An Optimization Model for Assessment Resilience Engineering in Social Technical Organizations as a safety Management Paradigm

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Abstract

An innovative safety administration paradigm, resilience engineering (RSE), is becoming more popular in today's sociotechnical organizations. It is thought that the properties of complicated social and technical structures better align with RSE. Especially when it comes to measuring and modeling, RSE is much more difficult due to its various criteria character and the inclusion of both qualitative and quantitative latent components. Using the extant neutrosophic TODIM (Portuguese of interactive and multi-criteria decision-making) approach, this study seeks to create a neutrosophic mixed multi-criteria decision-making (MCDM) framework for assessing and evaluating resilience. Several indicators of resilience were defined as part of the first assessment methodology. After that, the neutrosophic TODIM technique was used to assign relative importance to the various resilience indicators and to rate the effectiveness of the various operational units. As an illustration of the model's efficacy, we conducted a risk assessment of a gas refinery, a prototypical sociotechnical structure.

Keywords: Neutrosophic Set; TODIM; Resilience Engineering; Safety; sociotechnical organizations.

1. Introduction

Emerging risks in chemical manufacturing processes cannot be fully identified. These structures will be fraught with uncertainty as a result of the complex nature of the connections between their technological, human, and organizational components. Mistakes in the process sectors often arise because of a lack of better ways to comprehend the emerging nature of functional resonant. Some examples of sectors that fall under the category of "high-reliability organizations" (HROs) are the nuclear, medical care, flight, marine, and chemical manufacturing sectors. Since the advent of automated and electronic sensors, these HROs have grown more complex and technologically reliant[1], [2].

For quite some time, it was believed that human mistakes and technological malfunctions were the primary reasons for most mishaps. However, it is now understood that operational variability, organizational issues, and emerging phenomena are often at the root of accidents. The likelihood of catastrophic failure scenarios grows in tandem with a program's complexity. Sociotechnical structures, of which the process industry is an example, are more prevalent in today's world. Risks in such systems cannot be adequately assessed using traditional approaches[3], [4].

Concurrently reducing variability that may lead to bad effects and reinforcing uncertainty that may lead to good outcomes is the optimal strategy for managing uncertainty. Resilience engineering (RSE) is an innovative strategy that seeks to enhance organizations' ability to develop processes that are strong yet adaptable, compared to the traditional risk management mindset of looking backward and basing decisions on calculations of failure likelihood.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

RSE has many factors in the safety and social-technical sectors, so the concept of MCDM is used in this paper besides the neutrosophic sets to handle uncertain data[5], [6].

In other circumstances, however, the outcomes of the data are typically Information with indeterminacy, imprecision, ambiguity, inconsistency, and insufficient Information. Unquantifiable, missing, or insufficient data is a common cause of incorrect evaluations. Information ambiguity may be modeled using fuzzy sets (FSs). Only the membership function can be analyzed using FSs. Hence no further parameters of fuzziness may be arranged[7], [8].

While intuitionistic FSs can manage partial data for many practical themes, it is incapable of dealing with indeterminate data or other forms of ambiguity. As a result, Smarandache suggests the neutrosophic set (NS) with a degree of membership indeterminacy as a standalone component[9], [10].

Taking into account the risk attitudes of decision-makers is important when dealing with MCDM so that it can accurately portray the rising complexity in the real world. To address the challenges of MCDM while also taking into account the psychological behaviors of decision-makers, Gomes and Lima developed the TODIM (Portuguese for "Interactive Multi-Criteria Decision Making") technique. Some academics have paid attention to the MCDM's portrayal of the decision-makers' attitudes[11]–[13]. The use of fuzzy TODIM models, or intuitive fuzzy TODIM scenarios, has also been recommended by several academics.

2. Resilience Engineering (RSE)

The safety administration paradigm RSE emphasizes assisting individuals in handling complicated situations while under time constraints. Because of this, RSE stands out from other disciplines in its focus on how success is achieved, how people learn and evolve, and how they establish safety in a context where there are flaws, risks, trade-offs, and competing agendas. Wreathall also connects resilience with an organization's capacity to maintain or swiftly reestablish stability, enabling it to go on functioning despite suffering a devastating setback or operating under persistently high levels of stress. Thus, resilience encompasses not only the ability to prevent setbacks and losses but also the capacity to recover quickly and efficiently when they have happened[14].

When applied to devices with high levels of ambiguity and variation, (a) an elevated level of interconnection between each element of the system makes it very hard for the operator to predict the consequences of his choices, and (b) errors tend to spread quickly. The characteristics of RSE become more significant in such complicated circumstances.

