The science of decision
La ciencia de la decisión

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Abstract

People and activities, they carry out in daily life are subject to constant decision-making, the consequences of which are largely uncertain. This decision-making involves a rational process that is based on the quantity and quality of the information, the processing capacity and the use of the rationality of people, which allows facing scenarios in the short, medium and long term. In the current context, the difficulties in the development of this process are greater, due to the abundance of data, the doubt of its veracity and the speed of exchange, so that scenarios of chaos and uncertainty are generated. Under this dynamic, forecasting and prediction can be less effective, offer less certainty about the result and, at the same time, produce biases in the information. These predictive problems are observable, for example, in the estimation of economic growth, human behavior, stock markets, natural phenomena, conflicts, migration, the spread of diseases, geopolitics, negotiations, among others. These difficulties are caused, in large part, by the techniques or tools used for data processing and by the processing capacity of the information systems, which have limitations for the combination of different types of information. In this sense, the scientific community has endeavored to propose new methods and develop better techniques that allow capturing and processing the greatest amount of useful information in the decision-making process. This is known as decision science; a broad and transversal term to a large number of areas and fields of study, ranging from the human and social sciences to the pure sciences. Thus, this paper will focus on those areas that are dedicated to proposing methods and techniques that allow improvements and applications to be made in the aggregation and treatment of data for decision-making.

Keywords: decision-making; evolution of decision science; data processing; binary methods; non-binary methods.

Resumen

Las personas y las actividades que desarrollan en la cotidianidad están sujetas a una toma de decisiones constante, cuyas consecuencias, en gran parte, son inciertas. Esta toma de decisiones conlleva un proceso racional que se sustenta en la cantidad y calidad de la información, la capacidad de procesamiento y el uso de la racionalidad de las personas, lo cual permite afrontar escenarios a corto, mediano y largo plazo. En el contexto actual, las dificultades en el desarrollo de este proceso son mayores, debido a la abundancia de datos, la duda de su veracidad y la velocidad de intercambio, por lo que se generan escenarios de caos e incertidumbre. Bajo esta dinámica, la elaboración de pronósticos y predicciones puede ser menos efectiva, ofrecer menos seguridad sobre el resultado y, a la vez, producir sesgos en la información. Estos problemas predictivos son observables, por ejemplo, en la estimación del crecimiento económico, el comportamiento humano, los mercados bursátiles, los fenómenos naturales, los conflictos, la migración, la propagación de enfermedades, la geopolítica, las negociaciones, entre otros. Estas dificultades se dan, en gran parte, por las técnicas o herramientas usadas para el tratamiento de los datos y por la capacidad de procesamiento que tienen los sistemas de información, los cuales tienen limitaciones para la combinación de diferentes tipos de información. En ese sentido, la comunidad científica se ha esforzado por proponer nuevos métodos y desarrollar mejores técnicas que permitan capturar y procesar la mayor cantidad de información útil en el proceso de toma de decisiones. Esto se conoce como ciencia de la decisión; un término amplio y transversal a gran cantidad de áreas y campos de estudio, que va desde las ciencias humanas y sociales hasta las ciencias puras. Así, este escrito se enfocará en aquellas áreas que se dedican a la proposición de métodos y técnicas que permiten hacer mejoras y aplicaciones en la agregación y tratamiento de los datos para la toma de decisiones.

Palabras clave: toma de decisiones; evolución de la ciencia de la decisión; procesamiento de los datos; métodos binarios; métodos no binarios.

ISSN Printed: 1657 - 4583, ISSN Online: 2145 - 8456, **CC BY-ND 4.0**
How to cite: F. Blanco-Mesa, "The science of decision," *Rev. UIS Ing.*, vol. 19, no. 2, pp. I-V, 2020. doi: 10.18273/revuin.v19n2-2020020

Decision science has its foundations in George Boole's Laws of Thought (1835), in which a logical treatment of thought is formulated through binary rules, where a proposition cannot be both true and false, but "always" is true or false, that is, it is possible to express the reasoning with 0 and 1 [1], [2]. Under this logic, statistical instruments have been developed for the treatment of decision-making, which has been very effective and useful, since they offer a powerful capacity for measuring information; These include Bayesian networks, cooperative decision making involving multiple interacting agents; utility theory as a framework for understanding optimal decision making; the graphic model that captures the probabilistic relationships between the variables; Markov decision processes as a method to model sequential problems, among others [3]. However, it is emphasized that thinking and rationality are not binary, and are key factors in the decision-making process.

