Use of neutrosophy for the detection of operational risk in corporate financial management for administrative excellence

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Abstract. Operational risk is linked to the financial risks of companies. Financial risks are identified as credit risk, liquidity risk, market risk and operational risk, and they significantly affect the operations and results of entities, particularly those with investments. The measurement of operational risk in a qualitative manner implies probability associated with a potential loss of resources, which are linked to the economic and financial management of the institutions. For an adequate detection of risks, techniques, tools and methods applicable to knowledge must be used, such as Neutrosophy, which is favorable for interpreting knowledge that comes from linguistic terms. For this reason, the objective pursued in this work is to detect the operational risk in corporate financial management, for administrative excellence through the use of Neutrosophy.

Keywords: Financial risk, administrative excellence, business success, decision making, profitability - risk, Neutrosophy.

1 Introduction

Operational risk contributes to the uncertainty boom. Factors contributing to this uncertainty are diversification of activities and complexity of new products, complexity of mergers and acquisitions of products, complexity of new sales channels, large-scale globalization, automation of processes, outsourcing of activities and, above all, constant regulatory changes in institutions [1].

One definition of operational risk that leads to uncertainty was that of [2], which refers to operational risk as a changing, dynamic and complex process in the environment of financial institutions. Characteristics that lead to uncertainty due to its dynamism.

In accordance with the present concern with operational risk and the uncertainty associated with it, there was motivation on the part of the British Banker Association for the emergence of the first risk regulation through internal models. Subsequently, the second consultative document for the new Basel Accord was created, which established a causal definition, risk of loss arising from inadequate or failed internal processes, people or systems or from external events.

This type of risk includes legal risk, but excludes strategic, systematic and reputational risks, as well as the opportunity cost associated with operational failures and indirect losses, due to their difficult quantification. Therefore, it was demonstrated that operational risk is an element that can result from internal (related to errors in processes, systems and people) or external events.

The operational risk to be identified, in an institution, requires two parameters that characterize it and contribute to its quantification, these parameters are:

- Severity or amount of loss
- Frequency or probability

For the detection of operational risk, in corporate financial management for administrative excellence, it is required to treat the category present in it, which is uncertainty. In order to do this, it is necessary to follow a process that begins with the realization of controls, in order to concretize the objectives of risk management and determine the most relevant factors; consequently, initiatives that articulate efforts and responsibilities are required [3]. The characteristics of these controls are dined in a Database, which is useful for the stored results to offer an adequate response on the information needs requested and, in particular, on the probability of present operational risk.

The authors [4], refer that the database for the detection of operational risk should include information about the amount of loss reported, the description of the event that caused the operational risk, the type of event, the business unit to which it corresponds, the date of the loss and the time when it was recorded, the date on which the event ended, management actions taken, recovery (insurance and other mechanisms) and loss estimation adjustments.

Once the data are obtained, risk indicators are designed, defined from the information stored in the Database, in order to reflect the exposure to risks in a specific institution. The combination of these indicators and the rest of the data stored will reveal a risk profile, at the desired extraction level, paying attention to those activities that require greater vigilance. The role of these indicators, in terms of monitoring and control, is fundamental. To this end, they must be combined with control diagrams.

Based on the above, this paper proposes the use of neutrosophy for the detection of operational risk in corporate financial management. For administrative excellence, in particular the neutrosophic logic is used because it allows financial risk analysis with a more structured view of operational risk when the information available is uncertain. Neutrosophic logic provides a rigorous theoretical framework for the treatment of vague, incomplete and subjective information or the treatment of qualitative information, which is a constant in the analysis of financial risks and many real-world problems.

Neutrosophic logic is an extension of Fuzzy logic that was created by Zadeh, as an extension of classical or Boolean logic, to allow the modeling of processes that possess a certain degree of uncertainty. The neutrosophic logic offers a different vision to the one given by the classic logic, it constitutes a tool that allows obtaining numerical values from qualitative variables in most of the financial models, it is defined as a domain integrated by variables associated to a neutrosophic set of values through a function of belonging.[5]

Neutrosophic logic is flexible and tolerant of data imprecision. It is based on natural language and can be constructed from expert knowledge. The elements that form part of a set to a certain degree are called the degree of belonging [6]. Each variable that intervenes as a hypothesis in a rule has a domino associated with it, which can be divided into the number of neutrosophic conjunctions that the expert considers appropriate. All these partitions have a linguistic variable associated with them.[7]

This technique is a multivalued logic, by means of which the notions of human thought and more common in natural processes are considered as frequent, very frequent or infrequent, and can adopt a mathematical formulation.