It was necessary to attempt to compile a set of fundamentals that could act as a reference for the approach to evaluation now proposed because no one set of RSE concepts has widespread support in academic circles and also because there are variances between the terminology utilized by various contributors. It's important to note that RE concepts may be employed everywhere in the hierarchy of a company's cognitive system, from the vantage point of an individual employee's workstation to that of the whole enterprise.

3. Resilience, Safety, and Health Management (HESA)

Health and safety (HESA) administration best practices are often normative and based on underlying concepts. Maintaining HESA management (HESAM) that is continually sufficient for developments to the sociotechnical framework within which the organization is placed is challenging since the concepts behind the leadership practices are unknown. Indeed, the HESA practice will only be helpful if it refers to a concept, a template, or has some other intellectual underpinning.

Adopting a set of standards is also crucial since it establishes the order of importance for various aspects of effectiveness. To illustrate the significance of this definition, multiple investigations have shown that distinct theoretical assumptions underpin various accident investigation techniques, leading to wildly divergent findings[15].

As a novel approach to HESA management, RSE has been pointed out in this context. To provide security in a world full of risks and competing priorities, it is essential to have a firm grasp on how performance is attained, how individuals and groups grow and change, and how this knowledge is applied. A key concept of RSE is that resilience is not merely the capacity to keep operating in the face of adversity; rather, it is the flexibility to make changes to how individuals and systems operate in response to change.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

In this essay, we'll look specifically at how the RSE paradigm has been used in the practice of auditing HESAM. Specifically, Costella et al. discussed MAHS, the HSMS evaluation technique created. The authors of this paper have used this approach in various firms, so they have access to actual data concerning its implementation, and it was selected because it directly ties the evaluation criteria of the HESAM with the concepts of RSE[16].

4. Resilience and Social Technical

There is a growing number of possible risks to sustainable development that people and society must contend with today. Man-induced (anthropogenic, natch) and man-made malevolent (terroristic) risk occurrences were just recently included in the list of dangers, which previously only included natural and man-made incidental occurrences. While still very uncommon, both the incidence and impact of such incidents are on the rise, at least in terms of public awareness. Due to rising urbanization, industrial, transit, and logistic agglomerations, these phenomena must be dealt with most acutely in highly populated urban centers[17], [18].

People, the community, ecosystems, economic sectors, and each level of administration and non-government members are more reliant on cyber-physical technological infrastructure of varying scales and degrees of complexity than ever before. Individual and societal anticipation of technological advances and services has increased exponentially. They are predicted to have smaller ecological footprints and higher degrees of security, protection, privacy, intelligence, flexibility, portability, wearability, visualization, and interface as their efficiency rises. Live-line grids and nodes, transportation and healthcare infrastructures and amenities, and accident and disaster administration systems are all examples of sociotechnical structures[19], [20].

Modern cyber-physical social-technical structures face a far more extensive and varied set of risks and failures. By expanding beyond a focus on solely technical structures, the term "sociotechnical systems" highlights the necessity of considering the interplay between technology and individuals in addition to human behavior. It may also be seen as including major elements from the High-Reliability Organization theory and the usual accident idea.

When compared to traditional technical structures, which had to deal with element or subsystem errors due to physical flaws or control errors produced within the framework, today's increasingly interconnected systems also have to account for element or subsystem errors that occur or even guided from without the systems, again by mistake or on purpose. As a result, even if the limits of a system are greatly expanded, the use of classical system definitions is on the decline. The result is a dramatic increase in the variety of potential breakdowns that might affect any given component, interface, or element[21], [22].

RSE is the practice of using social science-informed or-driven technical-engineering procedures, methodologies, and techniques to lessen the vulnerability (in a broad sense) or increase the resilience (non-vulnerability) of sociotechnical structures and procedures[23], [24].

Another way to describe RSE is to consider how technical, engineering and organic social scientific methods are used to address societal and technological difficulties. Extreme circumstances or loadings, unanticipated occurrences that the system was not initially built for, etc., all fit the bill here as examples of the kind of issues that might arise. This might be both the result of rapid decline or something that happens more slowly over time. According to this concept, recovering from disruptive events may include or even demand enhanced efficiency in the system and its activities.

