements result in military advancements. One of the primary responsibilities of militaries is to protect the country and strategize and equip themselves for potential future conflicts. Hence, the new technology's ability to demonstrate its military might and become a potent asset in the race for weaponry is regarded as a catalyst for military innovation [25]. Furthermore, Latour contends that technological innovation will be embraced and result in innovation if it is implemented and supported by cohesive social networks [26].

Military culture refers to the process of establishing and maintaining a set of rules, routines, behaviors, norms, and doctrines inside a military structure. These patterns of conduct become permanent and ingrained within the organization [27]. Farrell contends that culture plays a significant role in initiating and driving military innovation. Farrell highlighted that the military's response to the endorsement of innovation is influenced by its military culture, with a particular focus on European, American, and East Asian nations. According to Farrell, culture can impact military innovation through three mechanisms. Firstly, experienced military leaders, also known as the Military Elite, can initiate innovation by reconfiguring the existing culture. Secondly, external shocks can alter the culture and consequently influence military innovation. Lastly, international professional military culture can facilitate cultural change and military innovation by allowing military organizations to mutually influence each other [28]. Elizabeth Kier, a scholar, has highlighted the significance of cultural influence in achieving military innovation [29].

Competition between rival armies refers to the efforts made by a military power to enhance its capabilities and develop dominance or asymmetry over other armed forces in order to defend the country. Some argue that engaging in competition with opposing armies serves as a catalyst for military changes. Given that the primary objective of armies is to safeguard the nation, they typically adopt strategies to assess the nature of upcoming conflicts and the means by which victory can be achieved. The perception of a threat arises from the potential for asymmetry resulting from any military innovation that could disrupt the success of established war strategies employed by armies. Some think that this impression of threat causes militaries to respond and maybe overreact to new foreign developments. From this standpoint, the notion that competition between different branches of the military might stimulate advancements in military technology becomes prominent [30].

Operational requirements refer to the essential components that armed forces require in order to carry out their operational duties effectively. The significance of requirements that arise during and following operational experiences in influencing military innovation is underscored. The factors that contribute to this phenomenon are the belief that armies may stimulate military advancement by receiving feedback and addressing significant shortcomings in military capabilities during operations (Russell, 2010, pp. 595-624). Theo Farrell and other scholars contend that the demands arising from different military operations stimulate military innovation, particularly in terms of policy [31]. Operational deficiencies necessitate the military to achieve its purpose, which in turn has a beneficial impact on military innovation.

3. METHOD

The research employed the Fuzzy DEMATEL method. The questions were designed using a 5-point Likert-type scale to assess the relationship and ranking of elements that stimulate military innovation. To confirm the questions' validity and dependability, they were forwarded to three experts and modified based on their feedback. The final survey included 7 professionals, both civilian and military, who work and live in Türkiye. Three of the experts have military backgrounds and are also working in academia, so they are able to connect theory with practice. The other four experts are well-known scholars who specifically focus on security matters and the defense industry.

The DEMATEL is a technique that helps establish causal links among intricate real-world elements [32]. This method employs pairwise comparisons between criteria/ objectives during its procedure [33]. It relies on diagrams that leverage expert judgments to discern the components inside a system [34]. This approach involves the identification of groups that are impacted and groups that have an influence [35]. The DEMATEL method, in conjunction with fuzzy logic, is a methodology employed to address the issue of expert indecisiveness [36]. This approach involves the execution of the following procedures.:

a) Identification of Criteria and Determination of Fuzzy Scale (Linguistic Expression): Criteria are established by thoroughly examining existing literature and

consulting with experts in the field. Experts are required to compare these criteria. A digital form was generated to facilitate the process of comparing. The question in the form is: "To what extent does the criterion of civilian impact (AD1.) affect the criterion of changing threat perception (AD2.) in terms of military innovation?". Specialists evaluated the criteria by comparing them with language terms. This study utilized a trapezoidal fuzzy number set to represent linguistic phrases. Table 1 displays the linguistic scale employed in the study along with the accompanying fuzzy values.

Table 1: The fuzzy linguistic scale.

