A Neutrosophic Model for Identifying and Analyzing the Effect of Relational Leadership on Information Security Policy Compliance: A Case Study of the Hotel Industry

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Abstract

Leaders at hotels are keen to learn how to improve staff adherence to their newly implemented information security rules in the wake of a spate of events involving the compromise of sensitive customer data. In this research, we analyze the relationship between workers' compliance intentions and their perceptions of deterrence, and the leadership styles of their bosses. Gender, education, role, tenure based on ethical leadership, and information security policy compliance intention were some of the particular leadership aspects connected to the information security policy that were evaluated in our research. The overall relevance of the standards may be calculated using the average method, which is used in decision-making. The suggested novel version of the MULTIMOORA (Multi-objective Optimization by Ratio Analysis Plus Full Multiplicative Form) approach uses a single-valued neutrosophic set to handle directly with the uncertainty of the starting point. Developing a decision-support system that takes into account the new conceptual composite framework we offer for selecting criteria, alternatives, and other aspects of leadership and information security policy in hotels is a feasible next step.

Keywords: MULTIMOORA Method; Neutrosophic Set; Leadership; Information Security Policy; Hotel Industry

1. Introduction

Information technology (IT) is commonly used by hotels to facilitate operational procedures, including online reservation and service delivery. Because of the critical nature of the data contained in IT systems, hotels are increasingly at risk of cyberattacks. The hotel business comes third in the number of information security (IS) incidents, behind only the retail sector and the financial and insurance sector[1], [2].

In 2018, for instance, a data breach involving 500 million Marriott guests caused significant financial and reputational harm. Several more hotels have also had IS issues. Ransomware, banking details, chip-not-present information, user passwords, private information, and card trail information are just some of the sorts of information that can be stolen in the hotel business, as shown in the 2020 Trustwave Global Security Assessment[3], [4].

The hotel business is no different from others in that almost all data breaches occur inside private networks. However, 18% of IS events are the result of point-of-sale (POS) assaults, which have a significant impact on the hospitality business. However, only a tiny fraction of crimes are of this kind.

The effects of breaches in IS may be devastating for the businesses that suffer them. As shown by Goel and Shawky, [5,6] breaches in IS have a negative impact on a company's stock price. IS events have been proven to have a detrimental impact on client happiness, referral probability, and desire to return in prior research. As a result, hotel management becomes more focused on cutting down on data breaches. Employee misconduct is a common cause of IS problems, and threat actors are generally seen as a higher security danger than attackers. Hotel proprietors want to know how to improve staff compliance with IS rules so that fewer IS incidents occur.

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It is common practice to utilize deterrence as a tool for improving workers' adherence to policies. According to the deterrence hypothesis, two factors—deterrent intensity and certainty—influence workers' adherence to policies. When workers believe that the likelihood of being penalized is greater, they are more inclined to abide by IS regulations. However, past research has shown conflicting findings, and it is unclear whether policy compliance is affected by individuals' views of deterrent severity or confidence [7].

Additionally, Gibbs-based research [8] has argued that people make compliant choices relying on their deterrence impression after carefully weighing the intensity and reliability of the deterring. It's conceivable, however, that people don't always use purposeful information processing while making choices. Managerial leadership, according to Palanski [27], may influence workers to make snap choices like quitting without much consideration. Supervisors' leadership probably has a major influence on staff members' compliance with IS regulations in a similarly "effortless" fashion, given that these policies are applied in the settings of unique organizations.

Leadership and one's view of deterrence may be seen as two separate decision-making processes. The consequences of other systems for making choices (such as leadership) cannot be understood by concentrating alone on the deterrence impression. Managerial leadership has been found in the literature to affect the illegal behavior of workers. However, there is a dearth of research on the role of hotel management in ensuring that staff members follow all applicable rules and regulations. Such an analysis is necessary to inform hotel management about the forms of leadership most likely to increase policy compliance among staff members. Leadership and IS policy have many criteria, so the concept of multi-criteria decision-making is used to deal with this problem. Decision support systems (DSS) have coined the term "multi-criteria decision-making" to refer to a specific subset of this larger topic. A wide variety of data processing techniques, such as specialized regression frameworks, categorization strategies, ANN, and so on, are included in the decision support model.

Choosing the best way to arrange the options is another important part of using the MCDM methodology. We have adopted the MULTIMOORA approach, which was initially developed to address issues in managing projects. The MULTIMOORA technique was quickly extended to address real-world engineering challenges, although its original design was focused on a particularly terse kind of data[9]–[11].

