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Modelling a cause-and-effect relationship of resilience promotion by fuzzy DEMATEL- trapezoidal structure

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Abstract

Resilience has become a controlling concept in how soldiers make their decisions in the combat area. However, current assessments predominantly focus on statistical resilience assessment. This paper presents an alternative, more holistic approach that covers multiple viewpoints of soldiers' psychological resilience by utilizing a fuzzy DEMATEL model predicated upon new understanding of cause-and-effect relationships to analyse the ranking by using the problem of promoting military psychological resilience when compiled factual information manifests itself in terms of trapezoidal fuzzy numbers. We find that for assessment the proposed fuzzy- DEMATEL analysis is more "insightful," "comprehensive," and "unified" than the present approaches. With this new approach, testing causal-and-effect relationships can lead to an innovative vision of resilience promotion by (1) methodically finding relationships among dimensions that are typically evaluated separately, a portfolio of possible interventions to increase overall resilience; (2) observing connections between interpositions of resilience dimension factors, which may disclose accidental significances of resilience; and (3) finding an inclusive set of possible interventions to increase an overall psychological resilience in the military. We conclude that the proposed method may be beneficial for improving the resilience training programs.

Keywords: Cause and effect relationships; fuzzy DEMATEL; trapezoidal fuzzy number; resilience; influence–relation map

1. Introduction

Active service soldiers perform dangerous missions requiring mental, physical, and emotional effort. Typically, on a day-to day basis active-duty soldiers face and have to deal with stressors which are sudden, intense, and life-threatening, and can greatly affect both their psychological frame of mind and overall well-being. So, resilience and be hardy for militaries is vital and we can find a wide range of training programs prepared for military service members and their families (Master Resilience Training).

In general, resilience could be described as the individual's ability to maintain good mental and physical well-being under great stress (Wadi et al., 2020). This definition of resilience is very brief and can be seen as a parallel to its first description when resilience was defined as a set of personality traits (commitment, control, and challenge) that can show how a person is able to survive under severe high stress pressure (Kobasa et al., 1982). In addition, it should be noted that the previous research proposed that resilience is perceived as trait-oriented, and was primarily concentrated on such dimensions as optimism, self-efficacy, self-reliance, and personal competence. For the past few decades, the pattern of resilience was developed into a dynamic, multidimensional, and process-oriented viewpoint (Chmitorz et al., 2018). It should be pointed out that this broad approach has allowed researchers to expand the field of their studies and include constructs relating not only to people's internal capabilities but also to their social environment, which is an external structure that affect them in some specific ways such as colleagues, family members, organization, and broader

community connections (Wadi et al., 2020).

Taking into account that resilience can be represented by a multidimensional structure, it must be evaluated and modelled by employing the multiple-criteria decision-making (MCDM) method (Liu et al., 2019). MCDM can help conduct valuable investigations into identifying the cause-and-effect of resilience dimensions and rank them up in accordance with a degree of their importance. MCDM incorporates the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method which is powerful to capture the causal relationship between criteria. The Battelle Memorial Institute established the DEMATEL method as an essential tool which can be used to resolve problems associated with complex and multi-layered relationships of multicriteria in social science problems and can show signs of the significance and interconnectedness among several criteria or dimensions (Fontela et al., 1976). In addition, this method can compensate for the weakness of traditional statistical analysis methods, as DEMATEL analysis provides information on the directionality of the relationships under study and the degree of impact between the investigated criteria. Furthermore, this method is suitable to envisage the composition of an intricate causal relationship with models or by diagrams. Recent research concluded that the DEMATEL method was successfully employed to analyse factor correlation in many areas (Lin et al., 2016; Khatami et al., 2012; Jiao et al., 2020; Liu et al., 2020).

Given that up to now scholars have not identified the main factor or dimension to be playing a key role in the resilience promotion, representing resilience as a consistent attribute has been less acknowledged (Joyce et al., 2018). So, to clarify the trends of promoting resilience directions for active-duty soldiers, we selected the DEMATEL method being capable to solve group decision-making problems (Bekesiene et al., 2021). In addition, to avoid insufficient study results, the criteria assessment, instead of being traditionally measured with crisp values, and the directed influential degrees between pair-wise resilience criteria are expressed in trapezoidal fuzzy numbers.

The fuzzy technique with DEMATEL was used taking into account several motives. First, it has to do with the weakness of traditional methods of statistical analysis. Second, the experts' multi-criteria subjective judgment can be presented linguistically and later changed into fuzzy sets. Third, the fuzzy DEMATEL technique is appropriate for the assessment of undefined and multidimensional context of resilience. To our knowledge, the fuzzy DEMATEL with trapezoidal structure has not yet been employed to investigate the psychological resilience of active-duty soldiers.

The remaining part of this study representation is arranged in the following way. First, we demarcated an existing investigation gap on psychological resilience promotion in the military as well as our intention to employ fuzzy-DEMATEL modelling to fill it. In Section Two, we presented a literature review on the criteria of psychological resilience. The fuzzy numbers, arithmetic operations and ways of the fuzzy DEMATEL technique are examined in Section Three. In Section Four, the main findings are provided to show the effectiveness of the proposed method. In Section Five, we discuss the main study results which have implications for theory and practice. Lastly, the conclusions with recommendations for further investigation are drawn.