Linguistic terms	Linguistic values	$A^{\sim}$			
		A	b	C	d
Very Low Influence	VL	0	0	0.250	0.250
Low Influence	L	0	0	0.250	0.500
Mid Influence	M	0	0.250	0.500	0.750
High Influence	H	0.250	0.500	0.750	1.000
Strongly Influence	S	0.500	0.750	1.000	1.000

The fuzzy set is ($A^{\sim}$) and $\mu_A(x)$ is the fuzzy set member function. Unlike a crisp set where elements are either in the set or not (true/false, 0/1), a fuzzy set allows elements to have degrees of membership. The mathematical expression of this set is given in Equation 1. Figure 1 shows trapezoidal fuzzy numbers. In trapezoidal fuzzy numbers, a is the smallest value and d is the largest value. The fuzzy set $A^{\sim}$ represented as a collection of ordered pairs $(x, \mu_A(x))$ where each pair shows an element x and its degree of membership $\mu_A(x)$.

$$A^{\sim} = \{(x, \mu_A(x)) | x \in X\} \quad (1)$$

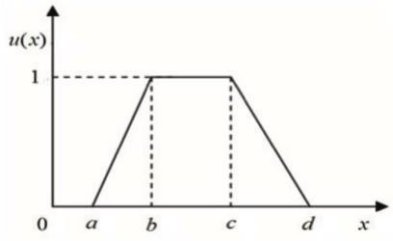

Figure 1: Trapezoidal fuzzy numbers [37].

The mathematical representation of μ_A (x) is shown in the following equation [38], Equation (2)

$$\mu_A(x) = \begin{cases} 0, & -\infty < x \le a \\ \dfrac{(x-a)}{(b-a)}, & a \le x < b \\ 1, & b \le x \le c \\ \dfrac{(x-d)}{(c-d)}, & c < x \le d \\ 0, & d \le x < \infty \end{cases} \quad (2)$$

b) Construction of Fuzzy Direct Relationship Matrices (X): The fuzzy pairs matrix illustrates the interrelationships between factors in a fuzzy manner. Experts are requested to compare the criteria among themselves. Experts answer these questions based on linguistic phrases. Afterward, fuzzy direct relationship matrices (X) are generated, where the numerical values match the linguistic statements (Equation 3).

$$X = \begin{bmatrix} 0 & \cdots & (f^a_{1n}; f^b_{1n}; f^c_{1n}; f^d_{1n}) \\ \vdots & \ddots & \vdots \\ (f^a_{n1}; f^b_{n1}; f^c_{n1}; f^d_{n1}) & \cdots & 0 \end{bmatrix} \quad (3)$$

c) Creating Average Fuzzy Direct Relationship Matrix: After creating the fuzzy direct relationship matrices of each expert, the average fuzzy direct relationship matrix is created by taking the arithmetic mean of the trapezoidal fuzzy numbers in these matrices.

d) Creating the Normalized Fuzzy Direct Relationship Matrix (E^~): After creating the average fuzzy direct relationship matrix, this matrix needs to be normalized. For the normalized fuzzy direct relationship matrix, the following equations are used (Equation 4 and Equation 5)**:**

$$E^{\sim} = \frac{c}{r_j} = \left(\frac{a_{ij}}{r_a}, \frac{b_{ij}}{r_b}, \frac{c_{ij}}{r_c}, \frac{d_{ij}}{r_d}\right) \quad (4)$$

$$\begin{aligned} r_a &= \max_{1 \le j \le n} \left(\sum_{n=1}^{G} a_{ij}\right) \\ r_b &= \max_{1 \le j \le n} \left(\sum_{n=1}^{G} b_{ij}\right) \\ r_c &= \max_{1 \le j \le n} \left(\sum_{n=1}^{G} c_{ij}\right) \\ r_d &= \max_{1 \le j \le n} \left(\sum_{n=1}^{G} d_{ij}\right) \end{aligned} \quad (5)$$

$$G = Number\ of\ Experts$$

e) Creating the Fuzzy Total Relationship Matrix (T): The fuzzy total relationship matrix is obtained by taking the limit of the created matrix [39]; Equation 6 and Equation 7).