New areas of study and their associated communities of practice (like RSE) often locate their identity in opposition to older, more established disciplines. This may lead to descriptions of the conventional field that are oversimplified or even deceptive, overlooking the reality that there are more points of agreement than there are differences among viewpoints. Considering how much RE borrows thoughts and ideas from other disciplines, it would be dishonest to characterize RE as fundamentally creative[25], [26].

5. Model Development

The TODIM method, which was designed with the decision maker's psychology in mind, is a powerful tool for addressing MCDM issues. This method, which is grounded in prospect theory, uses a function of multi-attribute values to illustrate the relative strengths of several options[27]–[29]. Figure 1 shows the steps of the proposed method.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

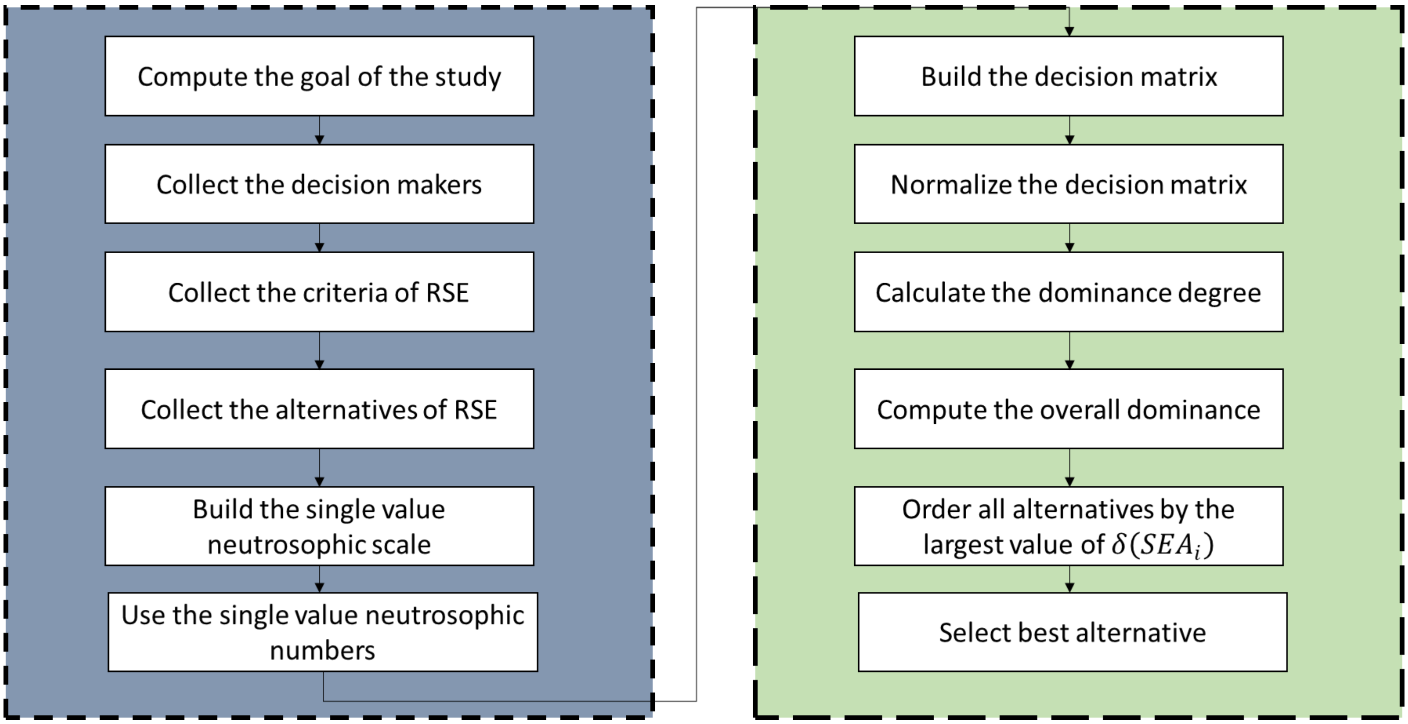

Figure 1: The neutrosophic TODIM method.