2. Literature Review Focused on Resilience Promotion

According to the definition of psychological resilience, one did a review of the previous scientific papers. This review helped to identify the main dimensions established by scholars who contributed to psychological resilience and subfactors that reinforce the evidence base related to each factor. The main resilience dimensions were characterized depending on whether they acted at the individual (A), family (B), organizational (C), and community (D) levels. The internal factors that promote an individual's resilience were clearly distinguished from those that were more related to other individuals that could be described as one of the basic units in society such as family, organization, community. There are four dimensions and seventeen criteria for promoting psychological resilience, which were carefully considered by Hooley et al. (2005). Hooley and other researchers approved and exploited the above-mentioned dimensions and criteria in their works. So, seven factors of individual-level as dimension A were chosen: A1 – the process of managing demanding situations (positive coping); A2 – the mental faculty of perceiving the comical in stressful scenarios without bitterness or when contending with a challenge (positive affect); A3 – having positive outcome expectations (positive thinking); A4 – having realistic outcome expectations (realism); A5 – modifying emotional reactions to accomplish a goal (behavioural control); A6 – the ability to function efficiently and effectively (physical fitness); A7 – the motivation to help without reward (altruism). Consequently, four factors of family-level as dimension B were selected: B1 – bonding among family members (emotional ties); B2 – defining a problem and managing relationships (communication); B3 – understanding that support cab be received from or provided to others (support); B4 – an easy adaptation to changes in military life together with flexible roles in the family (adaptability). Accordingly, for a unit-level as dimension C, three factors were carefully chosen: C1 – positive role modelling (positive command climate); C2 – coordination of work between team members (teamwork); C3 – the ability of a unit to

perform a combined action (cohesion). Finally, three common factors were identified that characterize the community-level as dimension D: D1 – integration, friendships and implementing institutional policies (belongingness); D2 – connections with the place and its people (connectedness); D3 – perception of group members about the group's ability to work together (collective efficacy). Supplementary details of the above-presented dimensions and factors about military resilience are substantiated in a wide range of previous studies, and some of them are enclosed as supporting literature for these conducted investigations (see Table 1).

Table 1. Supporting literature for dimensions and factors of psychological militaries' **r**esilience.

Resilience dimension and supporting factors		Description	Research authors
Individual-Level (A)	Positive coping (A1)	Individual's endeavour to cope with both individual and interpersonal issues with a view to diminishing or accepting stress.	Gelkopf et al, 2008; Vernberg et al., 2008; Williams et al., 2004;
	Positive affect (A2)	Demonstrating positive emotions, optimism and feeling enthusiastic.	Vernberg et al., 2008; McCraty et al. 2009;
	Positive thinking (A3)	Information acquisition, deriving meaning from a situation, anticipating positive results, and psychological awareness.	Gelkopf et al, 2008; Vernberg et al., 2008; Williams et al., 2004; MacDermid et al. 2008;
	Realism (A4)	Realistic mastery of the possible, perceived control, and acceptance of what cannot be changed.	Gelkopf et al, 2008; Vernberg et al., 2008; Williams et al., 2004; MacDermid et al. 2008;
	Behavioural control (A5)	Individual's faculty of assessing and transforming emotional reactions to achieve a task .	Vernberg et al., 2008; MacDermid et al. 2008;
	Physical fitness (A6)	Physical strength to operate productively.	Palmer, 2008; Maddi, 2007
	Altruism (A7)	Sincere care for the welfare of others, incentive to help others without asking anything in return.	Haglund et al.,2007;
Family-Level (B)	Emotional ties (B1)	Emotional bond between family members, embracing entertainment and leisure activities.	Black & Lobo, 2008; Vogt & Tanner, 2007;
	Communication (B2)	Conveyance of thoughts, opinions, or information, incorporating problem-solving and relationship management.	Black & Lobo, 2008; MacDermid et al. 2008; McCraty et al., 2009;
	Support (B3)	Understanding that support can be received from and provided to others along with emotional, tangible, instrumental, informational, and spiritual assistance.	Black & Lobo, 2008; Maddi, 2007;
	Adaptability (B4)	Facile adaptability to the vagaries of military life, encompassing flexible family roles.	Speckhard, 2002; Black & Lobo, 2008;
Unit-Level (C)	Positive command climate (C1)	Mitigating and nurturing intra-unit interaction, establishing pride/support for a mission, realizing institutional policies; leadership and positive role modelling.	Castro, 2007; Campbell D., Campbell K., & Ness, 2008; Paton, 2006; Mazeikiene et al., 2021; Smaliukiene et al., 2021;
	Teamwork (C2)	Flexibility and work organization among team members.	Jue et al., 2020; Bekesiene et al., 2021; Bekesiene et al., 2022; Smaliukiene et al., 2021;
	Cohesion (C3)	Capability of a unit to carry out joint tasks; sticking together, keeping a pledge to each other, and being committed to the mission.	Lambić , 2018; Salo, 2008; Jue et al., 2020; Bekesiene et al., 2021; Bekesiene et al., 2022; Smaliukiene et al., 2022;
Community-Level (D)	Belongingness (D1)	Incorporation as equals into society and friendships: taking part in spiritual/faith-based organizations, protocols, ceremonies, social services, schools, etc. and executing institutional policies.	Black & Lobo, 2008; Vogt & Tanner, 2007; Butler, Morland, & Leskin, 2007; Bowen et al., 2003;
	Connectedness (D2)	Quality and number of social connections in a community, which refers to a close bond with a place or between its people, including the aspects of commitment, structure, roles, responsibility, and communication.	Vernberg et al., 2008; Hobfoll et al., 2007; Rohall & Martin, 2008;
	Collective efficacy (D3)	Understanding that group members are capable of working coherently.	Maguire & Hagan, 2007; Bliese & Castro, 2003; Jue et al., 2020; Bekesiene et al., 2021; Smaliukiene et al., 2021;

3. Materials and Methods

The main goal of this study is to establish the relation between cause and effect within the dimensions of military psychological resilience. These investigations were conducted using the structured methodology. First, the scheme of research steps was developed, covering an entire structure of analytical processing and helping investigate issues consistently, and, consequently, identify a cause-and-effect relationship for those factors which foreground the description of promoting military resilience.

