CAUSAL ANALYSIS OF INDONESIA ARCHIPELAGO MARINE DEFENSE SYSTEM: A DELPHI-DEMATEL APPROACH

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ABSTRACT

The development of science and technological advances as well as the era of globalization encourage the emergence of new layers and dimensions of shifting perceptions of threats as well expanding scale and destructive power for increasingly complex state life. These changes affect the policy of the national defense strategy which has an impact on the role and approach of the Indonesian Navy towards the concept of the archipelago's maritime defense and security system (SPLN). A country's maritime defense strategy is no longer limited to its territorial waters or the surrounding sea, but also oriented both regionally and globally. The Indonesian Navy's strong posture plays an important role for the Indonesian Navy in determining the strategy to be implemented to address the problems. This research uses the DELPHI-DEMATEL framework which aims to identify and provide an overview of the relationship between variables from the Indonesian Navy's Posture and the development of the strategic environment in the implications of the Archipelago Sea Defense System (SPLN). The methodological design of this study identified several variables from TNI AL and the development of the strategic environment posture through a literature review resulting in 10 main variables, using the DELPHI method analysis obtained 8 variables that were feasible for further analysis. DEMATEL was used to process and interpret the collected data and cause-effect relationships were established between variables. DEMATEL's analysis shows that the variables Technology, Socio-Cultural, Strength, Capability, Operational Degree, and Potential Threats fall into the causal group. These factors are very important because they directly affect the Real Threat, Economy, Politic and Defense factors.

Keywords: DELPHI-DEMATEL, Archipelago Marine Defens System (SPLN), Indonesian Navy Posture.

1. INTRODUCTION.

The science and Technology Developments, which were marked by the rapid exchange of information and communication, these advances have had positive and negative impacts on the life of the nation and state(Ellitan, 2020). This also has an impact on the National Interest which includes all important matters for the survival and welfare of the Indonesian state in the aspects of security, defense, economic stability, foreign policy, and people's welfare. With changes in threat perception that are increasingly dynamic, this paradigm also influences national defense strategy policies that have an impact on the role and approach of the Indonesian Navy toward the concept of the archipelago's maritime defense and security system. A country's maritime defense strategy is no longer limited to its territorial waters or the surrounding sea but is also oriented both regionally and globally. According to Ugur Yetkin, the modern Navy has multiple missions: nuclear deterrence and ballistic missile defense, control of the sea, projection of force, order at sea, and maritime consensus (Yetkin, 2013).

With the development of warfare technology and weaponry pioneered by the superpowers and their allies, this has further expanded the scale, dimensions of war, and the destructive power caused by war for the survival of the state. Competition for the military strengthening of a country in a region has contributed to the escalation of tensions due to the emergence of a feeling of insecurity and friction between the interests of each country (Posen, 1993). To balance this progress, the Indonesian Navy's posture is required to continue to experience modernization and adjustments in line with advances in weapons technology, also in

proportion to the actual and potential threats that pose a challenge in realizing the interests of the state and maintaining of Indonesia sovereignty and the Unitary State (Cordesman et al., 2015)

2. MATERIALS AND METHODOLOGY.

2.1. Maritime Security

Zumwalt classifies naval missions: Strategic deterrence, Force projection, Naval command, and Naval presence. Thus, a theoretical understanding of naval capabilities and the use of military force in a state's efforts to preserve its existence and protect its interests is developed (Geoffrey Till, 1982). Currently, various things appear to pose a threat to the use of the sea in Indonesia. Indonesia, which has so far maintained its image as an "honest broker" in the maritime structure in the South China Sea, has experienced many challenges to its territorial claims. Under President Jokowi, Indonesia's approach to the South China Sea conflict has changed. The initial intention to find a peaceful solution to the dispute in the area has become a policy that serves Indonesia's national interests in Natuna waters, much to the displeasure of China. (Connelly, 2015). As a marine military force in Indonesia, the Indonesian Navy is expected to be able to direct its focus and capabilities on securing Indonesian waters.