5.1 Build the decision matrix

The decision matrix is built by the single-valued neutrosophic numbers (SVNNs) between criteria and alternatives. Where the set of criteria is $RSEC_1, RSEC_2, \ldots .. RSEC_n$, and the set of options is $RSEA_1, RSEA_2, \ldots .. RSEA_m$. Where $i = 1,2,3 \ldots m; j = 1,2,3, \ldots . n$

5.2 Normalize the decision matrix

$$N_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}} \quad (1)$$

5.3 Calculate the dominance degree

The dominance degree is computed by comparing $RSEA_1$ over $RSEA_2$ concerning the criteria.

$$\delta(SEA_i, SEA_t) = \sum_{j=1}^{n} \delta(SEA_i, SEA_t) \quad (2)$$

Where $i, t = 1,2,3 \ldots m$

$$\delta(SEA_i, SEA_t) = \begin{cases} \sqrt{\frac{w_j(N_{ij}-N_{tj})}{\sum_{j=1}^{n} w_j}} & if\ N_{ij} - N_{ti} > 0 \\ 0 & if\ N_{ij} - N_{ti} = 0 \\ -\frac{1}{\exists}\sqrt{\left(\sum_{j=1}^{n} w_j\right)\frac{(N_{tj}-N\_ij)}{w_j}} & if\ N_{ij} - N_{ti} < 0 \end{cases} \quad (3)$$

Where ∃ refers to the factor of loss

5.4 Compute the overall dominance

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$$\delta(SEA_i) = \frac{\sum_{t=1}^{m} \propto (SEA_i, SEA_t) - \min_i\{\sum_{t=1}^{m} \propto (SEA_i, SEA_t)\}}{\max_i\{\sum_{t=1}^{m} \propto (SEA_i, SEA_t)\} - \min_i\{\sum_{t=1}^{m} \propto (SEA_i, SEA_t)\}} \quad (4)$$

5.5 Order all alternatives by the largest value of $\delta(SEA_i)$

6. Results

This section introduces the result of the single-valued neutrosophic TODIM MCDM methodology. We used the single-valued neutrosophic numbers to evaluate the criteria and alternatives by the decision-makers. Then we apply the steps of the suggested method to obtain the rank of alternatives. This paper used ten criteria and ten alternatives, as shown in Figure 2. First, let the decision maker evaluate the criteria and alternatives as shown in Table 1.

Figure 2: The data are collected in this study.

Table 1: The single valued neutrosophic numbers between criteria and options.

	RSEC$_1$	RSEC$_2$	RSEC$_3$	RSEC$_4$	RSEC$_5$	RSEC$_6$	RSEC$_7$	RSEC$_8$	RSEC$_9$	RSEC$_{10}$
RSEA$_1$	(0.80,0.25,0.20)	(0.35,0.65,0.55)	(0.90,0.15,0.15)	(0.35,0.65,0.55)	(0.90,0.15,0.15)	(0.70.,0.30,0.25)	(0.80,0.25,0.20)	(0.90,0.15,0.15)	(0.70.,0.30,0.25)	(0.80,0.25,0.20)
RSEA$_2$	(0.80,0.25,0.20)	(0.15,0.95,0.85)	(0.90,0.15,0.15)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.65,0.35,0.30)
RSEA$_3$	(0.70.,0.30,0.25)	(0.90,0.15,0.15)	(0.90,0.15,0.15)	(0.15,0.95,0.85)	(0.35,0.65,0.55)	(0.80,0.25,0.20)	(0.35,0.65,0.55)	(0.70.,0.30,0.25)	(0.80,0.25,0.20)	(0.65,0.35,0.30)
RSEA$_4$	(0.80,0.25,0.20)	(0.90,0.15,0.15)	(0.80,0.25,0.20)	(0.35,0.65,0.55)	(0.80,0.25,0.20)	(0.35,0.65,0.55)	(0.80,0.25,0.20)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.65,0.35,0.30)
RS	(0.90,0.	(0.15,0.	(0.15,0.	(0.90,0.	(0.15,0.	(0.70.,0.	(0.90,0.	(0.35,0.	(0.65,0.	(0.90,0.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