Recent studies have focused heavily on taking into account the ambiguity or "fuzziness" of the original data. As a result, we also create some imprecise MULTIMOORA modifications[12]–[14].

Leaders often confront the challenge of accounting for the imprecision of initial knowledge when they attempt to tackle complicated real-world practical challenges[15], [16]. While several fuzzy set kinds have been created and used for MCDM problem-solving, this still does not account for all of the ambiguities that crop up when attempting to solve actual engineering issues. Understanding "knowledge of neural thought" and including this "neutral" component in models for data uncertainty has recently been made possible by the concept of the neutrosophic sets initially developed by Smarandache[17]–[20].

When faced with a taking decisions dilemma including neutrosophic data, the current approaches regulated by fuzzy sets and their special types might be cumbersome[21], [22]. Neutrosophic set theory assigns a truth value, an indeterminacy value, and a falsehood value to each variable in the query. By neutrosophic logic, the significance of the indeterminacy level is independent of truth and falsity levels[23], [24].

This study aimed to develop a model with the MULTIMOORA method with the single-valued neutrosophic set for ranking criteria and alternatives of leadership with IS policy in hotels.

2. Ethical Leadership

IS policy compliance among people may be improved through ethical leadership. Leaders should act ethically towards their staff. Thus, it has been discovered that moral management may lessen the prevalence of antisocial conduct. Mo and Shi [28] argue that responsible management contributes to a culture where workers feel valued and respected by their superiors. Therefore, ethical leadership promotes healthy interactions among management and staff. If workers have faith in their superiors, they are less inclined to act inappropriately.

Hotel personnel are expected to be familiar with IS rules that outline proper procedures for handling guests' personal information. A hotel's staff are more likely to follow data security procedures if its executives treat them responsibly. Based on the research, it is safe to assume that ethical leadership raises compliance intentions among workers through

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building connections characterized by reciprocal trust, given that breaching information security law is a kind of deviant behavior[25], [26].

Leaders are well-known to hotel staff because of their frequent interactions with and impact on day-to-day operations. This suggests that the natural way to handle data is mirrored in the impact of ethical leadership.

2.1 Relational Leadership

Leadership in a relational context is characterized by both leaders and subordinates engaging in a series of mutually beneficial interactions through which they make meaning of events, decide what needs to be completed, and figure out how to get it done. By "relational leadership," we mean management that encourages and prioritizes the development of productive, mutually supportive relationships among employees. Interpersonal knowledge that may be utilized to understand social data and exhibit social behaviors is developed within the context of a dyad (leader and learner).

Recent studies have broadened the definition of an executive to include those who have earned informal authority inside an organization (such as an organizational user) in addition to those who have official authority (such as a boss). Relational leadership is defined by Uhl-Bien [29] as "a societal impact mechanism through which spontaneous organization and transformation (e.g., novel principles, views, methods, behaviors, and philosophies) are developed and generated." As a result, persons beyond the usual confines of an organization might be involved in relational leadership.

To enable workers to succeed as collaborators, relational leaders must first concentrate on building strong, trustworthy connections in the workplace. A Chief Security Officer (CSO) is an executive who oversees all aspects of a company's data safety system (ISS), including its management and administration, as well as its introduction, development, and implementation.

A chief security officer (CSO) acts as an expert in technology and a management planner in charge of protecting a company's intellectual property. Human resource management is another common responsibility for chief security officers. Humans constitute one of the most crucial factors in ISS performance since most data thefts and ISS threats are caused by workers.

CSOs highlight the significance of ISS administration and examine security concerns from both a business and a technological vantage point to better align ISS with the rest of the company and IT. CSOs that practice relational leadership are more likely to achieve organizational success by fostering harmony among business and IT executives.

The Chief Security Officer (CSO) and company leaders may discuss both company and technological concerns via the exchange of information in individual conversations, group gatherings, and project briefings. Strong, trustworthy connections inside and outside of the group's limits are the foundation of social wealth, which may increase the group's efficiency. There is a correlation between relational leadership and increased social influence, and more social capital in the workplace leads to increased social congruence.