$$\lim_{U \to \infty} E^{\sim} + E^{\sim 2} + E^{\sim 3} + \cdots E^{\sim G} \quad (6)$$

$$T = E^{\sim}(I - E^{\sim})^{-1} \quad (7)$$

$$I = Unit\ Matrix$$

f) Clarification: Using the following equation, the Center of Area Method was applied to facilitate the analysis of the values [40] ; Equation 8).

$$x_{ij}^{*} = \frac{\left(c_{ij}^2 + d_{ij}^2 + c_{ij}d_{ij}\right) - \left(a_{ij}^2 + b_{ij}^2 + a_{ij}b_{ij}\right)}{3\left[\left(c_{ij} + d_{ij}\right) - \left(a_{ij} + b_{ij}\right)\right]} \quad (8)$$

g) Identification of Affected and Influencing (Sender and Recipient) Groups: The sum of the rows in the stabilized fuzzy total relationship matrix $R_j$represents the influence of other criteria and the sum of the columns $C_j$represents the influence of other criteria.

h) Determination of Criteria Weights: The weights of the criteria were calculated with the following equations [41]; Equation 9 and Equation 10).

$$W_i = \sqrt{\left(R_j + C_j\right)^2 + \left(R_j - C_j\right)^2} \quad (9)$$

$$w_j = \frac{w_i}{\sum_{j=1}^{n} w_i} \quad (10)$$

4. FINDINGS

In this research, 7 experts were asked to prioritize and compare the factors that trigger military innovation among themselves. In the selection of the experts, they were important that the specialized in military innovation. However, in order to ensure diversity, attention was paid to the fact that they have worked on different subjects [42].

As a result of the experts' evaluation, the linguistic expressions of the military innovation criteria are given below (Table 2).

Table 2: Linguistic assessments of experts.

Experts	Criteria	C1	C2	C3	C4	C5	C6	C7
Expert 1	**C1**	0	VL	S	H	OE	L	VL
	C2	H	0	S	S	M	S	S
	C3	S	H	0	M	M	S	VL
	C4	L	L	L	0	H	H	S
	C5	M	L	H	M	0	H	L
	C6	H	S	S	S	M	0	H
	C7	H	S	M	S	L	S	0
Expert 2	**C1**	0	M	M	H	M	M	H
	C2	M	0	S	H	H	H	H
	C3	M	H	0	H	H	H	H
	C4	H	M	M	0	H	H	H
	C5	M	M	M	H	0	M	H
	C6	M	H	H	S	H	0	H
	C7	H	H	S	S	H	H	0
Expert 3	**C1**	0	M	H	S	VL	M	L
	C2	M	0	S	S	L	H	S
	C3	S	S	0	L	M	H	L
	C4	L	S	M	0	H	S	S
	C5	VL	M	S	H	0	S	S
	C6	VL	S	S	S	H	0	S
	C7	L	H	H	S	H	H	0
Expert 4	**C1**	0	M	S	S	H	S	M
	C2	M	0	S	H	M	S	S
	C3	H	H	0	S	S	S	H
	C4	M	M	S	0	M	S	S
	C5	S	H	H	H	0	H	M
	C6	M	S	S	S	M	0	S
	C7	H	H	S	S	M	S	0
Expert 5	**C1**	0	L	M	H	L	M	VL
	C2	L	0	H	M	H	H	S
	C3	L	M	0	L	L	H	H
	C4	H	H	H	0	L	H	H
	C5	L	M	H	M	0	H	M
	C6	L	H	H	M	M	0	M
	C7	M	L	H	H	L	H	0
Expert 6	**C1**	0	H	S	M	S	M	H
	C2	M	0	H	L	M	H	H
	C3	L	M	0	H	M	L	M
	C4	H	H	H	0	M	L	H
	C5	L	L	VL	VL	0	L	L
	C6	L	VL	VL	M	L	0	L
	C7	L	L	M	VL	M	VL	0
Expert 7	**C1**	0	M	S	S	L	H	L
	C2	S	0	S	H	M	S	H
	C3	H	H	0	H	H	H	M
	C4	L	L	L	0	S	S	S
	C5	S	M	H	H	0	3	S
	C6	H	S	S	S	H	0	S
	C7	L	H	H	S	H	H	0

Averaging the mathematical representations of the expert assessments produces the following average fuzzy direct relationship matrix.