EA5	15,0.15)	95,0.85)	95,0.85)	15,0.15)	95,0.85)	30,0.25)	15,0.15)	65,0.55)	35,0.30)	15,0.15)
RSEA6	(0.70.,0.30,0.25)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.15,0.95,0.85)	(0.70.,0.30,0.25)	(0.80,0.25,0.20)	(0.65,0.35,0.30)	(0.80,0.25,0.20)	(0.90,0.15,0.15)	(0.65,0.35,0.30)
RSEA7	(0.65,0.35,0.30)	(0.65,0.35,0.30)	(0.90,0.15,0.15)	(0.15,0.95,0.85)	(0.80,0.25,0.20)	(0.90,0.15,0.15)	(0.65,0.35,0.30)	(0.35,0.65,0.55)	(0.80,0.25,0.20)	(0.90,0.15,0.15)
RSEA8	(0.90,0.15,0.15)	(0.15,0.95,0.85)	(0.65,0.35,0.30)	(0.90,0.15,0.15)	(0.15,0.95,0.85)	(0.65,0.35,0.30)	(0.90,0.15,0.15)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.70.,0.30,0.25)
RSEA9	(0.70.,0.30,0.25)	(0.35,0.65,0.55)	(0.80,0.25,0.20)	(0.35,0.65,0.55)	(0.80,0.25,0.20)	(0.15,0.95,0.85)	(0.35,0.65,0.55)	(0.65,0.35,0.30)	(0.35,0.65,0.55)	(0.80,0.25,0.20)
RSEA10	(0.80,0.25,0.20)	(0.90,0.15,0.15)	(0.70.,0.30,0.25)	(0.90,0.15,0.15)	(0.80,0.25,0.20)	(0.90,0.15,0.15)	(0.15,0.95,0.85)	(0.90,0.15,0.15)	(0.70.,0.30,0.25)	(0.90,0.15,0.15)

Then compute the weights of the criteria. The weights of the criteria are computed by the average method, as shown in Figure 3.

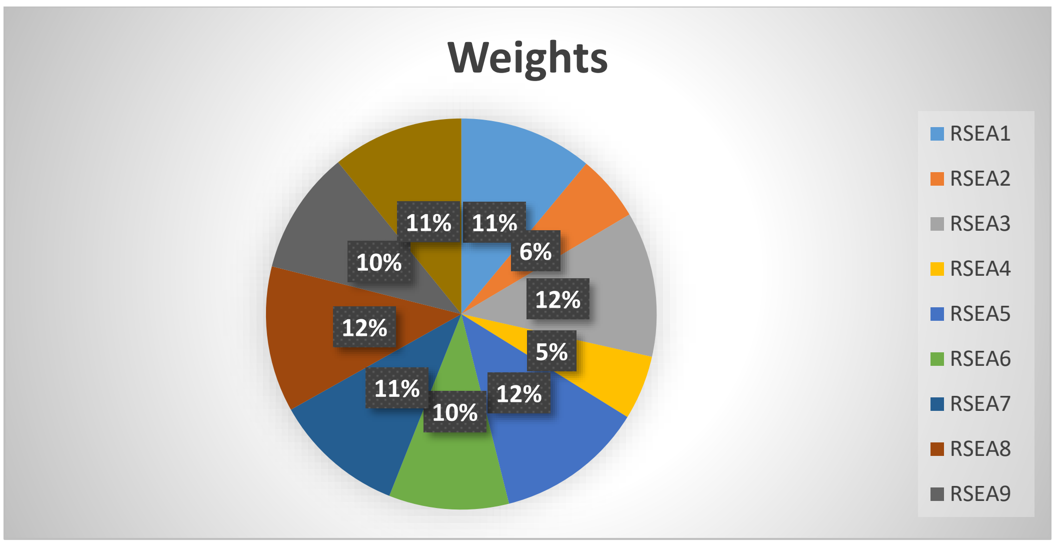

Figure 3: The weights of factors.

Then normalize the decision matrix by using Eq. (1), as shown in Table 2. Then compute the dominance degree by using Eq. (2 and 3) as shown in Table 3. Then compute the overall dominance degree by using Eq. (4). Then rank the alternatives by the largest value of the overall dominance as shown in Figure 4. The values of the overall dominance degree show that alternative ten is the best and alternative 4 is the worst of all alternatives.

Table 2:The values of N_{ij}

	$RSEC_1$	$RSEC_2$	$RSEC_3$	$RSEC_4$	$RSEC_5$	$RSEC_6$	$RSEC_7$	$RSEC_8$	$RSEC_9$	$RSEC_{10}$
$RSEA_1$	0.101952	0.080419	0.12037	0.085502	0.144444	0.114058	0.126685	0.148997	0.103614	0.103753
$RSEA_2$	0.101952	0.024476	0.12037	0.085502	0.111111	0.061008	0.107817	0.065903	0.096386	0.0883
$RSEA_3$	0.093276	0.181818	0.12037	0.026023	0.063889	0.124668	0.061995	0.123209	0.113253	0.0883
$RSEA_4$	0.101952	0.181818	0.108796	0.085502	0.130555	0.061008	0.126685	0.065903	0.096386	0.0883
$RSEA_5$	0.112798	0.024476	0.016204	0.193308	0.019445	0.114058	0.140162	0.065903	0.096386	0.11479

