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Risks and Operational Research. The new challenges based on the approaches used

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Abstract. One of the concerns in public and private sectors that remains over the time is the timely identification of situations that destabilize the main objectives of organizations. Invariably, the first step in any risk assessment methodology is the identification of the risks and this should be done meticulously. In this paper, we analyze several approaches that have been addressed for the identification or risks arising from the past, the current approaches and the needs for the future. These necessities show the challenges in tools, and methodologies. This paper also presents a methodology of complex systems as an alternative to address the problems of the determination of many factors, the interdependences between them, and the operations research techniques that exist.

Keywords: Risk Identification, Operations Research, Complex Systems.

1. Introduction

Risk management is a common practice in many fields such as industrial, financial, banking, business and construction, to name a few. When organizations are aware of the risks, they can face it by elaborating control plans to use them when required. The management systems consider many factors and tools to obtain knowledge about the risks associated with the enterprise. Because the commercial practices are a core part of every country, the legal requirements have been increasing. For this reason, the administrations must incorporate tools that can meet current needs and get the expected results.

The first step in risk management is Risk Identification, no matter what methodology is in use. This step is the initial point to be able to control or mitigate any unwanted event in organizations. That is why this concept has become robust through the years, and more hard tools have been used. However, there are different methodological approaches that have been addressed over the years using different tools, soft and hard.

This paper presents the approaches and methodologies used and the current needs in Risks framework. The first section establishes the definitions of risks identification, and the elements that have been incorporated in the concepts at present. Then, in the second section, the approaches and methodologies that have been created for Risks Identification are analyzed. We also analyze the literature that exists concerning the context or the environment. As the last section, a methodology of complex systems is explained in order to analyze the advantages that could be applied in the identification of complex systems.

2. Risk Identification

Through the time, the definition of risk identification has been changed, because the requirements of different sectors and areas are more, so the attributes to treat the risks increase. Due to these needs, the definitions of risk and risk identification has been changing across the time.

Risks are events, factors or even challenges that have negative consequences. Risks affect the successful completion of projects in terms of achievements of system products, delivery of products or services, or adverse effects on research, time, cost and quality [1].

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Risk Identification is an important initial step in the process of mitigation and control of risks under conditions of limited available resources [2]. This step is defined as the process of finding, recognizing and describing risks, which involves the identification of risk sources, events, their causes and potential consequences [3,4]. It is one of the key steps in any risk management process, in any area such as supply chains, construction, finance or disaster reduction [2]. Also, implies the determination of which risks can affect the project and the documentation of its characteristics [5]. In addition, it is considered important to make sure that the risk range is also identified because, if this step is not determined, some events may be out of range and not identified as a risk in a timely manner and therefore will not be evaluated or administered. Some authors consider that this step includes examining how a compliance requirement, for example, a prohibition or obligation, can generate a risk [6].

It is very important to focus on how an external or internal variable can cause instability in the system. This means that there may be environmental factors, which could trigger the system to a risk state, changing the system from the environment abruptly.

3. Approaches and methodologies used in Risks Identification

In this section, it is shown the approaches and methodologies used in Risk Identification, the tools used and the future trends.

3.1 Methodologies and Approaches

The quantitative risk assessment approach has not much changed since the early 1980s. Some of its most important limitations are that the whole risk framework cannot be updated and that dynamic assessment approaches are complex [7].

Other proposed approaches are based on risk minimization. This methodology seeks to define a trajectory that describes the behavior of the system. However, it reduces the system to a deterministic path. First, external variables are approximated by deterministic functions. Exponential functions are then used to construct the model and it is as assumed that the data is accurate and repeatable. Although in practice the data are inaccurate and unrepeatable [8].

In addition, in the literature has been proposed a methodology for quantifying the risks and opportunities associated with international projects, using an Analytical Hierarchy Process (AHP) to compare how attractive a decision maker's options [9].

One of the methodologies found with systematic risk approach, is applied in the construction area and focuses on developing a model for project risk assessment. However, these authors establish a step called "risk assessment" after risk identification, which is a bit different from other methodologies. In this paper, it is defined the identification of risks as the exhaustive identification of the sources and causes of the risks. While the risk assessment (which is the second step) consists in the determination of the characteristics of the risks and the establishment of interdependencies. A mathematical model for identifying risks in a discrete time is proposed, and a mathematical simulation is used to know the influence of the risks in different environments of the projects [10].