A first approach to non-binary thinking was proposed by Jan Lukasiewicz (1878-1956) [4] in the trivalent system, in which he states that the propositions are neither true nor false, but indeterminate. Thus, the "valence principle" is enunciated, which affirms that each proposition has a truth value. Based on this idea, Lofti Zadeh (1965) [5] proposes the concept of fuzzy subset, in which each element of the subset has different degrees of belonging, represented with values between 0 and 1; Also, it includes in its studies the notions of inclusion, union, intersection, complement, relationship, convexity, etc. Thus, the theory of fuzzy subsets is proposed and allows capturing perception, reasoning, logic and human semantics in simple methods to understand and use. Therefore, under this approach, the meaning of the information is given more importance than its measurement [6]. Based on this, new hybrid methods have been proposed that complement statistical and probabilistic tools in multicriteria, multiple attribute and multiple objective decision making [6], [7].

Under these two perspectives, research in decision science indexed in the Web of Science (WoS) has had a significant evolution from 1975[1] to 2019 (see figure 1). It is observed that, of the 13,101 publications made, 401 are located in Latin America and 43 in Colombia. Likewise, it is observed that research in decision science in the country began in 2009, while in Latin America this science has been studied since 1994. Finally, it is notable that the highest level of productivity occurs between the years of 1996 and 2004.

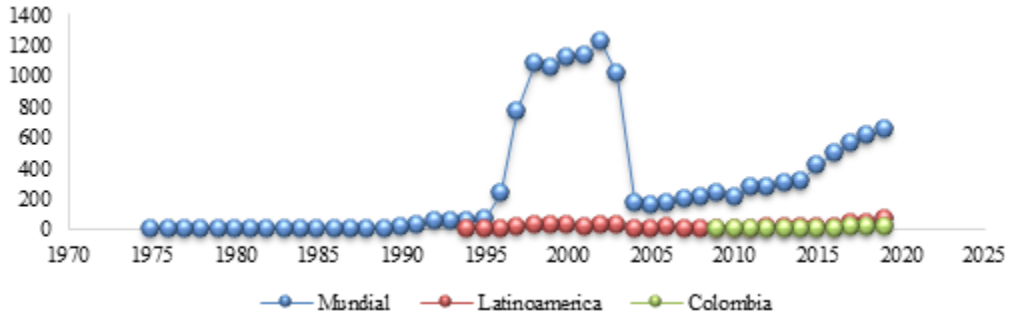

Figure 1. Evolution of decision science. Source: own elaboration based on data from the Web of Science.

Similarly, it should be noted that according to the level of productivity in each of the countries, the United States concentrates 37.5% of the publications made, followed distantly by the United Kingdom with 9.7%. The first Latin American country to appear on the list is Brazil with 1.36% of the publications (see figure 2). Other Latin American countries who have been actively working in decision science are Chile with 0.49%, Mexico with 0.48%, Colombia with 0.33% and Argentina with 0.23%, which represents 2.89% of world publications, this value is close to Taiwan's scientific production. In this sense, it can be said that these five countries promote research in decision science and that their leader, by level of productivity, is Brazil. Therefore, it is observed that studies in decision science have been carried out for a considerable time and that Latin American countries, especially Colombia, have recently ventured, thus contributing to the development of this field of research.

[1] Los datos fueron filtrados por las áreas de investigación Business Economics, Computer Science, Engineering, Operation Research Management Science, Mathematics, y se obtuvieron 14.235 resultados. Con base en estos datos, se aplicó otro filtro por las categorías de la WoS Operations Research Management Science Or Economics Or Computer Science Interdisciplinary Applications Or Computer Science Artificial Intelligence Or Computer Science Information Systems Or Engineering Industrial Or Computer Science Cybernetics Or Business Or Engineering Geological Or Environmental Sciences Or Engineering Electrical Electronic Or Computer Science Theory Methods Or Engineering Ocean Or Engineering Environmental Or Mathematics Applied Or Engineering Aerospace Or Statistics Probability Or Engineering Petroleum Or Engineering Manufacturing Or Engineering Civil Or Engineering Multidisciplinary Or Engineering Mechanical Or Mathematics Interdisciplinary Applications Or Business Finance Or Mathematics Or Engineering Biomedical Or Engineering Chemical Or Engineering Marine, y, finalmente, se obtuvo una muestra de 13.101.