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

$RSEA_6$	0.093276	0.080419	0.092593	0.026023	0.119444	0.124668	0.107817	0.13467	0.125301	0.0883
$RSEA_7$	0.086768	0.13986	0.12037	0.026023	0.130555	0.137931	0.107817	0.065903	0.113253	0.11479
$RSEA_8$	0.112798	0.024476	0.092593	0.193308	0.019445	0.106101	0.140162	0.065903	0.096386	0.094923
$RSEA_9$	0.093276	0.080419	0.108796	0.085502	0.130555	0.018568	0.061995	0.114613	0.055422	0.103753
$RSEA_{10}$	0.101952	0.181818	0.099537	0.193308	0.130555	0.137931	0.018868	0.148997	0.103614	0.11479

Table 3: The values of $\delta(SEA_i, SEA_t)$

	$RSEC_1$	$RSEC_2$	$RSEC_3$	$RSEC_4$	$RSEC_5$	$RSEC_6$	$RSEC_7$	$RSEC_8$	$RSEC_9$	$RSEC_{10}$
$RSEA_1$	0	0.055943	0	0	0.033333	0.05305	0.018868	0.083095	0.007229	0.015452
$RSEA_2$	0.008677	-0.1014	0	0.059479	0.080556	-0.01061	0.06469	0.025788	-0.00964	0.015452
$RSEA_3$	0	-0.1014	0.011574	0	0.013889	0.05305	0	0.083095	0.007229	0.015452
$RSEA_4$	-0.01085	0.055943	0.104166	-0.10781	0.124999	0	-0.01348	0.083095	0.007229	-0.01104
$RSEA_5$	0.008677	0	0.027778	0.059479	0.025	-0.01061	0.018868	0.014327	-0.02169	0.015452
$RSEA_6$	0.015184	-0.05944	0	0.059479	0.013889	-0.02387	0.018868	0.083095	-0.00964	-0.01104
$RSEA_7$	-0.01085	0.055943	0.027778	-0.10781	0.124999	0.007958	-0.01348	0.083095	0.007229	0.00883
$RSEA_8$	0.008677	0	0.011574	0	0.013889	0.09549	0.06469	0.034384	0.048193	0
$RSEA_9$	0	-0.1014	0.020833	-0.10781	0.013889	-0.02387	0.107816	0	0	-0.01104
$RSEA_{10}$	0.101952	0.080419	0.12037	0.085502	0.144444	0.114058	0.126685	0.148997	0.103614	0.103753

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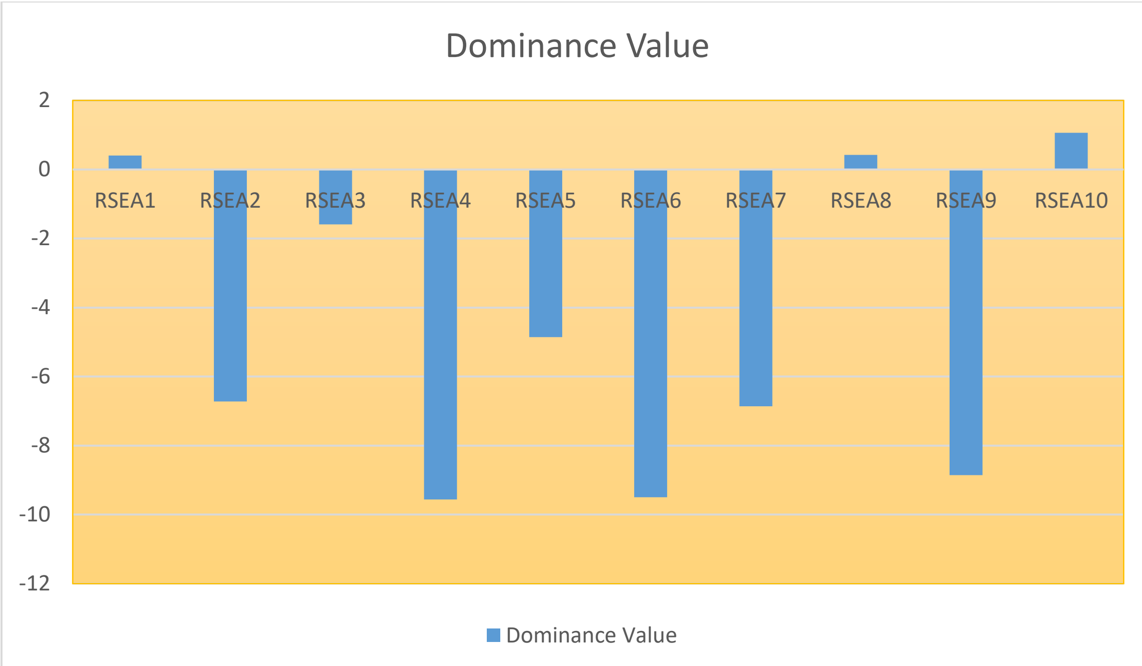

Figure 4: The values of overall dominance degree.