3.1. Steps of Study Design

The DEMATEL technique is an analytical method particularly suitable for identifying causal relationships between selected dimensions or factors. The main steps of the conducted analysis design are presented below, in Figure 1. The first objective of this study was to select the main factors – identified in previous studies – of psychological resilience that would be mainly relevant to the active-duty soldiers. So, a general survey of idiosyncrasies pertaining to military psychological resilience across several databases were examined by several keywords. Twenty-seven original articles satisfying the determined standards and describing the promotion of military resilience were carefully chosen.

The acknowledged factors on which psychological resistance is based were grouped according to similar characteristics and elements corresponding to the same theme. For military psychological resilience we identified four main dimensions: the individual (A), family (B), organizational (C), and community (D) levels. The second step was to prepare a questionnaire for pair-wise criteria assessment. Later, were invited active-duty officers from the Lithuanian Armed Forces to express their judgements on resilience factors.

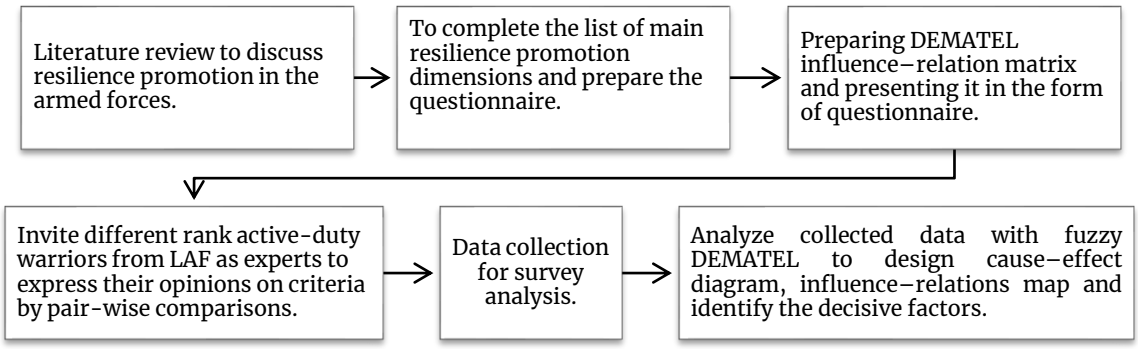


Figure 1. The steps of scientific investigations presented by scheme numbers.

Starting from the third step, we conducted the fuzzy technique with DEMATEL for examining and assessing an indefinite and equivocal background of military psychological resilience. The multidimensional and interactive nature of military resilience was studied by comprehensive methodology; the fuzzy theory was used to convert expert assessments of semantic resilience factors into the evaluator's assessment degree value through the membership function with trapezoidal fuzzy numbers. Finally, the modelling results were presented in two diagrams: a cause-and-effect diagram and an influence–relations map.

3.2. Fuzzy – Trapezoidal DEMATEL Method

The solution generated by fuzzy numbers is a valuable result as it helps perceive the uncertainty and diversity of sensations of linguistic decisions necessary to express essential associations. So, we used five linguistic terms to describe the assessment scores of linguistic variables (Chen-Yi et al., 2007): "*No influence*" (NI), "*Very low influence*" (VLI), "*Low influence*" (LI), "*High influence*" (HI), "*Very high influence*" (VHI). These five linguistic terms were associated with positive trapezoidal–fuzzy numbers (Table 2). To conduct procedures which deal with uncertain linguistic term when the trapezoidal fuzzy numbers are used and to express the collected data, we followed the rules provided in previous research work (Kaufman & Gupta, 1991; Fan &Liu, 2010).

Table 2. Term code relations description to trapezoidal fuzzy

Value/term code	Linguistic terms (abbreviations)	Fuzzy trapezoidal values			
		a_1	a_2	a_3	a_4
1=S1	No influence/(**NI**)	(0.00,	0.00,	0.00,	0.25)
2=S2	Very low influence/(**VLI**)	(0.00,	0.00,	0.25,	0.50)
3=S3	Low influence/(**LI**)	(0.00,	0.25,	0.50,	0.75)
4=S4	High influence/(**HI**)	(0.25,	0.50,	0.75,	1.00)
5=S5	Very high influence/(**VHI**)	(0.50,	0.75,	1.00,	1.00)

Note: Five linguistic terms describe the linguistic variables assessment scores (Chen-Yi et al., 2007).