2.2 Social Knowledge

Social interactions and institutional knowledge are two examples of intangible goods and services that are gaining prominence in today's knowledge-based economy. According to social capital theory, a company should be seen as "a social group specializing in its rapidity and effectiveness in the generation and transfer of information." Social capital, which is the total of the assets entrenched in, accessible via, and generated from a person's social connections, is seen as a resource for activity and information transmission among members of an organization. Social capital has several forms, including fundamental, mental, and relational, according to Nahapiet and Ghoshal.

The structural scale, as defined by Nahapiet and Ghoshal [30], is the general pattern of interconnections among persons. This includes both the number of people you can contact and the methods you can use to do so. There may be interpersonal routes for the transfer of information if there are coworkers (i.e., network relationships) who permit to use of materials within an organization. The cognitive component consists of people's common understandings, beliefs, and ways of looking at the world. Building a foundation of mutual understanding is crucial in every kind of social interaction. Trust, credibility, and social standards are all aspects of interpersonal connections that the aspect of relationships examines. It is difficult to get integrated information if people are hesitant to trust one another in social interaction.

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Aligning business and IT leaders emphasize their cross-domain interconnection, which is central to the social capital theory and hence essential to the development of integrated knowledge. The three relationship-driven components of social alignment are called connections and include fundamental, intellectual, and interpersonal alignments. Having regular direct interaction and multidisciplinary teamwork on projects may help business, and IT leaders better understand one another, as seen by the network architecture observed in presentations and project videoconferencing. How well business and IT leaders understand one other's jargon, terminology, and worldviews constitutes the "cognitive connection."

Business and IT leaders may be able to communicate more effectively with one another if they adopt a common lexicon and build shared storylines. The connectedness of the connections highlights their unique characteristics, like trust and dependability. People in the company and IT departments are more likely to work together if they trust one another and vice versa. The integration of information is more likely to be effective if people are inspired to take part in it. Collective trust is fostered over time via trust and collaboration, which may encourage involvement and lead to consolidated understanding.

Leaders in both the company and IT sectors must continually work on their social alignment, which includes activities such as information exchange and incorporation. For "IT and business leaders to be able to get involved in the other's primary procedures and to appreciate each other's distinctive contributions and difficulties," it is necessary for them to have a common understanding of each other's fields.

Integrative information is the outcome of individuals interacting and combining their existing bodies of information to produce novel insights. The goal of social alignment is to create a shared language that facilitates successful interaction and may even serve as a catalyst for interdisciplinary learning. The demands of a company are reflected in the approaches of ISS, which adapt to the marketplace and surroundings. Misalignment may arise when a functional unit adjusts, but the IT unit does not. When business and IT leaders aren't on the same page, it may be detrimental to the company's progress.

2.3 Information Security Policy

One way to define organizational efficiency in a corporate environment is via the attainment of goals or the production of output. Similarly, ISS's success is measured by how well the program protects sensitive company data and how well it accomplishes its stated aims. The efficacy of an ISS is measured by how well it can protect an organization from internal as well as external dangers.

Organizational variables like instruction for users and safety policy enforcement; technological variables like software and hardware instruments; and mixed variables like the number of hours per week dedicated to ISS danger mitigation and deterrence as well as a commitment to information safety are the three categories of factors that have been utilized for assessing ISS efficiency. Previous studies on the efficacy of ISS have often only looked at one facet of an overall strategy. For the sake of this investigation, we assume that technological, organizational, and other measures taken to lessen both internal and external risks work together to make ISS successful.

Remember that the efficacy of ISS is measured by how well it prevents data breaches caused by accidental or malicious human action. To be successful, an ISS plan must stress the significance of both the technology and the socio-organizational setting. Successful ISS implementation may be attained, for instance, via the use of formal organizational frameworks that specify making choices, authority, and responsibilities.

If executives from IT and businesses in an organization have an established system, they may better communicate with one another, share information, and collaborate on projects. Efficient ISS administration may be facilitated by coordinated activities established via interaction and knowledge sharing. Therefore, the more interconnected an organization's information is, the greater its potential to investigate and implement measures to avoid security lapses.

As stated previously, it has been found that successful ISS using scientific and organizational methods positively influences the general success of organizations, while inefficient ISS causes organizations to incur economic and negative publicity, which in turn severely affects their organizational effectiveness and market value. Based on past research, we predict a favorable correlation between ISS efficiency and the efficacy of government agencies' organizational results.

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2.4 Technical Information

Safety, including infrastructure and entry oversight, is only one aspect of safety that the CSO is responsible for overseeing. Because of the complexity of the conversations, concerns, challenges, and disagreements that may arise with different customers, CSOs need to have a deep awareness of not just the technical aspects of IT (such as architecture and apps) but also of the business area, the law, and management.