Frequently within the methodologies are used different types of tools, both soft and hard. However, the disadvantages of soft tools are the vagueness of terms, arbitrariness or lack of transparency to determine the worst scenarios [11].

In addition, an improvement in risk management methodology with an efficient risk identification approach was [11]. The authors proposed to determine the specific inputs in the risk identification step which are, environmental factors of the organization, assets of the organizational process, the scope of the project and the risk management plan. As a result of the identification of risks, a list of known risks, potential response actions, root causes of risks and categories of risks are expected. Also, the tools that this methodology proposes are reviews of documentation, brainstorming, Delphi method, interviews, root cause identifications, SWOT analysis, interventions, influence diagrams, cause diagrams, among other soft techniques. Finally, the scenarios are obtained from the SWOT analysis.

One more approach is named integrated. This approach includes elements of governance, risk and compliance (GRC) in the same management system [6]. What this approach promises to avoid duplicate efforts by taking into account aspects of GRC at the same time. This methodology proposes to analyze the critical activities of the organization and then to detect the failures that can arise in each activity. With brainstorming as a tool, the causes of possible scenarios are detected. There may be two

approaches, one focusing on the requirements and the other on the facts. The first one, focuses on the requirements as a framework determining all the rules of compliance, which means that the goals are linked to the requirements of a document and not to government or client while the second one, seeks the assets [6]).

The structured approach for the risk identification of projects is based on a typology of risks for using in brainstorming technique. The risks obtained are weighted in a matrix by means of linguistic probabilities [13]. The classification of every risk is an interesting contribution that combined with other techniques, could be helpful to identify the risks with either soft or hard tools of operations research.

A proposal for a systemic approach to risk identification has also been published [14], which analyzes the need for methodologies with modeling approaches, requiring multilevel models and multilayer networks using different techniques that meet these requirements.

Current approaches require tools that allow risk identification to be dynamic and continuous [2]. It is a tendency to evaluate risks with a risk-based thinking [15,16, 17, 18]. And the use of the term "dynamic" denotes and additional attribute to know the probabilities of system dynamics [2].

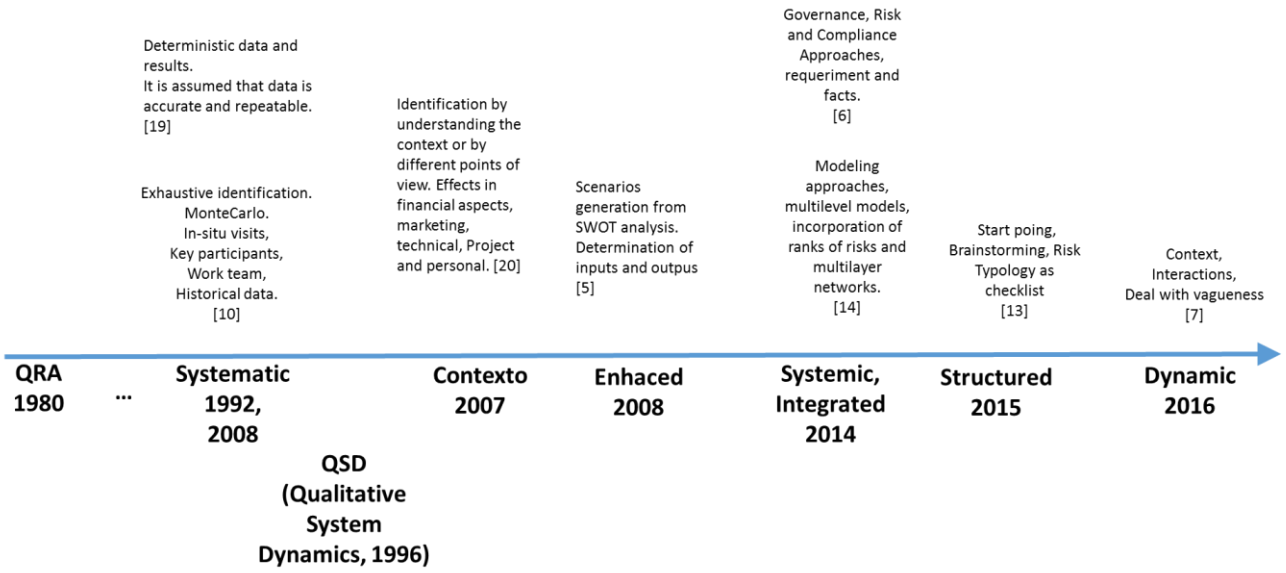

Fig. 1. Evolution of different approaches for Risk Identification.