2.2 Delphi

Delphi is a group process that involves communication between a researcher and a group of experts on a particular topic, usually using a questionnaire. (Yousuf, 2007). This method is used to build consensus on future predictions/trends using a systematic data collection process. This method is useful when the opinions and judgments of experts and practitioners are needed to solve problems. This is especially useful when experts cannot be present at the same time (Renalda et al., 2021). The Delphi method aggregates decisions on complex questions when relevant information is not available (Skutsdh et al., 1973). The Delphi process is described with the following six stages (Linstone et al., 2002):

a. Identify group members whose consensus opinion is needed. The group must be able to represent a variety of viewpoints that are proportionally represented.

b. First questionnaire. Ask each member to write down goals, considerations, or issues related to the expected consensus goals. Next, arrange the information so that it is organized. Then prepare a second questionnaire with a more structured format so that an assessment can be carried out.

c. Second questionnaire. Each member was asked to provide an assessment of the results of the first recap, each panelist gave a reason/brief explanation. The results of the first questionnaire were displayed in the second questionnaire, and each panelist was asked again to provide an assessment and ranking and to give reasons for deciding to be in a different position from the group.

d. The results of the second questionnaire were tabulated and presented as group consensus results.

In the early stages, the informants will answer based on the information, knowledge, and experience they have. The informants provided their answers or opinions with a rating scale between 1 (one) to 9 (nine) based on the level of importance of the instrument to be developed. The information on that scale is 1 (very unimportant) and 9 (very important). Furthermore, the results of the assessment from the resource persons were tabulated and processed into the Delphi method formula so that they became a presentation of the results of the agreement of the resource persons group.

The instruments that have converged or reached a consensus from sources who consider it important to develop are using statistical analysis with the following approaches (Linstone et al., 2002):

a. Standard deviation. A criterion is stated convergence or reach the consensus rating is when the standard deviation of all responses or ratings from all sources is <1.5. The formula is below:

$$S = \sqrt{\frac{\sum(xi - x)2}{n-1}} \sqrt{\frac{\sum xi^2 - \frac{(\sum x1)2}{n}}{n-1}} \ldots\ldots (2.1)$$

b. The interquartile range is a measure of convergence or other consensus judgment when the responses or estimates from all sources have an interquartile range less than 2,5. The formula for the interquartile range is:

$$Q1 = \frac{x\left(\frac{n-1}{4}\right) + x(\frac{n+3}{4})}{2} \ldots\ldots\ldots\ldots (2.2)$$

$$Q2 = x\ \frac{2(n+1)}{4} \ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

$$Q3 = \frac{x\left(\frac{3n-1}{4}\right) + x(\frac{3n+5}{4})}{2} \ldots\ldots\ldots (2.4)$$

A criteria is stated convergence or reach the consensus rating is when the standard deviation of all responses or ratings from all sources is <1.5 and the interquartile range is < 2.5. If neither the standard deviation nor the interquartile range is < 1.5 and < 2.5, then the instrument is declared not convergent or there is no consensus that the instrument is not important and has the potential to be developed. After an evaluation has been carried out which states that the instrument is convergent or it is agreed (consensus) that the instrument is important and has the potential to be developed, the next step is to rank it with the highest average value for each convergent instrument.

2.3. DEMATEL

DEMATEL is a method used to describe the correlation of complex cause-effect connection between variables of a system and obtain the level of influence of these variable. Complex interactions between system components can be visualized in DEMATEL (Zhou et al., 2011). The steps taken in carrying out the analysis using the DEMATEL method, shown the below:

First Step is Determind the avg Matrix. We have several experts (H) to give their opinions and N reasons to consider. each stakeholder was asked to explain his belife that factor i affects factor j. The pairwise comparison of the i-th factor with the j-th factor is given by the k-th expert, which is indicated by b_{ij} which in integer starting from following below:

Table 1. The Value of Importance Level

Mark	Information
0	No effect
1	Low impact
2	Moderate impact
3	High impact
4	Very high impact

.