3. Research Methodology

The proposed method is based on combining the crispness of the MULTIMOORA method given by Brauers and Zavadskas [20] with the operational capability of single-valued neutrosophic sets algebra. MULTIMOORA-SVNS is the name of the new system.

The suggested approach begins, like other MCDM techniques, with the building of an assessment matrix.

The decision matrix can be built as:

$$Y = \begin{pmatrix} y_{11} & \cdots & y_{1m} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{nm} \end{pmatrix} \quad (1)$$

Where $n\ and\ m$ refer to the alternatives and criteria

1. Ratio System

1.1 In a ratio system, the normalization matrix is obtained

$$Y^* = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} y_{ij}^2}} \quad (2)$$

1.2. Compute the crisp values

Replace the linguistic terms of SVNS with the single-valued neutrosophic number (SVNN)

1.3. Compute the first objective of the MULTIMOORA method

This step computes the value of the first objective of the MULTIMOORA method as:

$$O_j = \sum_{i=1}^{g} w_i (y_n^*)_{ij} + \left(\sum_{i=g+1}^{g} w_i (y_n^*)_{ij}\right)^c \quad (3)$$

Where g and n-g refer to the positive and negative criteria

1.4 Compute the multiplication by the neutrosophic number

$$\gamma(y_n^*)_1 = \left(1 - (1 - T_{n1})^\gamma, (I_{n1})^\gamma, ((F_{n1})^\gamma)\right) \quad (4)$$

2. Deviation Form

2.1. Compute the reference point for positive and negative criteria

$$\left(\min_j \left(\max_i \left| D\left(p_i - w_i (y_n^*)\right)_{ij} \right| \right)\right) \quad (5)$$

$$p_i = \max_j \left(w_i (y_n^*)_{ij}\right) \quad (6)$$

$$p_i = \min_j \left(w_i (y_n^*)_{ij}\right) \quad (7)$$

2.2 Compute the distance measure of the neutrosophic set

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$$T = \sqrt{\frac{1}{3}((T_{n1} - T_{n1})^2 + (I_{n1} - I_{n1})^2 + (F_{n1} - F_{n1})^2)} \quad (8)$$

3. Full Multiplicative Form

3.1 Compute the full multiplicative from

$$F_j = \frac{Q_j}{R_j} \quad (9)$$

$$Q_j = \prod_{i=1}^{g} w_i (y_n^*)_{ij} \quad (10)$$

$$R_j = \prod_{i=g+1}^{n} w_i (y_n^*)_{ij} \quad (11)$$

4. Case Study

This section provided the case study in hotel size to identify the most important criteria for leadership with IS policy and select the best alternatives. Figure 1 shows the proposed model of this paper. The first part in Figure 1, preprocessing of data, first determines the criteria and alternatives. This study used seven criteria and nine alternatives, as shown in Figure 1. These criteria and alternatives are concerned with leadership and IS policy in the hotel industry. These criteria are collected from previous studies. Then compute the weights of the criteria.