Table 3: Average of initial direct-relation fuzzy matrix.

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.000	0.036	0.321	0.321	0.107	0.107	0.071
	0.000	0.214	0.571	0.571	0.250	0.321	0.179
	0.000	0.464	0.821	0.821	0.500	0.571	0.429
	0.000	0.679	0.929	0.964	0.679	0.786	0.607
C2	0.107	0.000	0.429	0.250	0.071	0.357	0.393
	0.321	0.000	0.679	0.464	0.286	0.607	0.643
	0.571	0.000	0.929	0.714	0.536	0.857	0.893
	0.786	0.000	1.000	0.893	0.786	1.000	1.000
C3	0.214	0.214	0.000	0.179	0.143	0.286	0.107
	0.393	0.464	0.000	0.357	0.357	0.500	0.286
	0.643	0.714	0.000	0.607	0.607	0.750	0.536
	0.821	0.929	0.000	0.821	0.821	0.929	0.750
C4	0.107	0.143	0.143	0.000	0.179	0.321	0.393
	0.250	0.321	0.321	0.000	0.393	0.536	0.643
	0.500	0.571	0.571	0.000	0.643	0.786	0.893
	0.750	0.786	0.786	0.000	0.857	0.929	1.000
C5	0.143	0.036	0.214	0.143	0.000	0.179	0.179
	0.286	0.214	0.429	0.357	0.000	0.393	0.357
	0.536	0.464	0.679	0.607	0.000	0.643	0.607
	0.679	0.714	0.857	0.821	0.000	0.857	0.786
C6	0.071	0.357	0.357	0.357	0.107	0.000	0.286
	0.214	0.571	0.571	0.607	0.321	0.000	0.500
	0.464	0.821	0.821	0.857	0.571	0.000	0.750
	0.679	0.893	0.893	0.929	0.821	0.000	0.893
C7	0.107	0.214	0.250	0.393	0.107	0.286	0.000
	0.250	0.393	0.500	0.607	0.286	0.500	0.000
	0.500	0.643	0.750	0.857	0.536	0.750	0.000
	0.750	0.857	0.929	0.893	0.786	0.893	0.000

Table 4: Normalized initial direct-relation fuzzy matrix.

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.000	0.021	0.188	0.188	0.063	0.063	0.042
	0.000	0.070	0.186	0.186	0.081	0.105	0.058
	0.000	0.102	0.180	0.180	0.109	0.125	0.094
	0.000	0.124	0.170	0.176	0.124	0.144	0.111
C2	0.063	0.000	0,250	0.146	0.042	0.208	0.229
	0.105	0.000	0,221	0.151	0.093	0.198	0.209
	0.125	0.000	0,203	0.156	0.117	0.188	0.195
	0.144	0.000	0,183	0.163	0.144	0.183	0.183
C3	0.125	0.125	0.000	0.104	0.083	0.167	0.063
	0.128	0.151	0.000	0.116	0.116	0.163	0.093
	0.141	0.156	0.000	0.133	0.133	0.164	0.117
	0.150	0.170	0.000	0.150	0.150	0.170	0.137
C4	0.063	0.083	0.083	0.000	0.104	0.188	0.229
	0.081	0.105	0.105	0.000	0.128	0.174	0.209
	0.109	0.125	0.125	0.000	0.141	0.172	0.195
	0.137	0.144	0.144	0.000	0.157	0.170	0.183
C5	0.083	0.021	0.125	0.083	0.000	0.104	0.104
	0.093	0.070	0.140	0.116	0.000	0.128	0.116
	0.117	0.102	0.148	0.133	0.000	0.141	0.133
	0.124	0.131	0.157	0.150	0.000	0.157	0.144
C6	0.042	0.208	0.208	0.208	0.063	0.000	0.167
	0.070	0.186	0.186	0.198	0.105	0.000	0.163
	0.102	0.180	0.180	0.188	0.125	0.000	0.164
	0.124	0.163	0.163	0.170	0.150	0.000	0.163
C7	0.063	0.125	0.146	0.229	0.063	0.167	0.000
	0.081	0.128	0.163	0.198	0.093	0.163	0.000
	0.109	0.141	0.164	0.188	0.117	0.164	0.000
	0.137	0.157	0.170	0.163	0.144	0.163	0.000

In Table 5, the fuzzy total relationship matrix is constructed by taking the limit of the normalized fuzzy direct relationship matrix.