These studies provided analysis on the grouping procedure of trapezoidal fuzzy numbers and presented how linguistic terms $[S_l, S_u]$ and $[S_\alpha, S_\beta]$ can be changed to a corresponding trapezoidal fuzzy number by using arithmetic operations and the membership function represented by equation (1):

$$\mu_{\tilde{a}}(X) = \begin{cases} \dfrac{X - a_1}{a_2 - a_1}, a_1 \le x \le a_2, \\ 1, a_2 \le x \le a_3, \\ \dfrac{a_4 - X}{a_4 - a_3}, a_3 \le x \le a_4, \\ 0, \quad otherwise. \end{cases} \tag{1}$$

where $\tilde{a}$ is a fuzzy set of real numbers R and membership can be presented as $\tilde{a}: R \to [0,1]$, $x \in R$, $\tilde{a}(x) = 1$. So, the aggregation operations (addition ($\oplus$), substraction ($\ominus$), multiplication ($\otimes$) and division ($\oslash$)) between two linguistic terms $[S_l, S_u]$ *and* $[S_\alpha, S_\beta]$ can be expressed by the equations presented below:

$$[S_l, S_u] \oplus [S_\alpha, S_\beta] = \left(a_{lu}^1 + a_{\alpha\beta}^1, \cdots, a_{\alpha\beta}^4 + a_{lu}^4\right); \tag{2}$$

$$[S_l,S_u] \ominus [S_\alpha,S_\beta] = (a^1_{lu} - a^1_{\alpha\beta}, \cdots, a^4_{\alpha\beta} - a^4_{lu}); \quad (3)$$

$$k \otimes [S_l,S_u] = (k \times a^1_{lu},\ k \times a^2_{lu}, k \times a^3_{lu},\ k \times a^4_{lu}); \quad (4)$$

$$[S_l,S_u]^{-1} \cong \left(\frac{1}{a^4_{lu}}, \frac{1}{a^3_{lu}}, \frac{1}{a^2_{lu}}, \frac{1}{a^1_{lu}}\right). \quad (5)$$

Consequently, the whole fuzzy DEMATEL approach process can be completed after eight steps of analysis.

Step 1. Make the direct – relation matrix $\hat{M}_k = [\hat{m}_{ij}]_{n\times n}$. First the finite set of resilience dimensions $D = \{D_1, D_2, \cdots, D_n\}$ was selected, where D_1 represents the i^{th} dimension with $i \in \{1,2,\cdots,n\}$. Also, the set of experts was used $E = \{E_1, E_2, \cdots, E_l\}$, and E_k represents the k^{th} expert $k \in \{1,2,\cdots,l\}$. Then we collected individually completed matrixes of experts' decision as a set of linguistic terms $T = \{t_0, t_1, \cdots, t_g\}$, where t_s represents the s^{th} linguistic term, $s \in \{1,2,\cdots,g\}$. Accordingly, the direct -relation matrix provided by each expert E_k was set up and is presented in the following equation (2):

$$\hat{M} = [\hat{m}_{kij}]_{n\times n} = \begin{matrix} D_1 \\ D_2 \\ \vdots \\ D_n \end{matrix}\begin{bmatrix} 0 & \hat{m}_{k12} & \cdots & \hat{m}_{k1n} \\ \hat{m}_{k21} & 0 & \cdots & \hat{m}_{k2n} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{m}_{kn1} & \hat{m}_{kn2} & \cdots & 0 \end{bmatrix}, \quad k \in 1,2,\cdots,l\,. \quad (6)$$

where $k \in \{1,2,\cdots,l\}$.

Step 2. Following the equation (1) the values in direct -relation matrices must be changed into trapezoidal fuzzy numbers. Experts participated in this study are said to be of equal importance and the arithmetic mean of all of these judgements can be used to make the main criteria assessment matrix. For this step the arithmetic operations on trapezoidal fuzzy numbers must be applied, and the matrix $\hat{M} = [\hat{m}_{kij}]_{n\times n}$ will be transformed into $\tilde{M} = [\tilde{m}_{kij}]_{n\times n}$. Principally, all direct-relation matrices $\hat{M}_1, \hat{M}_2, \cdots, \hat{M}_k$ are aggregated into the main matrix by arithmetic procedures presented in equations 2 and 4.

Step 3. Now the set of uncertain direct- relation matrix $\tilde{M} = [\tilde{m}_{kij}]_{n\times n}$ can be designed, and each $\tilde{m}_{kij} = (m^1_{kij}, m^2_{kij}, m^3_{kij}, m^4_{kij})$ element for this matrix can be calculated by the following equations from 7a to 7d:

$$m^1_{kij} = \frac{1}{n}\sum_{k=1}^{n} m^1_{kij}, \qquad i,j = 1,2,\cdots,n; \quad (7a)$$

$$m^2_{kij} = \frac{1}{n}\sum_{k=1}^{n} m^2_{kij}, \qquad i,j = 1,2,\cdots,n; \quad (7b)$$

$$m^3_{kij} = \frac{1}{n}\sum_{k=1}^{n} m^3_{kij}, \qquad i,j = 1,2,\cdots,n; \quad (7c)$$

$$m^4_{kij} = \frac{1}{n}\sum_{k=1}^{n} m^4_{kij}, \qquad i,j = 1,2,\cdots,n. \quad (7d)$$