Risks assessment and identification methods have so far been effective in managing hazards and sources of causes; they have the disadvantage that they have been static. A dynamic approach is a method capable of taking into account new risks and new warnings and systematically updating related risks [21]. Dynamic Risk Management Framework (DRMF) is a methodology, which consists of defining the limits of study and considering early warnings of the system. It also defines the structure and the context of the organization. The hazards related to the process, as equipment or substances used are then identified. So, the users of this methodology can get scenarios of potential accidents, where the risks are. This first part includes the definition of the system and the obtaining of the scenarios is done with the Bow-Tie method, where the critical events are identified [21].

Actually, the challenges in risk management methodologies are the dealing with complexity, uncertainty and ambiguity. Complexity refers to the difficult task of identifying and quantifying causal links between a multitude of potential risks and specific adverse effects. This difficulty is due to interactive effects, such as synergism and antagonism, long delay periods between cause and effect, individual variations, intervening variables and others. It seems prudent to include additional uncertainty components in procedures of risk management. High complexity and uncertainty favor the emergence of ambiguity [22].

There is a connection between the generation of scenarios and the underlying dynamics of the system since future behavior can be predicted [23]. The states that are obtained as output from the system can be a consequence of the initial conditions along with the mechanisms of the operations of the organization that are affected by any exogenous input of the system [2]. The structures and the process of the systems are complex and usually multiscale in nature and difficult to analyze through the average approach as commonly done [24].

The incorporation of the dynamic approach has application in different aspects that are inherent in industrial processes such as accident modeling and its consequences, process design, implementation of safety systems, systems control, asset integrity and maintenance planning, internal and external factors [7]. Currently, risk assessment and risk identification continues to be developed, combining both hard and soft tools of operations research that allow real time results or broad systems knowledge to be able to perform in the best way.

3.2 Trends of context.

Another key trend point is the environment and the context in which the system under analysis is developed. In general, the environment is complex and in addition, it presents complex interactions between its elements. This can be seen from a complex dynamic system where the whole is more than the sum of its parts [20]. Risks must also be identified from different contexts or points of view. Over the years, multidisciplinary groups have been assembled to meet this objective. Although not exhaustive, it has sought to involve both, personnel from different areas and different levels of the organization as it has different points of view. However, it is necessary to introduce tools that consider different contexts and their interrelations. The strategic part seeks to identify the effects on finance, staff development, customer and business processes with a balanced scorecard [25]. One of the tools that have been used to manage contexts is to analyze an organization from its business, financial, market, technical, project and personnel context [26] and finally interrelate them to each other [27].

3.2 Methods used in methodologies.

Until now, the most common methods used in some methodologies are mathematical programming, probability and statistics, simulation, decision theory, queuing theory, fuzzy sets, stochastic programming, Markov chains, bow-tie analysis and Monte Carlo simulation, and some variations of the previous methods [2]. Monte Carlo simulation has been used to generate the cumulative density function of some projects. Soft methods use brainstorming, although is considered relative mild for the context of compliance because it involves a group of experts from different disciplines [6]. The method called Qualitative System Dynamics (QSD) [28], which is a documented and extensive technique that includes the development of influence diagrams to structure the simulation model. Which is a very useful tool to generate knowledge of the system, however not all variables can be defined numerically. Same situation with causal diagrams. However, these tools generate insights of the system.

4. Complex systems approach

With previous information, it is easy to note the challenges and trends in all related to risk management, including every single step as risk identification. So, this part presents a theoretical alternative for dealing with uncertainty, ambiguity and complexity.

Complexity science is the study of systems with many interdependent components, which, in turn, may interact through many different channels. Most complex systems include multiple subsystems and layers of connectivity, and they are often open value-laden, directed, multilevel, multicomponent, reconfigurable systems of systems, and placed within unstable and changing environments. They evolve, adapt and transform through internal and external dynamic interactions affecting the subsystems and components at both local and global scale [29]. When a complex system is changed, its system parameters, stability, and dynamics may be affected. Everything depends on the interactions of the system elements. Unsuitable interactions can cause that system behaves dynamically unstable or that it gets trapped in a suboptimal state [30].