Scores of each an expert constructs a non-negative matrix with answer an xn. So, ,... is the response matrix of H experts. The diagonal elements of each response matrix are all set to zero, which means there is no effect by itself.

$$B^k = \left[b_{ij}^{(k)}\right]_{n \times n} B^1 B^2 B^{(H)} B^k$$

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} b_{ij}^{(k)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

For the next step, we know the causal relationships between each pair of factors by visualize a influence map (Chang et al., 2018). Arrows in influence maps indicate the value and strength of influence. DEMATEL can transform the structural relationships between system factors into understandable system maps (Hsu et al., 2014).

Second Step:Determine the initial normalized direct relationship matrix.The initial normalized correlation matrix is obtained by normalizing the average matrix A in the following way (Yang and Tzeng, 2011): $D = \left[d_{ij}\right]_{n \times n}$

$$S = \max\left(max \sum_{j=1}^{n} a_{ij}\ max \sum_{i=1}^{n} a_{ij}\right) \ldots\ldots\ldots\ldots\ldots (2.6)$$

$$D = \frac{A}{S}$$

The sum of each row in the direct relationship matrix are show the total direct effect of factor to another factor. The positive scalar S takes the greater of the two as the scale factor, and matrix

D is obtained by dividing each element of A by scalar S. Note that each element of matrix D is between 0 and 1 (Ilham and Asvial, 2022).

$\sum_{j=1}^{n} a_{ij}\ \sum_{i=1}^{n} a_{ij}\ d_{ij}$ .....(2.7)

Third Step is Determine the Total Relation Matrix. The normalized strength the beginning direct relationship matrix, called the indirect effect, can be used to represent the Length of effects. The total effect can be determine by summing DEMATEL assuming it will be converted to a zero matrix and the total relationships matrix (Calderbank et al., 1986). It can be obtained by

$D, D^m\ D, D^2, D^3 \ldots D^\infty\ D^m D + D^2 + D^3 + \cdots + D^\infty$

$T = \lim_{n\to\infty}(D, D^2, D^3 \ldots D^\infty) = D(1-D)^{-1}$.....2.8)

However, if it is assumed that , is wrong, then T = may not be obtained, then the total relation matrix T is as follows:

$\lim_{n\to\infty} D^m = [0]_{n\times n}\ D + D^2 + D^3 + \cdots + D^\infty$

$r = [r_i]_{n\times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n\times 1}'$..... ....(2.9)

$c = [c_j]_{1\times n} = \left(\sum_{j=1}^{n} t_{ij}\right)_{1\times n}$..... ....(2.10)

Fourth Step is Determine the threshold velue and impact digraph. In order to determine the structural relationship between factors while keeping system complexity at a manageable level, it is necessary to set thresholds to filter out some of the smaller effects of the T-matrix. Although each variable in the T-matrix provides information about how one variable affects the other, decision makers must set thresholds to reduce the complexity of modeling the structural relationships in the T-matrix. The effect ratio map shows only a few variables with an effect greater than the threshold value (Tzeng et al., 2007).

The steps of the DEMATEL method can be seen clearly in the summary diagram of work steps as follows:

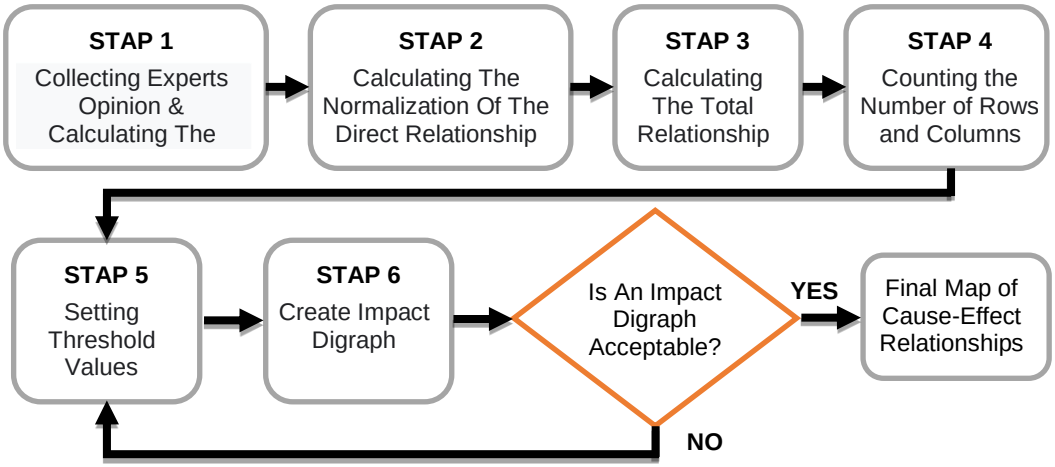

Figure 1. Steps in the DEMATEL Method

2.4. Frameworks Methodology

This study uses a four-step methodology to answer the research objectives. Studies using the multicriteria decision analysis (MCDA) method Delphi and DEMATEL are summarized in the Framework Diagram below.

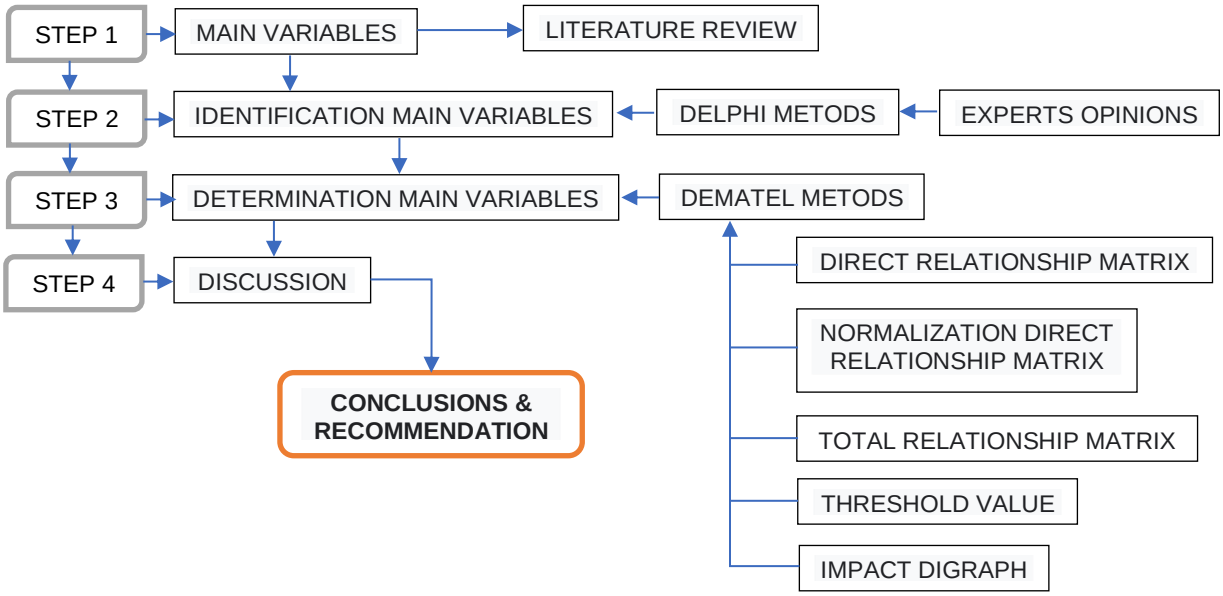

Figure 2. Research Framework

3. RESULTS AND DISCUSSION.

In this section, the results of the data processing performed in this study are displayed, while the results of data processing are as follows.

3.1. Key Variable Identification

Questionnaires were administered to several Experts to provide an assessment of the main variables obtained based on the literature review carried out based on the knowledge, experience and understanding of the Experts. The main variables of the criteria for the archipelago's marine defense system can be seen in the Table 2 below:

Table 2. Main Variable Criteria

CRITERIA	CODE	VARIABLE	REFERENCE
Threat Perception	K1	Real Threat	Decision head of the Indonesian Navy No. 6, 2016
	K2	Potential Threats	
Indonesian Navy Posture	K3	Capability	Decision head of the Indonesian Navy No. 6, 2016
	K4	Strength	
	K5	Power Projection	
Strategic Environmental Development	K6	Political	Decision head of the Indonesian Navy No. 6, 2016
	K7	Economy	
	K8	Socio-cultural	
	K9	Defense & security	
	K10	Technology	Experts Interview