Step 4. $\tilde{M} = [\tilde{m}_{kij}]_{n\times n}$ is transformed into the normalized indefinite direct-relation matrix $\tilde{Z} = [\tilde{z}_{ij}]_{n\times n}$, where each $\tilde{z}_{ij} = (z^1_{ij}, z^2_{ij}, z^3_{ij}, z^4_{ij})$ element for this matrix can be calculated by these equations from 8a to 8d:

$$z^1_{ij} = m^1_{ij} \Big/ \max_{1\le i\le n}\left\{\sum_{j=1}^{n} m^1_{ij}\right\}, i,j = 1,2,\ldots,n; \quad (8a)$$

$$z^2_{ij} = m^2_{ij} \Big/ \max_{1\le i\le n}\left\{\sum_{j=1}^{n} m^2_{ij}\right\}, i,j = 1,2,\ldots,n; \quad (8b)$$

$$z^3_{ij} = m^3_{ij} \Big/ \max_{1\le i\le n}\left\{\sum_{j=1}^{n} m^3_{ij}\right\}, i,j = 1,2,\ldots,n; \quad (8c)$$

$$z^4_{ij} = m^4_{ij} \Big/ \max_{1\le i\le n}\left\{\sum_{j=1}^{n} m^4_{ij}\right\}, i,j = 1,2,\ldots,n. \quad (8d)$$

where the main rule must be unbreaking, which is

$$\max_{1\le i\le n}\left\{\sum_{j=1}^{n} m^4_{ij}\right\} \neq 0, and\ 0 \le z^1_{ij} \le z^2_{ij} \le z^3_{ij} \le z^4_{ij} < 1. \quad (9)$$

Next, we will change the matrix $\tilde{Z}$ into four crisp-value matrices Z^1, Z^2, Z^3, Z^4:

$$Z^1 = \begin{bmatrix} 0 & z^1_{12} & \cdots & z^1_{1n} \\ z^1_{21} & 0 & \cdots & z^1_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z^1_{n1} & z^1_{n2} & \cdots & 0 \end{bmatrix}, Z^2 = \begin{bmatrix} 0 & z^2_{12} & \cdots & z^2_{1n} \\ z^2_{21} & 0 & \cdots & z^2_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z^2_{n1} & z^2_{n2} & \cdots & 0 \end{bmatrix},$$

$$Z^3 = \begin{bmatrix} 0 & z^3_{12} & \cdots & z^3_{1n} \\ z^3_{21} & 0 & \cdots & z^3_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z^3_{n1} & z^3_{n2} & \cdots & 0 \end{bmatrix}, Z^4 = \begin{bmatrix} 0 & z^4_{12} & \cdots & z^4_{1n} \\ z^4_{21} & 0 & \cdots & z^4_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z^4_{n1} & z^4_{n2} & \cdots & 0 \end{bmatrix}.$$

and calculate the $\tilde{Z}^k$ by conducting the multiplication procedure of crisp value matrices.

Step 5. Total-relation matrix $\tilde{G}$ can be defined by consequential steps presented below:

$$\tilde{G} = \lim_{k\to+\infty}(\tilde{Z}^1 \oplus \tilde{Z}^2 \oplus \ldots \oplus \tilde{Z}^k);\ \tilde{G} = [\tilde{g}_{ij}]_{n\times n} \quad (10)$$

Let matrix $\tilde{G}$ be presented as follows:

$$\tilde{G} = \begin{bmatrix} \tilde{g}_{11} & \tilde{g}_{12} & \cdots & \tilde{g}_{1n} \\ \tilde{g}_{21} & \tilde{g}_{22} & \cdots & \tilde{g}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{g}_{n1} & \tilde{g}_{n2} & \cdots & \tilde{g}_{nn} \end{bmatrix}, \quad where\ \tilde{g}_{ij} = (g^1_{ij}, g^2_{ij}, g^3_{ij}, g^4_{ij}). \quad (11)$$

Consequently, the total-relation matrix can be designed by following the equations 12a-12d:

$$[g^1_{ij}]_{n\times n} = G^1(I - G^1)^{-1},\ \ i,j = 1,2,\cdots,n; \quad (12a)$$

$$[g^2_{ij}]_{n\times n} = G^2(I - G^2)^{-1},\ \ i,j = 1,2,\cdots,n; \quad (12b)$$

$$\left[g_{ij}^{3}\right]_{n\times n} = G^{3}(I-G^{3})^{-1},\ \ i,j=1,2,\cdots,n; \tag{12c}$$

$$\left[g_{ij}^{4}\right]_{n\times n} = G^{4}(I-G^{4})^{-1},\ \ i,j=1,2,\cdots,n. \tag{12d}$$

Step 6. To identify the total strengths of influencing and influenced association of dimensions $D_1, D_2, \cdots, D_n$ included into analysis, the sum of each row ($\tilde{r}_i = (r_i^1, r_i^2, r_i^3, r_i^4)$ of matrix $\tilde{G}$ must be calculated. Additionally, we can calculate the sum of each column $\tilde{c}_i = (c_i^1, c_i^2, c_i^3, c_i^4)$ of matrix $\tilde{G}$ and identify the overall intensity in which the dimension D_n is influenced by others.

Step7. Now we can determine the uncertain distinction and relation of each dimension by calculating the sum of $\tilde{r}_i$ and $\tilde{c}_i$:

$$s_i^1 = r_i^1 + c_i^1, i = 1,2,\dots,n; \tag{13a}$$

$$s_i^2 = r_i^2 + c_i^2, i = 1,2,\dots,n; \tag{13b}$$

$$s_i^3 = r_i^3 + c_i^3, i = 1,2,\dots,n; \tag{13c}$$

$$s_i^4 = r_i^4 + c_i^4, i = 1,2,\dots,n. \tag{13d}$$

Also, the relations of analysed dimensions can be determined as the difference between $\tilde{r}_i$ and $\tilde{c}_i$:

$$d_i^1 = r_i^1 - c_i^1, i = 1,2,\dots,n; \tag{14a}$$

$$d_i^2 = r_i^2 - c_i^2, i = 1,2,\dots,n; \tag{14b}$$

$$d_i^3 = r_i^3 - c_i^3, i = 1,2,\dots,n; \tag{14c}$$

$$d_i^4 = r_i^4 - c_i^4, i = 1,2,\dots,n. \tag{14d}$$

Step 8. The crisp importance and relation of each factor is determined by employing the centroid (centre of gravity) procedures (Yager et al., 1994) presented as equations 15 and 16:

$$s_i = \frac{1}{4}\left(s_i^1 + s_i^2 + s_i^3 + s_i^4\right); \tag{15}$$

$$d_i = \frac{1}{4}\left(d_i^1 + d_i^2 + d_i^3 + d_i^4\right). \tag{16}$$

To present the study results in graphs, a causal diagram can be drawn on s_i and d_i calculated values. So, such visualization represents the importance and specifical classification of the investigated dimensions.

