Fuzzy systems and applications in innovation and sustainability

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1. Evolution of fuzzy systems

One of the main characteristics of humankind is the ability to interpret via natural language incomplete, imprecise, vague, subjective, fragmentary, or scarce information i.e. information in uncertainty and transform it to actions, reason and decision-making [9]. Fuzzy sets theory firstly introduced the treatment of such concepts in 1965 with the foremost influential paper "Fuzzy Sets" [29]. The groundbreaking standpoint of fuzzy systems allows the treatment of uncertain information with the utilization of a strict mathematical framework [8]. Ever since the publication of the pivotal paper from Zadeh, a plethora of contributions have shaped the fuzzy sets theory scope and applications, from developments in engineering, mathematics, computer, decision, life, physical, health, social sciences and humanities [17].

Fuzzy sets theory-oriented solutions have proven to be effective when addressing human-like dynamic systems [20], however, the path to a formal representation of vagueness has been a demanding endeavor. This is particularly observed in the 1950 s as several attempts were made, especially trying to capture and augment logic capabilities' representation, however not fully addressing the main concept [12]. A breakthrough is observed with the introduction of Zadeh's membership function and truth values [30], a notion of gradualness of the proposed Possibility Theory [34]. Nonetheless, classical standpoints compelled critical arguments to these ideas [35]. The skepticism towards the newly introduced fuzzy logic theory strongly decayed with the rapid advancements of information technologies, the capabilities of translating human-like thinking using fuzzy sets, fuzzy relations [31], fuzzy systems [32], fuzzy intervals and approximate reasoning [33], fruitful developments in several fields of knowledge [2].

The wide-ranging properties of fuzzy logic theory motivated numerous extensions and generalizations e.g. type-2 fuzzy sets [21, 33], intuitionistic fuzzy sets [5], interval-valued intuitionistic fuzzy sets [6, 7], fuzzy multi sets [27], hesitant fuzzy sets [23], Pythagorean fuzzy sets [28], among others. These

advancements comprehend an evolving toolbox of robust methodological approaches that allows academics, decision, and policy makers to address problems that require the inclusion and modelling of quantitative and qualitative data, a particularity that results especially interesting in social sciences [4, 10, 15, 37]. Moreover, these advancements are of interest in management and business challenges and situations, where flexible and agile solutions are required to be determined without leaving the required formal mathematical methods behind [14, 18].

2. Applications in innovation and sustainability

Based on the above, the advances in the application and use of diffuse methodologies for the treatment and analysis of information in the different areas of business management. One of the areas in which the application of these methodologies has ventured is related to innovation. These methodologies have been used to explain aspects related to innovation. Within these developments, the following approaches stand out: 1) Product development, which seeks to establish relationships between product development project characteristics and project outcomes [22], 2) Innovation capability and capacity, which are focused on measuring TICs requires Technology innovation and evaluation for the innovation capacity of financial institutions [16, 24], 3) Innovation collaboration highlights the importance Collaboration for innovation and innovative to gain competitive advantage tools [19], 4) Green Technology shows to analyze the combination and convergence of energy-intensive industries developed by ecological factors based on energy clusters [26], 5) Service innovation is focused on identifying and analyzing the factors that influence it [13], 6) Innovation Performance evaluates different financial and nonfinancial criteria in banking industry [25], 7) Innovation diffusion analyses the transfer of innovation and knowledge in mega-projects through project management [36], 8) Innovation support systems proposes a support system to evaluate innovation performance in higher education institutes [11] and 9) Innovation management measurement proposes a fuzzy tools for innovation activities measurement in small and medium manufacturing enterprises [3]. Thus, it can be seen how these approaches seek to explain or measure innovation activities using diffuse techniques in different sectors.

Of the approaches presented, the one related to the measurement of innovation management can be highlighted, since it contemplates in a holistic way how innovation is directed in small and medium enterprises. This proposition is focused on seven key innovation measurement dimensions consider innovation strategy, knowledge management, project management, new product portfolio management, the organization and structure of the firm, and external drivers [1, 3]. Also, expertons and aggregation operators allow to integrate subjective and objective dataset of these dimension in order to give a better information analysis and comprehend how firms carry out innovation activities [38]. Thus, this approach allows an accurate interpretation based on the specific conditions of the problem based on the flexibility of the parameters [3].

In this sense, the methods and applications of the tools coming from the field of fuzzy and uncertainty studies offer new perspectives for the treatment of the problems of business management and economy. In this specific case, related to innovation management, there are several proposals that have been developed with different approaches and that make the field attractive to continue proposing and developing research.

3. About the papers in this special issue

The special issue consists of 23 papers that have been presented in the III International Congress in Innovation and Sustainability that was held in Concepcion, Chile from 24–25 October 2019. The best papers were invited to be presented in this Special Issue. All the papers have been processed by a peer review process.

The papers in the special issue present different formulations and applications of fuzzy systems to approach a better understanding and solving different problems in different areas of innovation and sustainability. Among the main topics that can be found in the Special Issue are economic performance, information and communication technologies, women entrepreneurship, investment portfolios, innovation management, business size, customer relationship, tourism and destination competitiveness, supplier selection, balance score card, new business ventures, government transparency, sustainable tourism, price prediction, consumer behavior, bank efficiency and personality trait.

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