2 Preliminaries

In this section, we briefly review Neutrosophic Numbers and Neutrosophic Matrix concepts. Afterwards, we shall present relations amongOperational risks and Neutrosophic Cognitive Maps.

2.1 Neutrosophic Number and Neutrosophic Matrix

A statistical neutrosophic number is a number of the following form [8]:

$$N=d+i \quad (1)$$

Where d is the determined part and i is the indeterminate part [9]. For example s: a=1+I if i∈[5,5.4] the number is equivalent to a∈[6,6.4].

A neutrosophic matrix, on the other hand, is a matrix where the elements a = (a_{ij}) have been replaced by elements at ⟨R ∪ I⟩, where ⟨R ∪ I⟩is an intiger neutrosophic ring [10].

A neutrosophic graph is a graph in which at least one arc is a neutrosophic arc [11]. The neutrosophic adjacency matrix. The arcs mean: 0 = no connection between nodes, [0,1] = connection between nodes, I = indeterminate connection (unknown if it is or not). Such notions are not used in fuzzy theory, an example of which is shown below:

$$\begin{matrix} 0 & 0 & I \\ I & 0 & 1 \\ 1 & 0 & 0 \end{matrix}$$

An Special kind of neutrosophic matrix is a neutrosophic cognitve Map. A static analysis on neutrosophic cognitive maps according to[12] gives as initial result a neutrosophic number of the form$(a + bi)$, where I= indetermination). This result requires a process of de-neutrosification, as proposed by Salmerón and Smarandache . In the De-Neutrosification process, indetermination belongs to the interval 0 and 1, which is represented as; $I \in [0,1]$ [13].

2.2 Operational risks and Neutrosophic Cognitive Maps

To determine the operational risks in corporate financial management that often affect administrative excellence, a problem tree is used in this paper, as the technique that facilitates the identification and organization of the main causes and effects of operational risk in financial management. The problem tree is a technique that has as its fundamental logic; that each problem is the effect of the causes that appear below it and, in turn, is the cause of those that are on top, and it reflects the interrelationship between causes and effects.

Then a neutrosophic cognitive map [14] is used to interpret the causes and effects that have the greatest impact on the detection of operational risk in corporate financial management for administrative excellence. Neutrosophic cognitive maps are a generalization of Fuzzy cognitive maps, they are introduced by Axelrod [5], where nodes represent concepts or variables in a determined study area and arcs indicate positive or negative influences, which are considered causal relationships. They have been applied in different areas, especially in decision support and in complex systems analysis according to [6] [7].

For the analysis and detection of the causes and effects of greater incidence in the detection of the operational risk of business financial management, for administrative excellence a documental analysis of the different governing documents in the economic systems was carried out, analyzing the following aspects:

- Inadequate management of assets and liabilities
- Excessive granting of credit
- Misalignment of time limits and fees
- Volatility of captured resources
- Associative instability and capital volatility
- Concentration of catchments
- Exogenous causes
- Market risk

According to the analysis of the aforementioned aspects, the main causes are obtained - effects that cause operational risks in business financial management for administrative excellence, which significantly affect administrative excellence.

3 Case Study

He causes - effects, derived from the problem in question are obtained from the documentary analysis carried out, they are shown in the problem tree in Figure 1.