4. Study Results

The main eight steps were conducted to apply the fuzzy – trapezoidal DEMATEL method. First, sixteen experts were selected to express their judgements on four psychological resilience dimensions and seventeen sub factors by filling out a pair-wise comparisons questionnaire. All experts marked their opinions in linguistic terms which were introduced in a particularly prepared linguistic term set (see Table 2), and the completed questionnaires with expressed judgements about the strength of correlation between any two offered factors were collected. So, we used five linguistic terms: to describe linguistic variables assessment scores such as: S1="*NI*", S2="*VLI*", S3="*LI*", S4="*HI*", S5="*VHI*". These five linguistic terms were associated with positive trapezoidal–fuzzy numbers ($\tilde{m}_{kij} = \left(m_{kij}^1, m_{kij}^2, m_{kij}^3, m_{kij}^4\right)$, Table 2). This collected information let us proceed with a study analysis and all eight steps of the fuzzy – trapezoidal DEMATEL method were conducted.

4.1. Cause-and-Effect Relations Assessment Between the Main Resilience Dimensions

Step 1. We start from aggregation of initial direct-relation matrix constructed from experts' opinions in linguistic terms on four psychological resilience dimensions (A=individual, B=family, C=organizational, and D=community).

Table 3. Experts' opinions presented in initial direct-relation matrix

	A	B	C	D
A	–	LI	VLI	HI
B	VHI	–	VLI	VHI
C	HI	VLI	–	LI
D	HI	HI	VLI	–

Note: aggregated ten experts' opinions on four measurements A=individual, B=family, C=organizational, and D=community.

Step 3. Fuzzy initial direct-relationship matrix $\tilde{M}$ was prepared by computing the arithmetic average of assessments (see Table 4).

Table 4. Fuzzy initial direct-relation matrix.

	A	B	C	D
A	(0, 0, 0, 0)	(0, 0.25, 0.5, 0.75)	(0, 0.25, 0.5, 0.75)	(0.25, 0.5, 0.75, 1)
B	(0.5, 0.75, 1, 1)	(0, 0, 0, 0)	(0, 0, 0.25,0.5)	(0.5, 0.75, 1, 1)
C	(0.25, 0.5, 0.75, 1)	(0, 0, 0.25,0.5)	(0, 0, 0, 0)	(0, 0.25, 0.5, 0.75)
D	(0.25, 0.5, 0.75, 1)	(0.25, 0.5, 0.75, 1)	(0, 0, 0.25,0.5)	(0, 0, 0, 0)

Step 4. To continue analysis. We used equation 9 to calculate the maximum value and transformed fuzzy initial direct-relation matrix to the normalized fuzzy directed-relation matrix (see Table 5).

Table 5. The normalized fuzzy direct-relation matrix

	A	B	C	D
A	(0, 0, 0, 0)	(0, 0.25, 0.5, 0.75)	(0, 0.25, 0.5, 0.75)	(0.25, 0.5, 0.75, 1)
B	(0.5, 0.75, 1, 1)	(0, 0, 0, 0)	(0, 0, 0.25,0.5)	(0.5, 0.75, 1, 1)
C	(0.25, 0.5, 0.75, 1)	(0, 0, 0.25,0.5)	(0, 0, 0, 0)	(0, 0.25, 0.5, 0.75)
D	(0.25, 0.5, 0.75, 1)	(0.25, 0.5, 0.75, 1)	(0, 0, 0.25,0.5)	(0, 0, 0, 0)

To continue the present research, in Step 5 we did the procedures presented by equations 10 – 12d and constructed the generalized (overall) relation matrix $\tilde{G}$ which was defuzzied in Step 6 and all fuzzy values were changed to crisp values as is shown in Table 6.

Table 6. Defuzzied total-relation matrix.

	A	B	C	D

A	1.236	1.172	0.807	**1.435**
B	**1.841**	1.216	0.973	**1.780**
C	**1.452**	1.088	0.648	**1.349**
D	**1.601**	**1.310**	0.868	**1.297**

Note: According the mean average the threshold number α= 1.255.

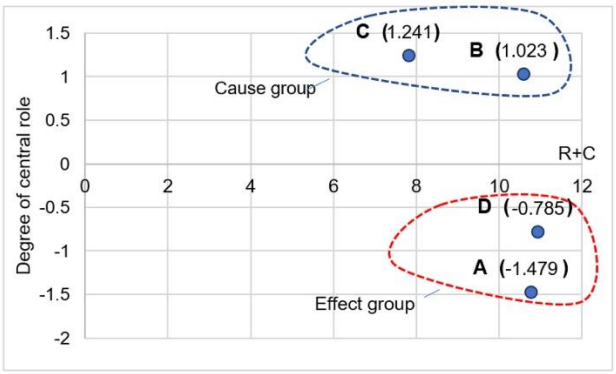
To follow the main aim of the DEMATEL method, the cause-and-effect relationship between determinants was assessed. Consequently, in Step 7 we used both equation 15 to compute the sum of each row and equation 16 – each column of the generalized relation matrix. Computation results are shown in Table 7. Additionally, in Step 8, to shape a structural model we draw a cause-and-effect diagram and an influence–relation map which are presented in Figure 2

Table 7. Final psychological resilience dimensions' assessment output.