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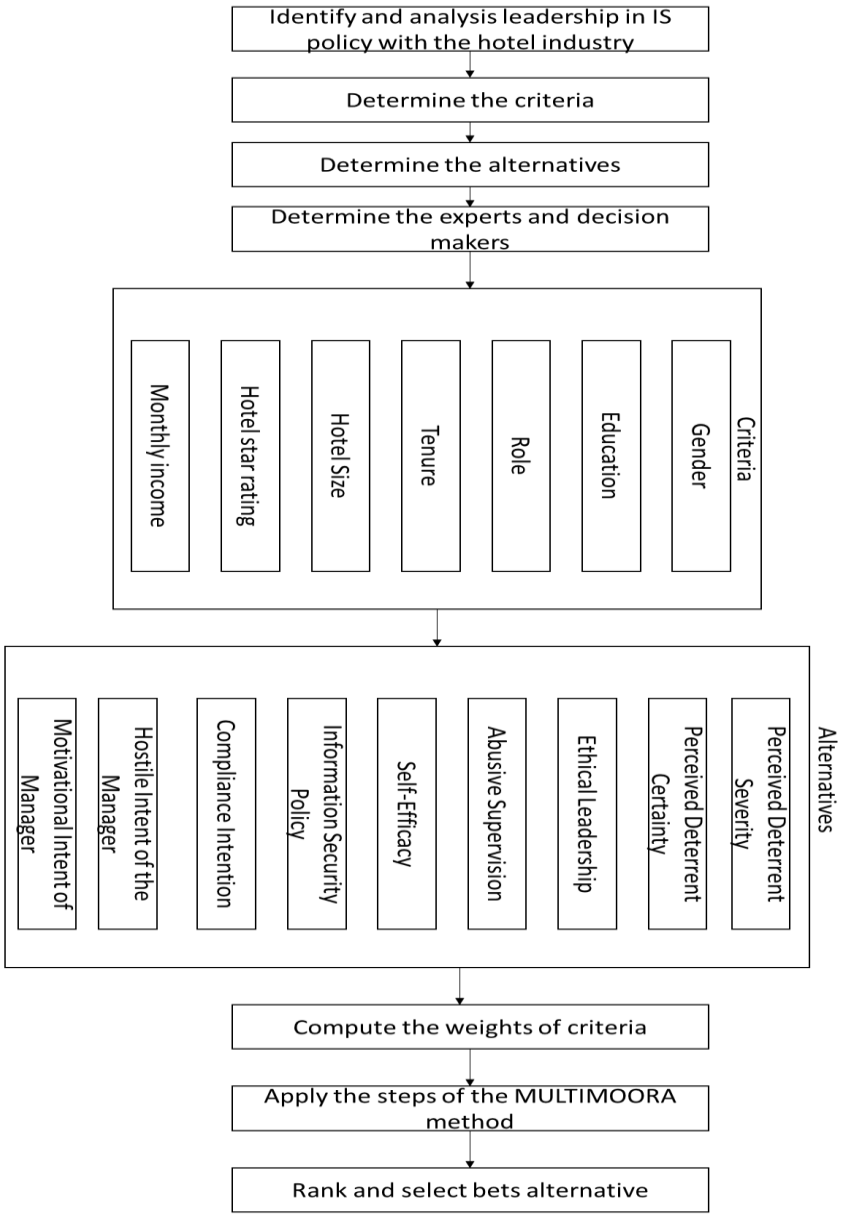

Figure 1: The proposed model of this study.

The weights of the criteria are computed by the average method. Let experts and decision-makers evaluate the criteria, then replace their opinions with single-valued neutrosophic numbers. Then compute the weights of the criteria as shown in Table 1. From Table 1, the fourth criteria is the highest importance, and the sixth criteria is the least important.

Table 1: The importance of gathering factors.

Factors	Importance
$LISF_1$	0.085688
$LISF_2$	0.223903
$LISF_3$	0.044427
$LISF_4$	0.332825
$LISF_5$	0.151236
$LISF_6$	0.044427

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$LISF_7$	0.117494

The third part of the proposed framework applied the N-MULTIMOORA method. This method is a MCDM method used to rank the alternatives. The first step is building the decision matrix by the seven factors and nine alternatives by a set of decision-makers and experts, as shown in Table 2.

Table 2: The values between factors and alternatives.