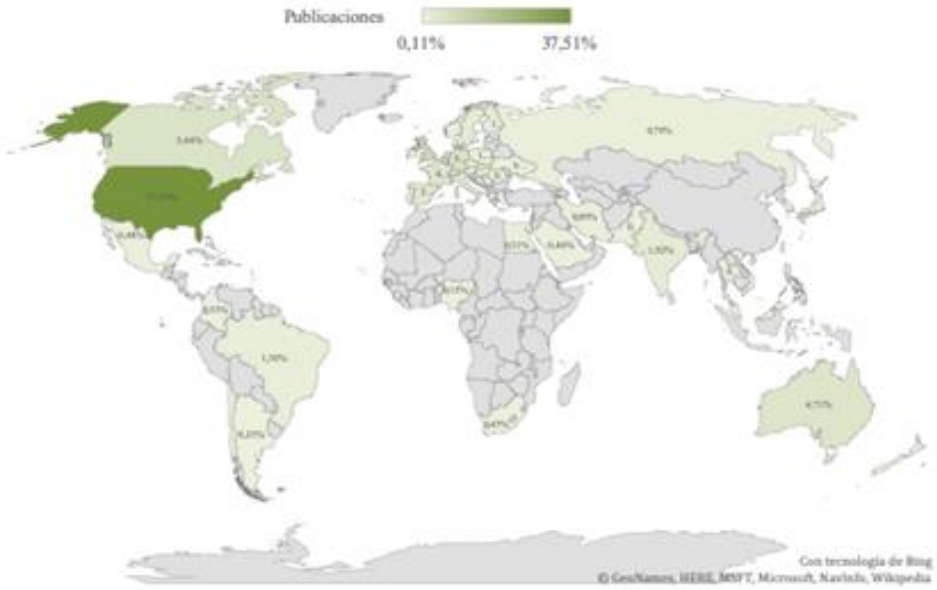

Figure 2. Percentage of publications by country.

Other aspects to highlight are the research areas on which advances in decision science are developed. It is observed that worldwide the highest percentage of research is done in Business Economics; in Latin America, in Engineering and, very close in score, in Business Economics; and in Colombia, they are focused on the Engineering area. Understandably, the largest number of investigations are oriented towards the areas of economics and business, since in these activities the direct action of people in decision-making processes makes it more complex to deal with aspects that include hard data (economic data). , time series, big data) and soft data (reasoning, subjectivity, attitude, and logic). These studies delve into the decision-making process and look for applications and solutions to problems specific to these areas.

Second, computer science and engineering develop multiple applications for data processing, generating solutions to integration problems, and aggregating data for more reliable results and information. Thus, it can solve real problems and contributing to the improvement of the decision-making process. To end this approach to decision science, it is pertinent to know what topics the researchers focus on and how they are related. For this, the bibliometric analysis tool VOSviewer [8], [9] is used, which allows establishing co-occurrence, co-citation and bibliographic coupling. In this sense, a co-occurrence analysis of the authors' keywords is made, which helps us to have an orientation of the topics on which the research focuses (see figure 4).

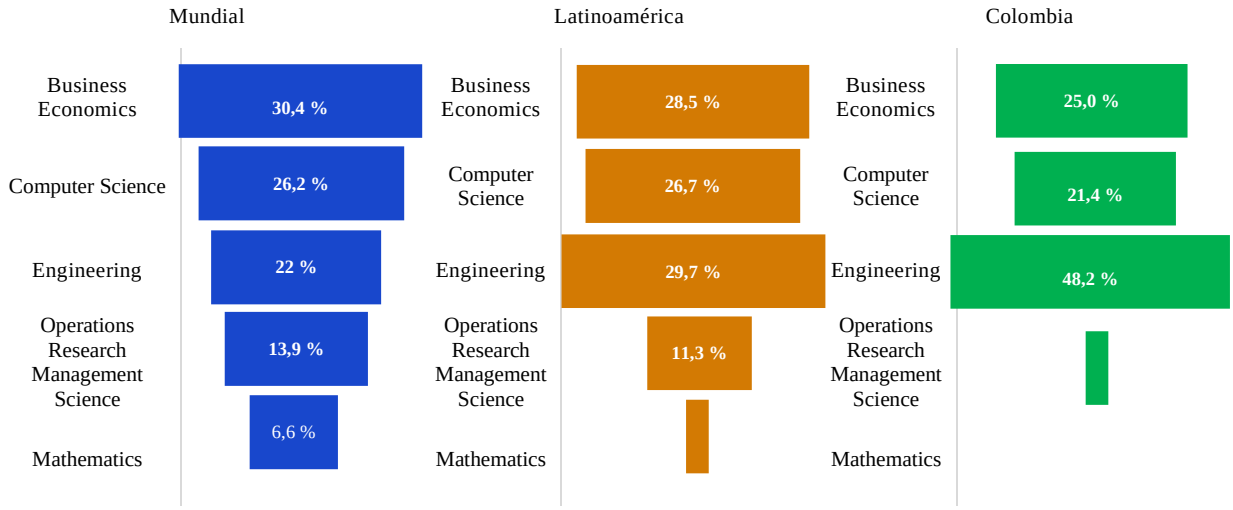

Figure 3. Research areas of decision science. Source: own elaboration based on WoS data.