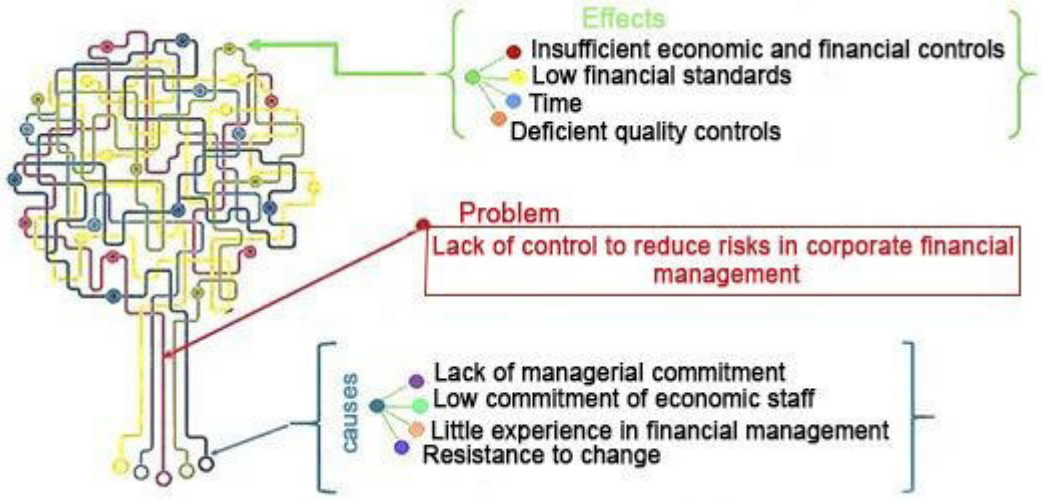

Figure 1: Tree problems of the main causes - effects on the risk of financial management. Source Own preparation.

The main causes - effects in the detection of the operational risk of the business financial management for an administrative excellence, represented in the problem tree highlights as a fundamental problem, the lack of existing control to diminish the operational risk. The causes - effects are presented in linguistic terms, which need to be interpreted.

For the interpretation of the linguistic terms, associated to the causes - effects of the operational risk - effects of the enterprise financial management for an administrative excellence, it is used in the present work the neutrosophic cognitive maps, those that contribute to obtain a greater interpretability of the data, to diminish the uncertainty associated to the operational risks with the purpose of supporting the decision making.

Neutrosophic cognitive maps, as a tool for the modeling of characteristics related to causes - effects on the detection of operational risk of business financial management, for administrative excellence, focus on the selection of concepts that play an important role in the modeling system [15]. This selection is based on the adjacency matrix that takes into account the absolute value of the weights [9].

Indetermination is replaced by maximum and minimum values. Essentially, to perform a static analysis on a neutrosophic cognitive map the steps shown in figure 2 must be followed.

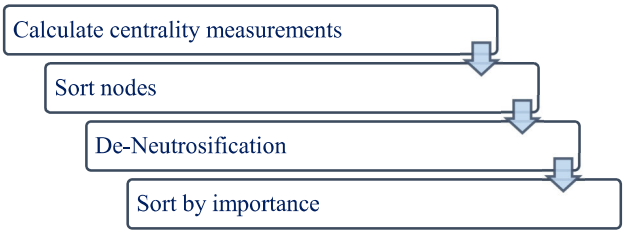

Figure 2: Steps to follow for static analysis in a neutrosophic cognitive map. Source: [13].

The evaluation of the most important causes in the detection of operational risk in corporate financial management, for administrative excellence through a neutrosophic cognitive map, is obtained once the neutrosophic cognitive map is constructed. The neutrosophic adjacency matrix generated is shown in Table 1.

	Cause 1 (lack of managerial commitment)	Cause 2 (low commitment of economic staff)	Cause 3 (little experience in financial management)	Cause 4 (reluctant to change)
Cause 1 (lack of managerial commitment)	0	0	-0.3	0
Cause 2 (low commitment of economic staff)	0	0	0	0
Cause 3 (little experience in financial management)	0	I	0	0
Cause 4 (reluctant to change)	0	0	0	0

Table 1: Neutrosophic adjacency matrix. Source: Own elaboration.

Centrality measurements are calculated through Outdegree and Indegree measurements. The Outdegree calculation is obtained from the sum of the rows in the neutrosophic adjacency matrix. To obtain the Indegree result, the columns are added together in the neutrosophic adjacency matrix. These results reflect the strength of

the outgoing relations of the variables of the rows and columns of the neutrosophic adjacency matrix. The result is shown in Table 2.

Causes	ID	OD
Cause 1 (lack of managerial commitment)	0	0
Cause 2 (low commitment of economic staff)	0	0
Cause 3 (little experience in financial management)	0.3	I
Cause 4 (reluctant to change)	0	0

Table 2: Measures of centrality, Outdegree, Indegree. Source: Prepared by the authors.

Once the centrality of the rows and columns that make up the neutrosophic adjacency matrix is obtained, the total centrality is calculated, which is no more than calculating the sum of the Indegree and the Outdegree of the variable ones. Once the measures of centrality have been calculated, they are classified and incorporated into the neutrosophic cognitive map as nodes, the result shown in Table 3.