	$LISF_1$	$LISF_2$	$LISF_3$	$LISF_4$	$LISF_5$	$LISF_6$	$LISF_7$
$LISA_1$	(0.90, 0.10, 0.10)	(0.60, 0.35, 0.40)	(0.10, 0.90, 0.90)	(0.90, 0.10, 0.10)	(0.40, 0.65, 0.60)	(0.10, 0.90, 0.90)	(0.90, 0.10, 0.10)
$LISA_2$	(0.10, 0.90, 0.90)	(0.70, 0.25, 0.30)	(0.30, 0.75, 0.70)	(0.20, 0.85, 0.80)	(0.70, 0.25, 0.30)	(0.20, 0.85, 0.80)	(0.10, 0.90, 0.90)
$LISA_3$	(0.90, 0.10, 0.10)	(0.60, 0.35, 0.40)	(0.90, 0.10, 0.10)	(0.60, 0.35, 0.40)	(0.90, 0.10, 0.10)	(0.10, 0.90, 0.90)	(0.90, 0.10, 0.10)
$LISA_4$	(0.20, 0.85, 0.80)	(0.70, 0.25, 0.30)	(0.40, 0.65, 0.60)	(0.70, 0.25, 0.30)	(0.40, 0.65, 0.60)	(0.20, 0.85, 0.80)	(0.10, 0.90, 0.90)
$LISA_5$	(0.10, 0.90, 0.90)	(0.60, 0.35, 0.40)	(0.40, 0.65, 0.60)	(0.60, 0.35, 0.40)	(0.70, 0.25, 0.30)	(0.90, 0.10, 0.10)	(0.40, 0.65, 0.60)
$LISA_6$	(0.90, 0.10, 0.10)	(0.70, 0.25, 0.30)	(0.60, 0.35, 0.40)	(0.70, 0.25, 0.30)	(0.30, 0.75, 0.70)	(0.10, 0.90, 0.90)	(0.90, 0.10, 0.10)
$LISA_7$	(0.20, 0.85, 0.80)	(0.70, 0.25, 0.30)	(0.90, 0.10, 0.10)	(0.70, 0.25, 0.30)	(0.30, 0.75, 0.70)	(0.90, 0.10, 0.10)	(0.30, 0.75, 0.70)
$LISA_8$	(0.10, 0.90, 0.90)	(0.60, 0.35, 0.40)	(0.30, 0.75, 0.70)	(0.10, 0.90, 0.90)	(0.90, 0.10, 0.10)	(0.20, 0.85, 0.80)	(0.10, 0.90, 0.90)
$LISA_9$	(0.90, 0.10, 0.10)	(0.60, 0.35, 0.40)	(0.90, 0.10, 0.10)	(0.70, 0.25, 0.30)	(0.20, 0.85, 0.80)	(0.90, 0.10, 0.10)	(0.90, 0.10, 0.10)

Then normalize the decision matrix by using Eq. (2), as shown in Table 3. Then replace the logistic terms with the SVNNs. Then compute the first objective of the ratio system by using Eq. (3). Then, identify the positive and negative criteria. Then compute the reference point by using Eqs. (5,6, and 7). Then compute the distance between two SVNNs by using Eq. (8). Then, compute the full multiplicative form by using Eq. (9, 10, and 11). Then obtain three ranks by the ratio system, deviation system, and full multiplicative form, as shown in Figure 2. Then apply the dominance strategy to obtain the final rank.

Table 3: The normalization decision matrix

	$LISF_1$	$LISF_2$	$LISF_3$	$LISF_4$	$LISF_5$	$LISF_6$	$LISF_7$
$LISA_1$	0.203362381	0.103639	0.024256	0.17050777	0.082332	0.031966	0.190515
$LISA_2$	0.027145748	0.120451	0.071608	0.044065728	0.141664	0.06189	0.025431
$LISA_3$	0.203362381	0.103639	0.181714	0.114706681	0.181189	0.031966	0.190515
$LISA_4$	0.052556616	0.120451	0.082571	0.133313244	0.082332	0.06189	0.025431
$LISA_5$	0.027145748	0.103639	0.082571	0.114706681	0.141664	0.239477	0.08657
$LISA_6$	0.203362381	0.120451	0.122245	0.133313244	0.071401	0.031966	0.190515
$LISA_7$	0.052556616	0.120451	0.181714	0.133313244	0.071401	0.239477	0.075077
$LISA_8$	0.027145748	0.103639	0.071608	0.022760163	0.181189	0.06189	0.025431
$LISA_9$	0.203362381	0.103639	0.181714	0.133313244	0.046826	0.239477	0.190515

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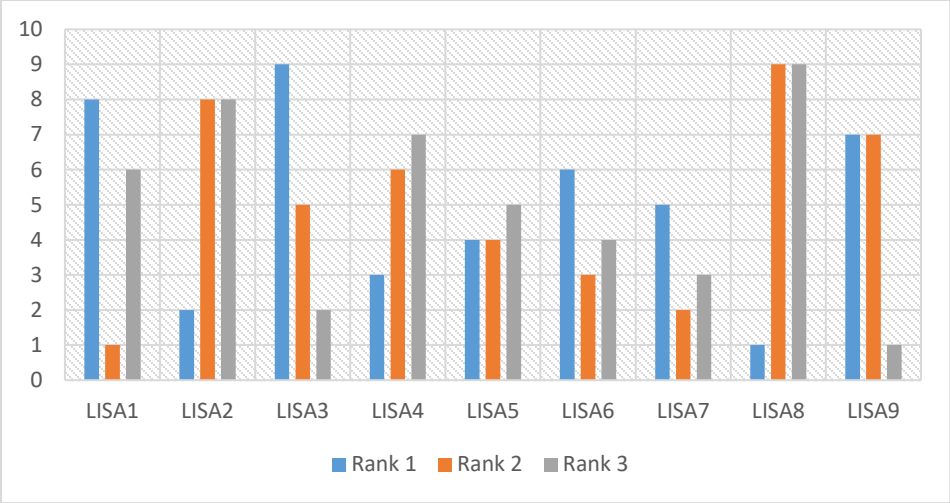

Figure 2: The three ranks of the MULTIMOORA method.