For those systems that include systemic risks, it is essential to identify the elements, which can trigger unexpected large-scale changes, and the literature recommends taking into account that systemic risks are mostly based on cascade spreading effects in networks. In the past decades, a variety of scientific techniques has been developed to address these challenges [30]. These include:

- Large-scale data mining,
- Network analysis,

- System dynamics,
- Scenario modeling,
- Sensitivity analysis,
- Non-equilibrium statistical physics,
- Non-linear dynamics and chaos theory,
- Systems theory and cybernetics,
- Catastrophe theory,
- The statistics of extreme events,
- The theory of critical phenomena and,
- Agent-based modeling.

In sum, if the complexity is considered as the valuable probability of the systems it is possible to establish models that allow us to quantify it [35]. So, the following models could function as a tool [35]:

a. Ashby´s Model of Cybernetic Variety
b. The model of the statistical measurement of the complexity or thermodynamic
c. The network complexity model
d. The model of computational complexity

These models allow an evaluation of the complexity of the system. This finding is what has led to contemporary epistemological research to renew the modes of representation of complexity from the observation that the complexity of a system changes [35].

There is an additional form related to the sudden shifts and irreversible movements and dynamics that are studied in the complexity sciences. It is the science of networks that allow, to study free scale nets, phenomena of percolation, irruptions and cascades of errors, being all concepts, models and approaches that explain magnificently how the network structure converts a phenomenon, system or dynamics into a complex system [36].

Systems are taking the form of networks, for example social, organizational, and business networks that relate companies. Typical network studies in sociology involve the circulation of questionnaires, asking respondents to detail their interactions with others. One can the use the responses to reconstruct a network in which vertices represents individuals and edges the interactions between them [37]. That information is useful to structure the network and then, with complex networks theory the system could be analyzed.

In recent years, however, we have witnessed a substantial new movement in network research, with the focus shifting away from the analysis of single small graphs and the properties of individual vertices or edges within such graphs to consideration of large-scale statistical properties of graphs. When the structure of the system is analyzed, a common question is "What percentage of vertices need to be removed to substantially affect network connectivity in some given way?" and this type of statistical question has real meaning even in every large network. Studies of the effects of structure on system behavior on the other hand are still in their infancy [37].

The most important phenomena in the life of human beings come from the microscopic scale but are reflected on the macroscopic scale [36]. There are theoretical methods and principles of physics that have been applied to analyze behaviors of the systems, and these are scaling and universality. Scaling has two categories of predictions; the first is a set of relations that serve to relate the various critical point characterizing the behavior of functions. The second category is a sort of data collapse. The predictions of the scaling hypothesis are supported by a wide range of experimental work, and by numerous calculations on model systems. Moreover, the general principles of scale invariance used have proved useful in interpreting a number of other phenomena, ranging from elementary particle physics and galaxy structure to finance.

Universality is the second concept. In the study of physical systems, the scaling properties of fluctuations in the output of a system often yield information regarding the underlying processes responsible for the observed macroscopic behavior. Some applications in different economic organizations where founded [38]. With the application of these two principles the relationships between variables can be known, even with a small set of variables a macroscopic behavior can be determined. Then, these universal relations can be inferred for different systems.

The complexity of a phenomenon or system lies precisely in the contents and modes of both, randomness and the uncertainty that the system has. The future or possible futures that the system has or may have increased the complexity of the phenomena at a given time [36].

Then, new methodologies and approaches in complexity emerge that become perfectly necessary. The generic title in which various methodologies are synthesized is the simulation [31]. Thus, complex systems can and should be simulated, it has to be considered the computational sciences, the tools, and the computing approaches [36] .The use of modeling and simulation is essential, since the science of complexity deal rather with realities with possibilities. Modeling and simulation do not simple play a representative role. The heuristics and metaheuristics methods explore models, solution spaces, dimensions and crosses between them [39].

Every technique is used depending on the system features and help to treat the complexity and uncertainty of the system. In the next part, some key elements of one methodology that exist are explained. This methodology has been used in social systems and recently is the base to propose a risk identification methodology.

4.1 Bases of a methodology of complex systems.

The study of a complex system involves introducing the notions of totality, hierarchy, self-organization, emergence and analyzing the phenomena that occur in it as derivatives of properties that arise in the whole but which are not manifest in the parts [31].

Knowledge is the construction, on the part of the subject that knows, of a conceptual representation of the object or process that is known, so that this representation is an adequate reflection of reality with a view to the solution of a problem. This process of constructing a conceptual model of reality based on perceptual experiences constitutes an epistemological process [32]. This process is aided by an instrument, which is the paradigm, and allows to interpret this reality from a world view [33]. One of the paradigms developed in recent years is that of complex systems. Through it, a portion of reality under study is conceptualized as a complex system, while the rest of the reality that includes or is influenced by the system is defined as the environment or environment of the system [32].