Analysis of the Delphi method was carried out in 2 (two) rounds which were used to identify the relevant main variables to be developed into the next analysis model. The results of the questionnaire to 5 (five) Experts were then processed using the Delphi method with the results that can be seen in Table 3 as follows:

Table 3. Results of the Delphi Method Analysis

NO	EXPERT	CRITERIA									
		K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	K-9	K-10
1	E1	5	8	9	9	8	8	6	6	8	9
2	E2	7	9	9	8	8	9	8	6	9	7
3	E3	8	7	9	9	7	7	7	3	7	8
4	E4	6	7	8	7	8	8	7	4	8	9
5	E5	7	9	9	8	6	8	8	5	8	9
SCORE		33	40	44	41	37	40	36	24	40	42
MARK		7,94	12.70	14,29	14,29	12.70	12.70	9.52	9.52	12.70	14,29
MIN		5	7	8	7	6	7	6	3	7	7
MAX		8	9	9	9	8	9	8	6	9	9
AVERAGE		6,60	8.00	8.80	8,20	7,40	8.00	7,20	4.80	8.00	8.40
STD DEV		1.14	1.00	0.45	0.84	0.89	0.71	0.84	1.30	0.71	0.89
CONVERGEN	= that the instrument is important and has the potential to be developed										
DIVERGEN	= that the instrument is not important and has no potential to be developed										

From processing data analysis using the Delphi method on the main variables of the Archipelago's Marine Defense Posture and Strategy, 8 (eight) main variables were obtained that were feasible to be developed in the next model analysis, the eight main variables were as follows:

a. Potential Threats
b. Ability
c. Strength
d. Power Projection
e. Political
f. Economy
g. Defense and security
h. Technology

3.2. Causal Interconction Relationship Between Variables

To find out the relationship between variables, the authors use the DEMATEL method of analysis to determine the most dominant variable. The results of the DEMATEL analysis are shown in *Inner Dependent Matrix*and Impact digraph as follows:

First Step is Determind the avg Matrix. The average matrix obtained from the expert questionnaire can be seen in the Table 4 below:

Table 4. Average Matrix

AVERAGE MATRIX			THREAT PERCEPTION	INDONESIAN NAVY POSTURE			STRATEGIC ENVIRONMENTAL DEVELOPMENT			SUM
			Potential Threats	Capability	Strength	Power Projection	Political	Economy	Defense	Technology	
			K2	K3	K4	K5	K6	K7	K9	K10	
THREAT PERCEPTION	**Potential Threats**	K2	0	3,6	3,8	4	3,6	3	4,4	4,4	26,8
INDONESIAN NAVY POSTURE	**Capability**	K3	3,8	0	4,8	4	3,2	3,4	4	3,2	26,4
	Strength	K4	3,8	4,4	0	4	4,4	3,8	4,2	3,8	28,4
	Power Projection	K5	3,8	3,6	4,6	0	3,6	3,6	4,2	3,4	26,8
STRATEGIC ENVIRONMENTAL DEVELOPMENT	**Political**	K6	3,4	2,8	3,6	3,4	0	4,4	4	3,2	24,8
	Economy	K7	3,4	3,2	3,8	3,4	3,8	0	3,6	3,4	24,6
	Defense	K9	3,6	4	3,4	3,6	3,8	3,6	0	3,8	25,8
	Technology	K10	4,4	4,6	4,2	3,8	4	4,4	3,4	0	28,8

SUM			26,2	26,2	28,2	26,2	26,4	26,2	27,8	25,2	0,035

Second Step is calculated the initial normalized direct relationship matrix Normalization of the direct relationship matrix is performed by multiplying the direct relationship matrix by the identity matrix. the results of the multiplication can be seen in the Table 5 below:

Table 5. Normalized Direct Relationship Matrix.