5. Sensitivity Analysis

This section provided a sensitivity analysis of changing the weights of criteria, then ranked the alternatives. This analysis changes the weights of criteria by eight cases. Figure 3 shows the eight cases of changing the weights of criteria. In the first case, we equal all criteria. In the second case, we put the first criterion with 0.2, and all other criteria are equal. In the third case, we put the third criterion with 0.2, and all other criteria are equal. In the fourth case, we put the fourth criterion with 0.2 and all other criteria are equal. In the fifth case, we put the fifth criterion with 0.2 and all other criteria are equal. In the sixth case, we put the sixth criterion with 0.2 and all other criteria are equal. In the seventh case, we put the second criterion with 0.2 and all other criteria are equal. In the second case, we put the seventh criterion with 0.2 and all other criteria are equal. In the eighth case, we put the eighth criterion with 0.2, and all other criteria are equal.

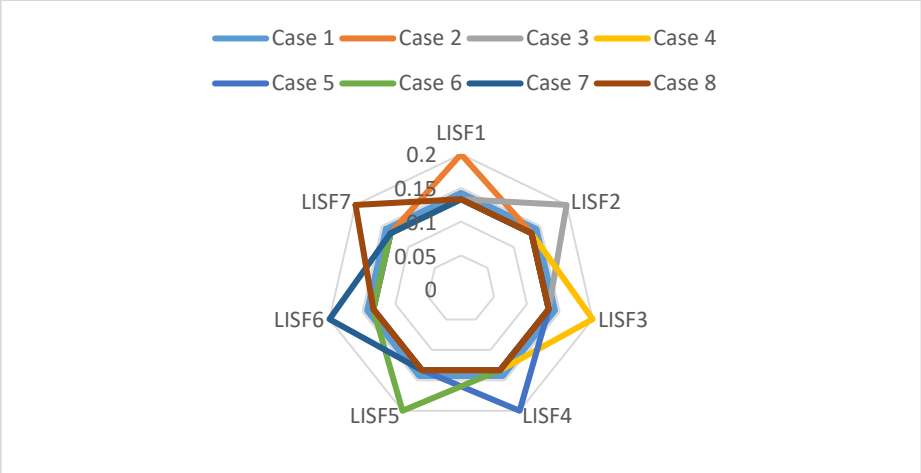

Figure 3: The eight cases in changing the weights of criteria.

Then apply the steps of the neutrosophic method with the eight cases to compute the rank of alternatives. Figure 4 shows the rank of alternatives by the eight cases.

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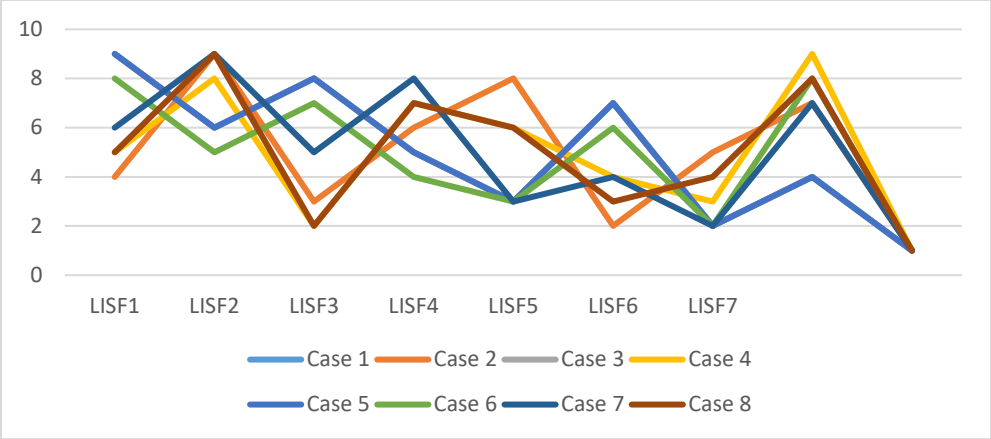

Figure 4: The rank of options by sensitivity analysis.