Table 5: Total-relation fuzzy matrix.

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.156	0.242	0.466	0.468	0.213	0.364	0.323
	0.313	0.470	0.672	0.663	0.424	0.595	0.522
	0.649	0.835	1.030	1.017	0.784	0.964	0.899
	1.319	1.537	1.696	1.684	1.507	1.682	1.571
C2	0.319	0.394	0.747	0.668	0.296	0.704	0.681
	0.531	0.571	0.911	0.844	0.571	0.870	0.829
	0.905	0.912	1.248	1.196	0.944	1.205	1.161
	1.648	1.647	1.946	1.912	1.738	1.953	1.854
C3	0.296	0.384	0.391	0.479	0.258	0.515	0.410
	0.464	0.586	0.586	0.676	0.494	0.703	0.611
	0.816	0.928	0.940	1.042	0.848	1.052	0.974
	1.557	1.687	1.678	1.790	1.640	1.829	1.711
C4	0.265	0.392	0.513	0.443	0.299	0.584	0.592
	0.438	0.570	0.702	0.598	0.519	0.736	0.725
	0.807	0.924	1.073	0.948	0.872	1.081	1.056
	1.554	1.676	1.812	1.668	1.653	1.838	1.754
C5	0.222	0.233	0.404	0.373	0.142	0.378	0.355
	0.388	0.460	0.625	0.598	0.338	0.599	0.555
	0.743	0.823	0.993	0.968	0.673	0.962	0.916
	1.448	1.562	1.708	1.686	1.416	1.714	1.617
C6	0.292	0.550	0.694	0.691	0.305	0.514	0.624
	0.477	0.693	0.840	0.835	0.553	0.664	0.761
	0.855	1.027	1.186	1.176	0.917	1.006	1.100
	1.548	1.695	1.831	1.817	1.652	1.697	1.744
C7	0.279	0.441	0.584	0.652	0.279	0.596	0.427
	0.451	0.603	0.763	0.780	0.505	0.746	0.567
	0.820	0.951	1.119	1.122	0.868	1.092	0.907
	1.556	1.688	1.834	1.811	1.646	1.835	1.601

The total relationship matrix as a result of the regularization process is shown below (Table 6).

Table 6: Total-relation matrix.

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.632	0.793	**0.987**	**0.980**	0.756	0.924	0.850
C2	0.876	0.908	**1.238**	**1.180**	0.913	**1.211**	**1.157**
C3	0.810	0.924	0.924	**1.023**	0.837	**1.053**	**0.952**
C4	0.793	0.918	**1.051**	0.941	0.863	**1.088**	**1.058**
C5	0.725	0.794	**0.956**	0.929	0.669	0.939	0.884
C6	0.816	**1.015**	**1.160**	**1.152**	0.880	**0.995**	1.080
C7	0.802	0.948	**1.100**	**1.116**	0.851	**1.095**	0.901

Table 7. Crisp values of ri, cj, ri + cj and ri – cj, weights.

Criteria	R_i	C_i	R_i+C_i	R_i-C_i	W	Ranking
C1-Civilian intervention	5.922	5.454	11.376	0.468	0.122	7
C2-Threat perception	7.482	6.299	13.781	1.183	0.149	4
C3- Alliances	6.523	7.415	13.938	-0.892	0.150	3
C4-Technological innovations	6.711	7.321	14.032	-0.610	0.151	2
C5- Military culture	5.896	5.769	11.665	0.126	0.125	6
C6- Competition with rival militaries	7.097	7.305	14.403	-0.208	0.155	1
C7-Operational requirements	6.814	6.881	13.695	-0.068	0.147	5

Table 7 shows the sender and receiver groups obtained from the total relationship matrix, and the weights are determined.