	Transmitter Node	Receiving Node	Ordinary
Cause 1 (lack of managerial commitment)			X
Cause 2 (low commitment of economic staff)	X		
Cause 3 (little experience in financial management)	X		
Cause 4 (reluctant to change)			X

Table 3: Classification of the nodes. Source: Own elaboration.

According to the results shown in Table 3, the nodes classified as Cause2 and Cause3 are transmitters and the nodes Cause1 and Cause4 are ordinary nodes. The total centrality is then calculated by adding the obtained Outdegree and Indegree values. The total result, obtained for each node representing the neutrosophic cognitive map, is shown in Table 4.

	Transmitter Node
Cause 1 (lack of managerial commitment)	0
Cause 2 (low commitment of economic staff)	I
Cause 3 (little experience in financial management)	0.3+I
Cause 4 (reluctant to change)	0

Table 4: Total centrality. Source: Own preparation

The next step is the process of de-Neutrosification as Salmeron and Smarandache refer to [12] $I \in [0,1]$ is replaced by maximum and minimum values. Table 5 shows the interval values.

	Td
Cause 1 (lack of managerial commitment)	0
Cause 2 (low commitment of economic staff)	[0,1]
Cause 3	[0.3,1.3]

(little experience in financial management)	
Cause 4 (reluctant to change)	0

Table 5: From - Total nitrification of the total centrality values. Source Own elaboration.

Finally, we work with the mean of the extreme values, which is calculated through equation 5, useful to obtain a single value according to [16]. Value that contributes to the identification of the most incidental causes of operational risk in corporate financial management for administrative excellence.

$$A > B \leftrightarrow {}^{(a_1 + a_2)}/_{2} > {}^{(b_1 + b_2)}/_{2} \quad (2)$$

Then;

$$\lambda([a_1 + a_2]) = {}^{(a_1 + a_2)}/_{2} \quad (3)$$

Based on equation 5, the median of the extreme values is obtained in order to analyze the factors with the greatest incidence with respect to operational risk in corporate financial management for administrative excellence. The results are shown in table 6.

	Td
Cause 1 (lack of managerial commitment)	0
Cause 2 (low commitment of economic staff)	0,5
Cause 3 (little experience in financial management)	0,8
Cause 4 (reluctant to change)	0

Table 1: Median of extreme values. Source Own elaboration.

The most incidental causes of operational risk in business financial management for administrative excellence are:

Cause 3 (little experience in financial management) > Cause 2 (low commitment of economic staff) > Cause 1 (lack of managerial commitment) > Cause 4 (reluctant to change).

The results obtained show that the causes that have the greatest impact on the operational risks of corporate financial management for administrative excellence are those associated with the few experiences in financial management, then the few commitments that have the economic staff of the institutions and then the lack of managerial commitment that leads them to be reluctant to change. The results obtained are in accordance with the incident factors and the central problem shown in the problem tree in Figure 1.

The causes - effects related to the detection of operational risk in business financial management for administrative excellence, made it possible to know the financial impact of the institutions in a general way, which they currently have, obtaining the following results:

a) Identification and evaluation of operational risk in corporate financial management, in order to determine which are the most significant and which are not.

b) The quantification of operational risks in financial management according to the causes - effects shown in figure 1, was based on the financial impact caused in the institutions, which were expressed in monetary terms. This quantification of risks contributed to determine the relative importance of these risks within the financial structure of the institutions, as well as to obtain the necessary information to help improve the combination of economic tools to be used for risk management.

c) To counteract the present problem, action plans were prepared by senior management, which determined the measures to be taken in the face of faults caused by risks in financial management:

- Liquidity in the markets

- Early cancellation of contracts
- Maintenance of unused open lines of financing
- The establishment of an adequate diversification both in terms of terms and sources of funding.
- The establishment of a maximum limit on the total number of open positions

Conclusion

Operational risks in financial management, which have been characterized by a domain of pre-selection, at the level accepted by society, contribute to refer to the main causes - effects that are caused by the environment, technology, human beings, organizations and the political sector. That is why in the present work were identified, through a tree of problems - causes - effects, relative to the lack of control to reduce operational risks. The causes - effects identified were quantified through the use of neutrosophic cognitive maps, which facilitated the measurement of the financial impact of the institutions, in terms of the detection of operational risk, in business financial management for administrative excellence. Future work will concentrate in the development of a software tool to automate the process.

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