6. Comparative Analysis

In this section, we compared the proposed method with different MCDM methods to test the robustness of the proposed model. We compared the neutrosophic MULTIMOORA method with different methods like TOPSIS, VIKOR, MABAC, and AHP method. First, we applied the compared method with the same data in this paper. Then compute the rank of the four methods. Figure 5 shows the rank of alternatives by the proposed method and the other four methods. We then applied the correlation coefficient between the proposed and MCDM methods, as shown in Figure 6. The correlation between the proposed method and other MCDM methods is highly strong. The correlation between the proposed method and TOPSIS and VIKOR is the greatest, followed by the MABAC and AHP methods.

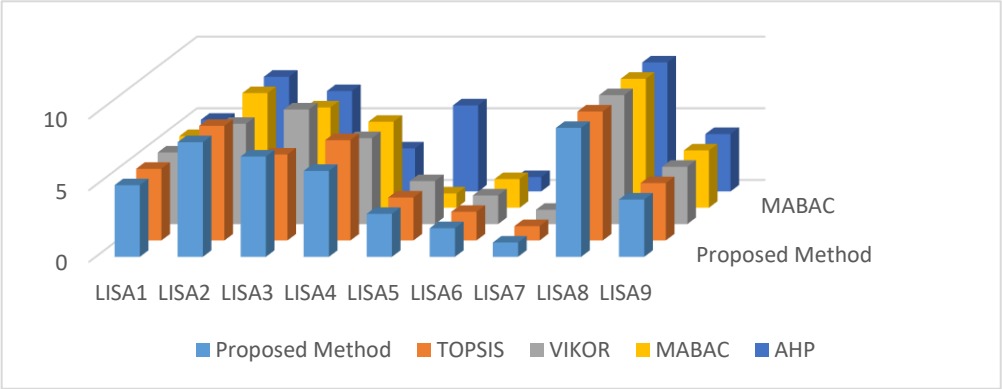

Figure 5: The comparative analysis by other MCDM methods.

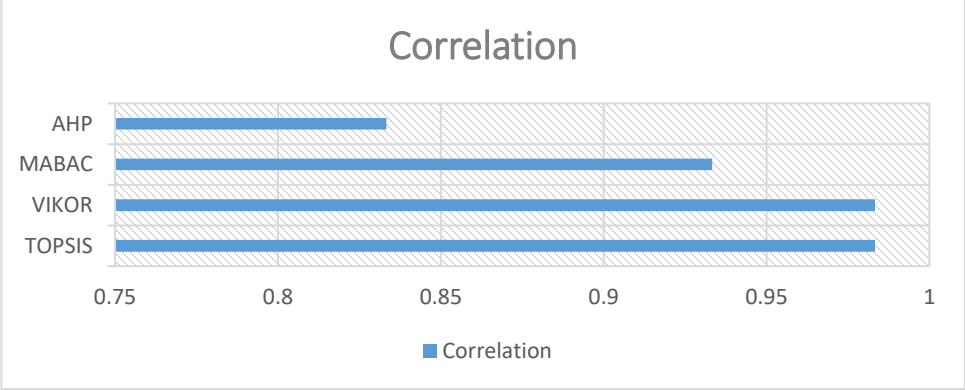

Figure 6: The correlation coefficient between the proposed method and MCDM methods.

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7. Conclusion

Leaders at hotels are keen to learn how they may improve staff adherence to data protection regulations in light of the growing urgency with which this problem must be addressed. In this research, we look at the role that disincentives and management have in shaping workers' intentions to follow a hotel's IS policy. Using the MCDM structure, a suggested approach is developed for choosing criteria and alternatives of leadership and information security policy for hotels. The updated MULTIMOORA-SVNS version of the concise MULTIMOORA approach enables the uncertainty of the first piece of data to be evaluated. This study used seven criteria and nine alternatives. The weights of the criteria are computed by the average method. Then the rank of alternatives is computed by the MULTIMOORA method. This paper applied sensitivity analysis with eight cases in changing the weights of criteria and obtained eight ranks of alternatives. Also, this paper applied comparative analysis with previous methods like TOPSIS, VIKOR, MABAC, and AHP methods, then ranked the alternatives by these methods. The results show the proposed method is robust, and the correlation between the proposed method and other MCDM methods is strong.

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