The paramount factor for military innovation has been ascertained to be the presence of competition from opposing armies. The factors encompass technological innovation, military and economic alliances, evolving threat perception, operational necessities, military culture, and civilian impact. Upon analyzing the weights, it becomes evident that numerous criteria possess equal weights. The data indicate that civilian influence and military culture have less significance in military innovation compared to other factors.

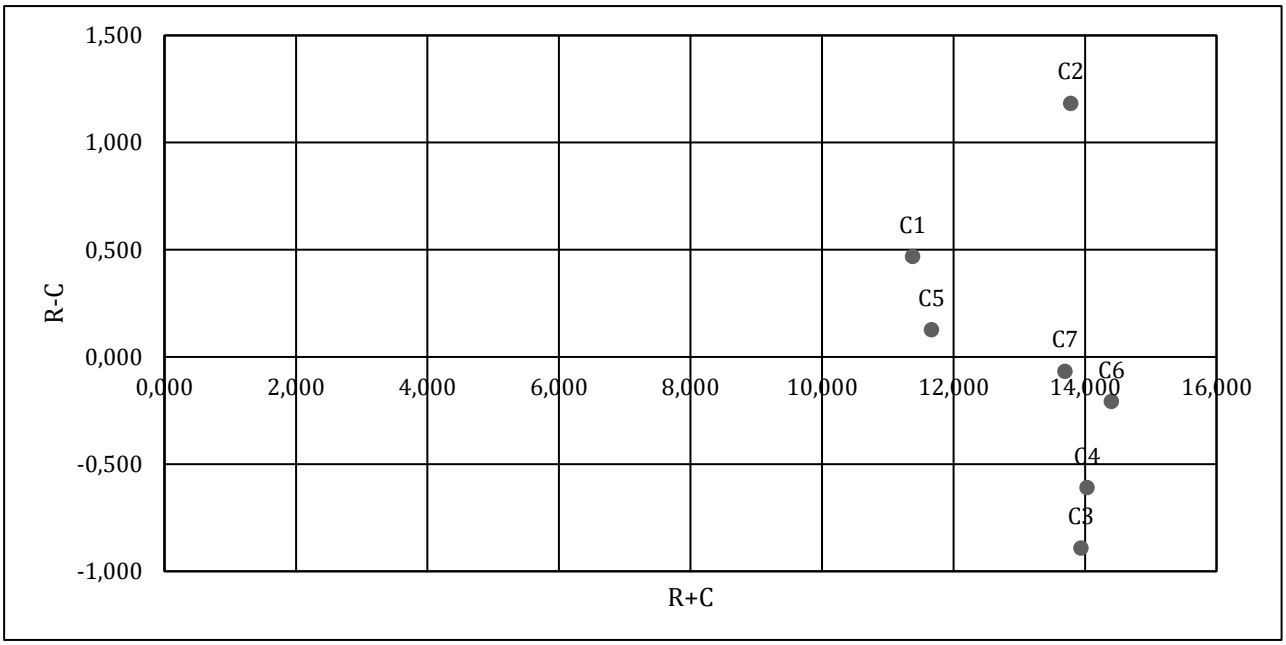

Figure 2: Cause and effect diagram.

The cause-and-effect diagram (Figure 2) shows that Threat Perception (C2), Civilian Influence (C1), and Military Culture (C5) impact Operational Necessity (C7), Competition with Rival Armies (C6), Technological Innovation (C4), and Military and economic alliances (C3).

5. DISCUSSION AND CONCLUSION

While the study of military innovation has long been a continuous field of interest for Western scholars, it remains a relatively new area of research for Türkiye scholars. The existing literature in this field is limited and primarily focuses on evaluating and discussing the various factors that prompt military innovation. Western researchers have extensively examined the evolution of armies through case studies, as well as the evaluation of military doctrines and experiences of change. In contrast, researchers in Türkiye have encountered limitations in accessing diverse information on military matters. The conservative approach to military issues has led to a focus on the publicized developments in the defense industry and the evaluation of well-known products in the literature. Therefore, the relatively older studies are constrained to discussions about embargoes and technological advancements.