7. Conclusion

The advent of RSE as a methodology has ushered in a sea change in conventional safety practices. Multiple studies have attempted to put a number on resilience, but some of the literature that has resulted from these efforts has failed to account for the inherent ambiguity of data in the fields of security and resilience. By harnessing the strength of neutrosophic sets and MCDM approaches, we are capable of dealing with the aforementioned issues since neutrosophic sets are adept at handling ambiguity and inconsistency and may be employed to measure resilience and, by extension, security. In this study, we evaluated an organization's capacity for resilience using a combination of MCDM approaches and a neutrosophic set. Neutrosophic TODIM was utilized to assign relative importance to resilience measures and to evaluate and order plant parts based on those ratings. The supplied application for resilience assessment demonstrates the feasibility of the proposed paradigm for handling a resilience analysis with insight and simplicity. With some minor adjustments to the criteria and their measurements, the proposed approach may be applied in any kind of sociotechnical organization. It is essential to achieve continual improvement in complicated structures, and the suggested model could work as a potent instrument to quantitatively determine the underlying vulnerability and straightness elements of the system's safety.

References

[1] E. Zarei, B. Ramavandi, A. H. Darabi, and M. Omidvar, "A framework for resilience assessment in process systems using a fuzzy hybrid MCDM model," *J. Loss Prev. Process Ind.*, vol. 69, p. 104375, 2021.

[2] F. Azizi, R. Tavakkoli-Moghaddam, M. Hamid, A. Siadat, and M. Samieinasab, "An integrated approach for evaluating and improving the performance of surgical theaters with resilience engineering," *Comput. Biol. Med.*, vol. 141, p. 105148, 2022.

[3] M. Samieinasab, M. Hamid, and M. Rabbani, "An integrated resilience engineering-lean management approach to performance assessment and improvement of clinical departments," *Socioecon. Plann. Sci.*, vol. 84, p. 101425, 2022.

[4] H. Bouloiz, "Sustainable performance management using resilience engineering," *Int. J. Eng. Bus. Manag.*, vol. 12, p. 1847979020976205, 2020.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

[5] G. A. Shirali, P. Rashnoudi, V. Salehi, and S. Ghanbari, "A hierarchical assessment of resilience engineering indicators in petrochemical industries using AHP and TOPSIS," *Hum. Factors Ergon. Manuf. Serv. Ind.*, vol. 33, no. 1, pp. 3–26, 2023.

[6] M. Omidvar, A. Mazloumi, I. Mohammad Fam, and F. Nirumand, "Development of a framework for resilience measurement: Suggestion of fuzzy Resilience Grade (RG) and fuzzy Resilience Early Warning Grade (REWG)," *Work*, vol. 56, no. 3, pp. 463–474, 2017.

[7] D.-S. Xu, C. Wei, and G.-W. Wei, "TODIM method for single-valued neutrosophic multiple attribute decision making," *Information*, vol. 8, no. 4, p. 125, 2017.

[8] S. Pramanik, S. Dalapati, S. Alam, and T. K. Roy, "NC-TODIM-based MAGDM under a neutrosophic cubic set environment," *Information*, vol. 8, no. 4, p. 149, 2017.

[9] Taif Khalid Shakir,Ahmed N. Al Masri, Single Valued Neutrosophic Set for Selection of Water Supply in Intelligent Farming, International Journal of Advances in Applied Computational Intelligence, Vol. 2 , No. 2 , (2022) : 37-44 (Doi : https://doi.org/10.54216/IJAACI.020204)

[10] D. Zhang, Y. Su, M. Zhao, and X. Chen, "CPT-TODIM method for interval neutrosophic MAGDM and its application to third-party logistics service providers selection," *Technol. Econ. Dev. Econ.*, vol. 28, no. 1, pp. 201–219, 2022.

[11] S. Pramanik and R. Mallick, "TODIM strategy for multi-attribute group decision making in trapezoidal neutrosophic number environment," *Complex Intell. Syst.*, vol. 5, no. 4, pp. 379–389, 2019.