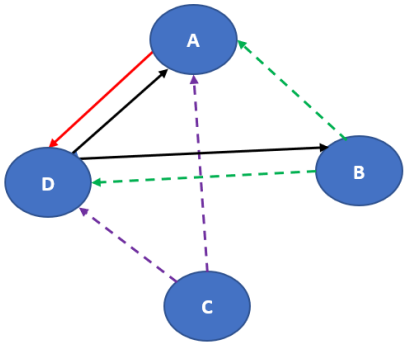
Dimension	C	R	C+R	C-R	Identity	Rank
A	4.65	6.130	10.780	-1.479	Effect	**4**
B	5.81	4.786	10.594	1.023	Cause	**2**
C	4.54	3.296	7.833	1.241	Cause	**1**
D	5.08	5.861	10.937	-0.785	Effect	**3**

Note: C= sum of column; R= sum of row; (C+R)=degree of centrality; (C-R)= representation of causality.

As is illustrated in the causal diagram in Figure 2 (a), the evaluation psychological resilience dimensions are visually divided into the causal criteria including: C – organizational and B – family dimensions, although the effect criteria including: A – individual and D – community dimensions.



(a)



(b)

Figure 2. Graphical illustration of the structural model with four psychological resilience dimensions (A=individual, B=family, C=organizational, and D=community): a) a cause-and-effect diagram; in this study, C and D are considered to be as causal factors, and A and B are regarded as an effect; b) an influence–relation map between four psychological resilience dimensions.

Following the afore-presented causal-and-effect diagram, one can have valuable insight into which criteria are the most significant with respect to promoting active-duty soldiers' psychological resilience. The (R+C) axis in Figure 2 (a) can be used to characterize the importance between this study dimensions, and (R+C) values can characterize the degree of importance in the over-all system structure. Thus, the following four dimensions of psychological resilience can be listed in rank order by their importance: organizational (C)> family (B)> community (D)> individual (A).

Additionally, the vertical axis (see Figure 2(a)), which represents the degree of a central role of each psychological resilience dimension included into this research, helps depict specifical gradation of what impact a dimension has on the over-all model structure. If (C-R) value is positive, it belongs to causal criteria group where we have two dimensions; that is, organizational (C) and family (B). Otherwise, if calculated causality (C-R) value is negative, it typifies an effect and there we have two dimensions: those of individual (A) and community (D). Additionally, it can be pointed out that the causal relationship analysis of centrality and causality let us identify that the strongest influence of resilience dimensions was shown as a positive effect of community (D). Also, the most affected resilience dimension was individual (A) (see Table 7). Moreover, in Figure 2(b) the influence–relationship map between four psychological resilience dimensions is illustrated. However, in order to properly identify the existing relationship between study variables and avoid an overly complex map of influence - relationships, we applied a threshold value that was calculated as an average (Hsu et al., 2007). So, those values which are greater than the threshold (α= 1.255) in the presented defuzzied total-relation matrix (see Table 6) were used as indicators of dimensions relationships, therefore the influence was distinguished by the identity of dimensions' (see Table 7). The dotted lines denote a dimension that affects another, and the arrows indicates which of the two constructs affect the other.

4.2. Cause-and-Effect Relations Assessment Between Resilience Factors

For a better understanding of how resilience factors representing the main four dimensions are interconnected, we conducted the same analysis procedure and the interrelationships between factors under each dimension were evaluated. The results of

the conducted analysis showed the degree of centrality (C+R) and causality (C-R) among resilience factors under each of four dimensions of military psychological resilience. Detailed information is presented in Table 8.

Table 8. Identified interrelationships between factors of military psychological resilience.

Resilience dimension and supporting factors		C	R	C+R (Centrality)	C-R (Causality)	Identity	Rank
Individual-Level (A)	Positive coping (A1)	5.595	5.264	10.859	0.330	Cause	**2**
	Positive affect (A2)	5.594	4.103	9.698	1.491	Cause	**1**
	Positive thinking (A3)	4.323	4.569	8.892	-0.246	Effect	**4**
	Realism (A4)	4.618	5.066	9.685	-0.448	Effect	**6**
	Behavioural control (A5)	4.113	5.229	9.343	-1.116	Effect	**7**
	Physical fitness (A6)	4.271	4.610	8.882	-0.339	Effect	**5**
	Altruism (A7)	4.424	4.096	8.520	0.328	Cause	**3**
Family-Level (B)	Emotional ties (B1)	9.778	11.533	21.311	-1.755	Effect	4
	Communication (B2)	10.922	9.285	20.206	1.637	Cause	1
	Support (B3)	9.671	9.028	18.699	0.642	Cause	2
	Adaptability (B4)	10.353	10.878	21.231	-0.525	Effect	3
Unit-Level (C)	Positive command climate (C1)	13.580	14.625	28.205	-1.045	Effect	3
	Teamwork (C2)	14.545	14.625	29.170	-0.080	Effect	2
	Cohesion (C3)	13.500	12.375	25.875	1.125	Cause	1
Community-Level (D)	Belongingness (D1)	13.580	14.625	28.205	1.045	Cause	1
	Connectedness (D2)	14.545	14.625	29.170	0.080	Cause	2
	Collective efficacy (D3)	13.500	12.375	25.875	-1.125	Effect	3

As for causality (C - R), the resilience factors A1, A2 and A7 were the cause-related signs having a positive value, and the strongest impact was identified for A1. In contrast, the effect indicators were A3, A4, A5 and A6 with negative causality (C - R) value. Additionally, the analysis based on causal relations of centrality and causality showed positive affect (A2) was the major determinant of influence. The most influenced indicator was behavioural control (A5) (see Table 8).