NORMALIZED MATRIX			THREAT PERCEPTION	INDONESIAN NAVY POSTURE			STRATEGIC ENVIRONMENTAL DEVELOPMENT			
			Potential Threats	Capability	Strength	Power Projection	Political	Economy	Defense	Technology
			K2	K3	K4	K5	K6	K7	K9	K10
THREAT PERCEPTION	Potential Threats	K2	1,00	-0,13	-0,13	-0,14	-0,13	-0,10	-0,15	-0,15
INDONESIAN NAVY POSTURE	Capability	K3	-0,13	1,00	-0,17	-0,14	-0,11	-0,12	-0,14	-0,11
	Strength	K4	-0,13	-0,15	1,00	-0,14	-0,15	-0,13	-0,15	-0,13
	Power Projection	K5	-0,13	-0,13	-0,16	1,00	-0,13	-0,13	-0,15	-0,12
STRATEGIC ENVIRONMENTAL DEVELOPMENT	Political	K6	-0,12	-0,10	-0,13	-0,12	1,00	-0,15	-0,14	-0,11
	Economy	K7	-0,12	-0,11	-0,13	-0,12	-0,13	1,00	-0,13	-0,12
	Defense	K9	-0,13	-0,14	-0,12	-0,13	-0,13	-0,13	1,00	-0,13
	Technology	K10	-0,15	-0,16	-0,15	-0,13	-0,14	-0,15	-0,12	1,00

Third Step is Determine the total relationship matrixTo calculate the total relationship matrix, which is done by inverting the matrix on the matrix that has been normalized. The results of the inverse matrix can be seen in the Table 6 below:

Table 6. Total Relationship Matrix.

NORMALIZED MATRIX			THREAT PERCEPTION	INDONESIAN NAVY POSTURE			STRATEGIC ENVIRONMENTAL DEVELOPMENT			
			Potential Threats	Capability	Strength	Power Projection	Political	Economy	Defense	Technology
			K2	K3	K4	K5	K6	K7	K9	K10
THREAT PERCEPTION	Potential Threats	K2	1,371	1,485	1,579	1,494	1,494	1,466	1,580	1,460
INDONESIAN NAVY POSTURE	Capability	K3	1,468	1,355	1,586	1,476	1,464	1,457	1,550	1,409
	Strength	K4	1,553	1,572	1,533	1,560	1,582	1,554	1,644	1,507
	Power Projection	K5	1,485	1,482	1,597	1,370	1,492	1,479	1,572	1,430
STRATEGIC ENVIRONMENTAL DEVELOPMENT	Political	K6	1,377	1,363	1,467	1,379	1,284	1,406	1,465	1,331
	Economy	K7	1,372	1,368	1,467	1,373	1,394	1,267	1,448	1,331
	Defense	K9	1,432	1,445	1,515	1,433	1,449	1,433	1,394	1,394
	Technology	K10	1,589	1,597	1,681	1,575	1,591	1,589	1,643	1,409

Fourth Step is Determine the threshold velue and impact. The threshold value is obtained from the average value in the total relationship matrix. From table 6 the threshold value is obtained by 1,474. While the value in column D is the result of the sum in each row of Total Relationship Matrix, while the value in column R is the result of the sum of each column in the Total Relationship Matrix. The results in step four can be seen in the following Table 7:

Table 7. Results of DEMATEL Data Analysis Method

VARIABLE			D	R	D+R	D - R	CAUSAL
THREAT FORECAST	K2	Potential Threats	12.94	12.71	25.65	0.231	Dispatchers
POSTURE INDONESIA NAVY	K3	Ability	12.88	12.94	25,82	-0.064	Receivers
	K4	Strength	13.74	13.55	27,29	0.190	dispatchers
	K5	Power Projection	13,1	13.06	26,15	0.041	Dispatchers
STRATEGIC ENVIRONMENTAL DEVELOPMENT	K6	Political	12,29	13,26	25.55	-0.965	Receivers
	K7	Economy	12.41	13.03	25,44	-0.617	Receivers
	K9	Defense & security	12.75	13.64	26,39	-0.885	Receivers
	K10	Technology	14,28	12.56	26,84	1,721	Dispatchers

4. CONCLUSION.

Conclusions about the above data processing can be drawn based on the results of data analysis and discussion conducted. The results of the analysis using the DELPHI-DEMATEL method for the main variables show that there are eight main variables that are feasible to continue for further analysis. While the causal interconnection relationship between the main variables is shown in table 8 and Figure 3 *Impact digraphs*as follows:

Table 8. Ranking Analysis of the Dematel Method

CODE	VARIABLE	D	R	D+R	RANK	D - R	INFORMATION
K2	Potential Threats	12.94	12.71	25.65	7	0.23	CAUSE
K3	Ability	12.88	12.94	25,82	6	-0.06	CAUSE
K4	Strength	13.74	13.55	27,29	1	0.19	CAUSE
K5	Power Projection	13,1	13.06	26,15	4	0.04	CAUSE
K6	Political	12,29	13,26	25.55	8	-0.96	EFFECT
K7	Economy	12.41	13.03	25,44	9	-0.62	EFFECT
K9	Defense & security	12.75	13.64	26,39	3	-0.89	EFFECT
K10	Technology	14,28	12.56	26,84	2	1.72	CAUSE

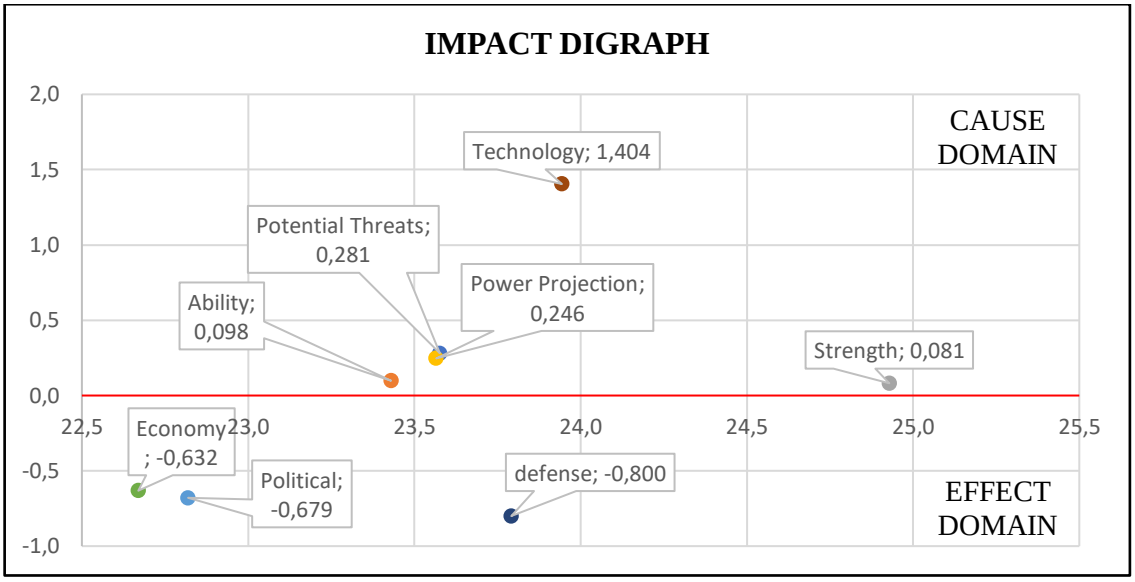

Figure 3. Impact Digraphs

The purpose of this study was to evaluate the relationship of different criteria to an effective and operational marine protection system using the DEMATEL method. Unlike the other MCDM models, this method can show a causal relationship between criteria (Ahmed et al., 2023). The DEMATEL analysis results above show that the strength variable (K4) is the main factor in implementing the Archipelago Marine Defense System, then followed by the Technology variable (K10), this is the most effective and efficient variable to be developed in supporting the Archipelago Sea Defense System (SPLN). The results of this study are in line with Yudi Listiono and Lukman Yudho Prakoso, who concluded that "the Indonesian Navy needs up-to-date technology in building strength in carrying out its duties" (Listiyono et al., 2019). based on the results of analysis between variables using the Delphi-DEMATEL method on the archipelago's marine defense system, it is found that the most variable are the assets used to carry out operations, technology that can support defense and security operations and stability. While the variables that most influence the archipelago's marine defense system are technological factors, potential threats, strength, power projection, and capabilities possessed by the Indonesian Navy.

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