In figure 4 two strongly related nodes stand out. The first is identified in green and highlights machine learning, big data, data mining, and decision support systems. These studies focus on big data processing, to find patterns within the chaos of existing information. It is one of the areas that has the most applications, both in academia and in productive sectors. The second node, identified with red color, contains uncertainty, artificial intelligence, project management, optimization, and decision support system. These studies show us two different approaches. On the one hand, artificial intelligence and uncertainty, which have had important theoretical advances, however, their applications are still scarce and incipient; These studies are supported by diffuse and hybrid methods, to simulate human behavior. On the other hand, project management and optimization are applications for decision-making support, which can have real use in the short and medium-term. The other nodes are derived from these two, of which text mining, bibliometric studies, simulations, and information processing stand out. Finally, decision-making as a general term appears twice and is taken together to demonstrate the application of tools that improve the decision-making process.

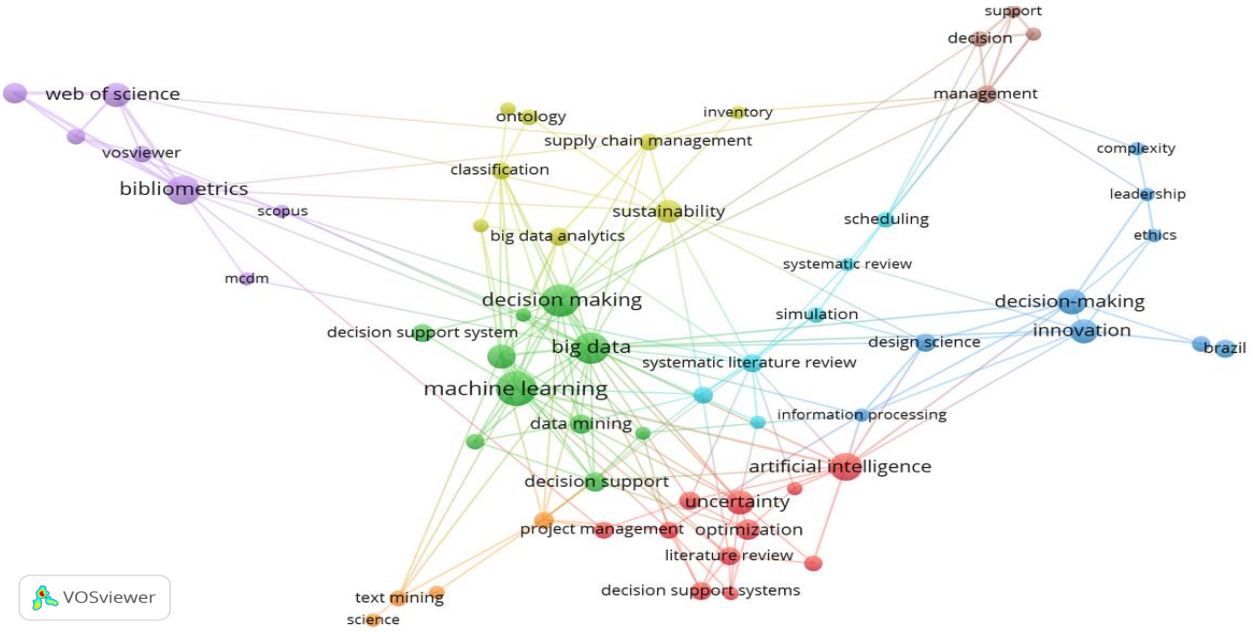

Figure 4. Selfoccurrence of authors' keywords. Source: own elaboration with VOSviewer.

In conclusion, it was evident that research in decision science has had a great development and evolution worldwide. The incursion of Latin America in this field of research stands out, and, likewise, of Colombia, although at a late age compared to other nations. In Colombia, research in decision science is still incipient, however, there is much potential to develop it despite the minimal investment in science and technology. Likewise, it was shown in which areas research in decision science is developed, and an analysis was made of the themes that is a trend for theoretical development and real applications in decision-making processes. Therefore, it is observed that there are two clear aspects: one oriented from binary methods and the other from non-binary methods (valence), which opens up a very wide possibility of proposing and creating new tools that help to add and process information. more efficiently and improve the decision-making process.

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This letter includes an editorial note for this issue, at the invitation of the editor of the *Revista UIS Ingenierías.*