Terriff and Farrell criticized the notion that the military would adapt in order to secure victory in war, underscoring the significance of cultural factors. Avant explains that the catalyst for change was the institutional flexibility inherent in military culture. She specifically notes that the British Army was able to achieve the objectives set by civilian authorities without resorting to coercion during the wars it engaged in. Kier analyzed the military cultures of France and Britain, focusing particularly on compulsory military service and the offensive and defensive doctrines of their armies. She identified culture as the underlying reason for the disparities between them. However, the cultural factor is a reality that is challenging to fully articulate in Türkiye, given the complexities of how military culture

influences military change due to the lack of research [45].

In discussions about military change, Posen's civilian influence element refers to civilian power intervening in the military sphere. This intervention may lead to crises, potentially slowing down or halting military change [46]. The conflict between civilians and military elites in Türkiye could have contributed to a negative perception of civilian influence in driving military innovation. However, this perspective contradicts Ateş's (2023) argument that cohesive social networks between civilians and the military have facilitated Turkish military innovation. This contradiction may stem from a lack of information. Additionally, public tensions in civil-military relations might have created a perception that civilian-military cooperation was not feasible in Türkiye [47].

In this study, the experts ranked the factors that drive military innovation for Türkiye in the following order: (Table 7) Competition with Rival Armies, Technological Innovation, Military and Economic Alliances, Changing Threat Perception, Operational Requirements, Military Culture and Civilian Influence. Despite limited previous research focusing on civil-military relations, the study results reveal that military culture and civilian influence are ranked lowest. This illustrates a notable difference between Western and Türkiye experiences.

According to the Influence Diagram (Figure 2) results, Changing Threat Perception (C2), Civilian Influence (C1) and Military Culture (C5) have emerged as the factors that affect the other elements the most, respectively. However, these factors are ranked lower among the factors that trigger military innovation in Table 7. In this context, it is concluded that in the perceptions of Turkish experts, Changing Threat Perception (P2), Civilian Influence (P1) and Military Culture (P5) have an important role in mobilizing other elements, even if they do not directly trigger innovation.

Competition with Rival Armies (C6), which is the first factor that triggers military innovation, affects Military and Economic Alliances (C3), Technological Innovation (C4) and Changing Threat Perception (C2) the most, respectively. In other words, a change in Competition with Rival Armies (C6) affects C3, C4 and C2. A change in Technological Innovation (C4) primarily affects Competition with Rival Armies (C6), Operational Requirements (C7) and Military and Economic Alliances (C3). A change in Military and Economic Alliances (C3) affects Competition with Rival Armies (C6), Technological Innovation (C4) and Operational Requirements (C7).

Sloan highlights the shift in security perceptions following the terrorist incidents in the United States, arguing that such painful experiences inevitably prioritize change [48]. In contrast, despite enduring terrorist attacks for an extended period, Türkiye has experienced relatively slow military changes. Consequently, Turkish experts may feel that the evolving threat perception has not directly spurred military transformation. King identifies international alliances as a crucial driver of change. A notable example is Türkiye's modernization and military advancements, which significantly accelerated after its accession to NATO in 1952. This reality serves as a key factor

influencing the perspectives of experts in the field.

In conclusion, it is evident that the military innovations of countries are closely tied to their own unique experiences. Therefore, it is underscored that the factors influencing military innovation include the country's history, experiences, security perceptions, and civil-military relations. It is strongly contended that competition with rival armies, technological innovation, as well as military and economic alliances act as catalysts for innovation. In order to ascertain changes in the perceptions of Turkish experts regarding military innovation and to analyze the direction of change, it is imperative to conduct further research at different time intervals. The study is limited by the small number of experts working on the subject. To unveil different dimensions of Turkish military innovation, it is recommended that future research utilizes different and larger sample sizes.

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AUTHOR CONTRIBUTIONS

Selçuk CANTÜRK: Conceptual Design, Literature review, Analysis Evaluation, Writing.

Fahri Alp ERDOĞAN: Methodology, Data Analytics.

Murat SAĞBAŞ: Methodology, Data Analytics.

COMPETING INTERESTS

The author(s) has/have no competing interests to declare.

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