The resilience dimension B is presented as "*Family-Level*" in Table 8. The centrality (C + R) measures show the greatest influence value for Emotional ties (B1). The values of B2 and B3 were positive according the causality (C - R), which means they represent the cause factors, and B2 is the strongest. On the other hand, the values of the B1 and B4 are negative, representing the effective factors. Focus on the causal relationship's analysis of centrality and causality, B2 is the strongest influence factor, and B4 is the most affected criterion.

The dimension C is offered as "*Unit-Level*" (see Table 8). The relationships among these dimension factors in view of centrality (C + R) show that the teamwork (C2) has the greatest impact. Consequently, the causality (C - R) assessment let us identify the two factors C1 and C2 with negative values and C3 with positive values representing causal relationships. Also, cohesion (C3) as Unit-Level (C) resilience factor was the strongest one.

Three factors were chosen to evaluate the resilience dimension "*Community-Level*" (D). According to centrality (C+R) ration, the relationships between factors showed that the factor connectedness (D2) has the highest impact. Regarding to the causality (C - R) part, the values of two factors D1 and D2 are positive and representing the causality. Also, the factor belongingness (D1) was the strongest in this dimension of psychological resilience, and D3 was the most affected criterion (see Table 8).

5. Discussion

This study was applied to clarify the developmental trends of psychological resilience that can help better prepare military personnel for their active-duty service. Before delving into scientific investigations, one undertook a literature review, and the main dimensions – that is, the individual (A), the family (B), the military unit (C), and the broader community (D) which pertain to the development of psychological resilience and are likely to be involved in military training programs to build a stronger combat force, were selected. Then, sixteen experts were invited to express their opinions on carefully chosen resilience criteria by completing a pair-wise comparison questionnaire. Taking into account the complexity of psychological resilience developmental aspects that can be presented as an important result of individual, interpersonal and intrapersonal relations, the linguistic terms were used for criteria assessment, and the trapezoidal fuzzy DEMATEL analysis was completed to predict causal relations between the chosen variables. Additionally, modelling results were presented as a cause-effect diagram to clarify the significant relations between variables and an influence–relations map model of four resilience dimensions.

The results of our study confirmed the insights of previous studies – that is, the military organizational

dimension (C), which, according to a literature review, can be defined as a military unit-level, can affect soldiers' resilience and has the greatest impact on development of the active-duty soldiers' individual resilience by C1 – a positive command climate (Castro, 2007; Campbell D., Campbell K., & Ness, 2008; Paton, 2006; Smaliukiene et al., 2022) C2 – teamwork (Jue et al., 2020; Bekesiene et al., 2021; Bekesiene et al., 2022), and C3 – cohesion (Lambić et al., 2018; Salo, 2008; Jue et al., 2020; Bekesiene et al., 2022; Smaliukiene et al., 2022). According to the development of psychological resilience, specific unit-level factors of military organization have a significant bearing on other aspects of resilience promotion resources. Any transformation in soldiers' individual competences leverages other facets of resilience. If a soldier's unit-level skills are high, this correspondingly can lead to high psychological resilience promotion potential in other dimensions of resilience. The other important outcome from this research is that it is similar to the results of other scientific investigations evidencing that the family-level dimension is the most significant factor determining the changes associated with a military-life approach (Black & Lobo, 2008; Vogt & Tanner, 2007). Moreover, our findings support the results of previous research concluding that soldiers should strive to build trust among family members, because good relationships can help them develop and adapt a far proper resilience-building approach in the present-day uncertain milieu (Black & Lobo, 2008; MacDermid et al. 2008; McCraty et al., 2009). The results of this study can put forward significant suggestions for designing and implementing the soldiers' resilience training programs.

6. Conclusions

This study employed the fuzzy DEMATEL method with trapezoidal numbers and determined the key success factors to assess the relationships among the main four military resilience dimensions. Twenty-seven original articles representing four resilience dimensions let us use a holistic approach for investigating the trends of promoting military psychological resilience. The present study showed the importance of two dimensions which can affect the resilience promotion strategy: family-level (B) with two cause factors B2 and B3, and organizational-level (C) with cohesion (C3) as a causal factor.

The findings of this study may help military organizations select appropriate strategies by concentrating on vital determinants in regard to the assets of military training programs. The fuzzy DEMATEL method shows that it is a promising modelling method that is likely to be utilized in developing an innovative rating scale to assess the promotion of resilience and make additional extensions or changes to the structure of resilience training programs for active-duty and reserve soldiers or conscripts.

We would like to point out certain research limitations. First, the pair-wise questionnaires for gathering expert opinions could possibly lead to both personal bias and individual insight. Second, only seventeen criteria representing four resilience dimensions were used. We thus suggest including additional factors for further studies, especially for those dimensions which affect the resilience promotion strategy.

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