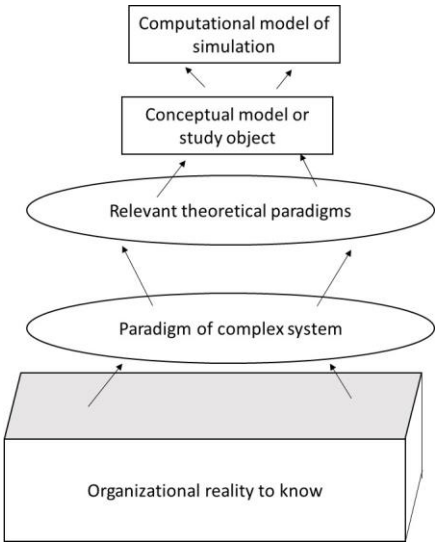

Fig. 2. Methodological scheme for the construction of the study object.

An organization is a complex adaptive system of social character, made up of human agents as basic members, who are interrelated through communication that fulfill different functions in an appropriate structure of division of labor, to arise the mission and objectives that have, both the organization and its members. The organization has properties, whose values depend on its history and define its present state, as well as how to transform a set of inputs and stimuli from the environment into responses and behaviors. These properties constitute their state variables and result from the process of interaction between the members of the system, called systemic composition. Organizations are open systems, because they require and are in active

interaction with a complex environment. In this process of interaction, an organization changes state over time and the states it adopts are the product of two factors: the internal dynamics of the organization and the intervention of exogenous actions and events that comes from its environment altering in a predictable way or unpredictable the state of the organization [32].

So, in this way this methodology considers the environment, the interactions and the system dynamics of the system. The study object is constructed based on the characteristics of the system and its environment. The figure 2 shows a general scheme with five key elements. The reality to know is the starting point, seen as the problematic that contains all the elements of the punctual problem. This reality has the trends, the necessities, and the available items in the present time for the problem. Once the reality is determined (or a part of reality) is necessary to establish the specific problem to be addressed, for example the problem could be the ignorance of different risk scenarios of an organization. In this part, is important to know the objectives of the system (the organization), the critical elements, the interactions between those elements and the environment, using synthetic microanalysis and recomposition as tools of system complex paradigm. This step is very important for studying how the system works and which elements are relevant from the environment. Complexity management requires decomposition and recomposition of systems. The black box approach allows that all that can be said of a system will be extracted from the information that is collected of the changes of states observed at the exit, according to the stimuli delivered to the input [35]. This is complemented by other theoretical techniques(next paradigm) as multilayer networks, simulation, mathematical tools and other theories. As soon as every part of the system, and the environment are not only identified but interrelated the study object is built. Note that both paradigms, are the way for constructing the study object. When the study object is established, it is easier to propose a simulation model where different methods can be used.

In the analysis of the internal dynamics of a system must always be considered the evolution of the organization. For the analysis of an organization, a teleological or intentional point of view must be taken to consider both, the influence of causal and teleological and anticipatory mechanisms in the behavior of the system and its members. In this analysis, the interactions between different hierarchical levels cannot be ignored, neither interactions between different aspects of the environment can be isolated. In this process, must intervene several areas of knowledge [32], and different tools as complex networks, simulation techniques, game theory, among other.

This methodology caught special attention because is very meticulous on how to establish the study object. And remembering that complexity is a big challenge in risk management, it is an option to deal with it. Besides, the uncertainty and the ambiguity can be incorporated using appropriate techniques throughout the established steps.

5. Conclusions and Future work

The methodological analysis related to the identification of risks allowed us to know the challenges of risk identification, mainly the necessity to incorporate the dynamics of the system to the models and tools used. In this sense, it is possible to propose the use of the methodology of complex system as an alternative for risk identification, because this let us to deal with complexity, uncertainty and ambiguity using different techniques. Moreover, it also considers the objectives of the system, the environment, the critical elements and the interrelationships.

There is a lot of work to do about the elaboration of methodologies. In particular the analysis of the results of the applications; since the feedback is important to improve the techniques. Furthermore, the methods are a core part of the methodologies, because they are the way to transform the data into system results. The right selection must be consciousness and is not only important the skills of the manager or risk administrator but also the complexity of the organization or the system. Finally, another important issue is to establish the concepts, the theories and paradigms with the researcher is going to work or wants to improve.

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