[12] D. Xu, X. Wei, H. Ding, and H. Bin, "A new method based on PROMETHEE and TODIM for multi-attribute decision-making with single-valued neutrosophic sets," *Mathematics*, vol. 8, no. 10, p. 1816, 2020.

[13] K. Zhang, J. Zheng, and Y.-M. Wang, "A heterogeneous multi-attribute case retrieval method based on neutrosophic sets and TODIM for emergency situations," *Appl. Intell.*, vol. 52, no. 13, pp. 15177–15192, 2022.

[14] M. Tavana, S. Nazari-Shirkouhi, and H. Farzaneh Kholghabad, "An integrated quality and resilience engineering framework in healthcare with Z-number data envelopment analysis," *Health Care Manag. Sci.*, vol. 24, pp. 768–785, 2021.

[15] F. Navazi, R. Tavakkoli-Moghaddam, and P. Memari, "Layout optimization of injection process by considering integrated resilience engineering: a fuzzy-DEA approach," *Int. J. Model. Simul.*, vol. 41, no. 1, pp. 52–66, 2021.

[16] M. Sarani, M. Hamid, M. Bastan, and M. Samieinasab, "A novel mixed resilience engineering and macroergonomics framework for performance evaluation of an insurance company," *Int. J. Comput. Appl. Technol.*, vol. 69, no. 3, pp. 228–243, 2022.

[17] I. Häring, S. Ebenhöch, and A. Stolz, "Quantifying resilience for resilience engineering of socio technical systems," *Eur. J. Secur. Res.*, vol. 1, pp. 21–58, 2016.

[18] R. Patriarca, A. Falegnami, F. Costantino, and F. Bilotta, "Resilience engineering for sociotechnical risk analysis: Application in neuro-surgery," *Reliab. Eng. Syst. Saf.*, vol. 180, pp. 321–335, 2018.

[19] A. W. Righi, T. A. Saurin, and P. Wachs, "A systematic literature review of resilience engineering: Research areas and a research agenda proposal," *Reliab. Eng. Syst. Saf.*, vol. 141, pp. 142–152, 2015.

[20] D.-H. Ham, "Safety-II and resilience engineering in a nutshell: An introductory guide to their concepts and methods," *Saf. Health Work*, vol. 12, no. 1, pp. 10–19, 2021.

[21] D. D. Woods, "Four concepts for resilience and the implications for the future of resilience engineering," *Reliab. Eng. Syst. Saf.*, vol. 141, pp. 5–9, 2015.

[22] W. Eljaoued, N. Ben Yahia, and N. B. Ben Saoud, "A Qualitative-quantitative resilience assessment approach for sociotechnical systems," *Procedia Comput. Sci.*, vol. 176, pp. 2625–2634, 2020.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023

[23] C. B. Rosso and T. A. Saurin, "The joint use of resilience engineering and lean production for work system design: A study in healthcare," *Appl. Ergon.*, vol. 71, pp. 45–56, 2018.

[24] I. Häring, B. Scharte, and S. Hiermaier, "Towards a novel and applicable approach for Resilience Engineering," in *Proceedings of the 6th International Disaster and Risk Conference (IDRC), Davos, Switzerland*, 2016, pp. 272–276.

[25] B. Pawar, S. Park, P. Hu, and Q. Wang, "Applications of resilience engineering principles in different fields with a focus on industrial systems: A literature review," *J. Loss Prev. Process Ind.*, vol. 69, p. 104366, 2021.

[26] R. Steen and T. Aven, "A risk perspective suitable for resilience engineering," *Saf. Sci.*, vol. 49, no. 2, pp. 292–297, 2011.

[27] M. Zhang, P. Liu, and L. Shi, "An extended multiple attribute group decision-making TODIM method based on the neutrosophic numbers," *J. Intell. Fuzzy Syst.*, vol. 30, no. 3, pp. 1773–1781, 2016.

[28] D. Xu and L. Peng, "An Improved Method Based on TODIM and TOPSIS for Multi-Attribute Decision-Making with Multi-Valued Neutrosophic Sets.," *C. Model. Eng. Sci.*, vol. 129, no. 2, 2021.

[29] D. Xu, Y. Hong, and K. Xiang, "A method of determining multi-attribute weights based on single-valued neutrosophic numbers and its application in TODIM," *Symmetry (Basel).*, vol. 11, no. 4, p. 506, 2019.

Doi: https://doi.org/10.54216/FinTech-I.020104
Received: August 22, 2022 Accepted: January 19, 2023