Modeling and Simulation -

The insight delivering tool for innovation

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Keywords

Abstract

The main purpose of this article is to comprehend the performance through the state of research of innovation to account for the characteristics of the findings on the criteria of modeling and simulation regarding the field.

A literature review is the tool chosen for the collection of data and development of this paper. A search was established to identify the existing literature using modeling, simulation and innovation as key words. After a thorough revision it was identified that what has been written in the field may be classified in the following categories: diffusion; networks, collaborations and communities, and validation of models and simulation, thus the performance will be approached from these angles.

Taking into account how researchers from different areas of knowledge implement them as helpful tools to grasp innovation processes, it becomes evident in this paper that modeling and simulation have implications as an insight delivering tool by contributing to a comprehensive approach of

how autonomous various uncertainties of a complex system are ultimately inter-reliant. This paper fulfils an identified need to understand the characterization that modeling and simulation have given to the field of innovation up to date.

Introduction

One of the main characteristics regarding research literature of the las decade is particularly a progressive growth of interest in developing material exploring the modeling and simulation effects when applied to the complexity of real world patterns. Considering it is a relatively new topic of research where constant important findings are being revealed in literature a need has been identified, there is a necessity to understand what is the characterization that modeling and simulation have given to the field of innovation up to date. This literature review will approach the field by finding common standpoints to be able to classify a series of grouping mechanisms.

A literature review is the tool chosen for the collection of data and development of this paper considering it attempts to contrast empirical evidence directly related to certain predetermined criteria to answer a specific research question (Higgins & Green, 2008). Firstly, a systematic search was established to identify the existing literature using modeling, simulation and innovation as key words. Following, a synthesis and systematic presentation of the results had to be made, this required the use of rigorous methods to determine the accuracy with which the information obtained was to be reported. The chosen instrument was bibliographic records.

The main findings this article has to offer are organized in the following structure: Initially there is a given introduction on the correlation modeling and simulation have with innovation; secondly a series of researchers will be mentioned regarding their modeling and simulation results around the complexity of diffusion in innovation; subsequently the impact networks,

collaborations and communities have on innovation processes will be examined through different models and simulations; afterwards the topic on models and simulation validation is examined; and lastly conclusions on the topics are established.

Innovation, modeling and simulation

"Innovation is a multifaceted phenomenon at the intersection of economics and technology" (Cevikarslan, 2013). Increasing innovations related to existing products and processes allow short-term financial goals to be sustained, while with developing radical innovation in new forms of business, products and services the organization establishes competitive advantages and continuous growth (Lameez and Van Knippenberg, 2014). Innovation has become one of the fundamental pillars for most organizations around the world, whom also have the choice to perform other modes of action such as routine behavior or imitation (Beckenbach, Daskalakis and Hofmann, 2012). Authors such as Sahal (1981), Kauffman and Macready (1995) and Ziman (2000) glimpse innovation as a constant evolution process, this considering that variables like uncertainties in technology, market, innovation benefits and institutional environment make innovation a big risk which constantly leads to high failure rates (Wu, Kefan, Hua, Shi, Olson, 2010).

However, nowadays certain tools are being developed that give the opportunity to obtain a closer approach to innovation predicting the results and behaviors of certain predetermined variables allowing one to get a glimpse of the strategic enforcement of the innovation. The findings of this review manifest how modeling and simulation can be used to aid intuition about innovation (Ma and Nakamori 2005).

Contemplating the aforementioned, we will refer to a model as a simplification; A smaller, less detailed, less complex form of some structure or system (Gilbert and Troitzsch, 2005). So taking into account that "to derive universal results requires limiting the size of one's universe" (Chang and Harrington Jr., 2006), a model is a formalized representation to help understand the environment.

As with, simulation is one of the representations that modeling develops. In many cases certain variables are difficult to discover directly, that's is where one finds the importance of simulation, it helps to obtain a greater understanding when establishing certain assumptions that allow to evidence "what would happen if ...". Still, modeling and simulation are not only based on assumptions, they have "the capability to show how collective phenomena come about and how the interaction of the autonomous and heterogeneous parts leads to their genesis" (Gilbert, Pyka and Ahrweiler, P, 2010).

Diffusion

One of the main topics about innovation is how modeling and simulation capture the complexity of its diffusion. For Ning Nan, Robert Zmud, and Emre Yetgin (2014) a model that helps to get a better understanding of innovation diffusion has not been yet develop, this is why they come to it using two modeling approaches; firstly, they foster a computationally codified model with a decision making entity called an agent-based model, which allows the behavior of the social system under study to then be extracted from the simulation results (Schwarz and Ernst, 2010). Secondly, they apply a theoretical model of innovation diffusion by which innovations are adopted by users within a population of agents (Jaffe, Newell and Stavins, 2003). Studying the obtained results in both the agent based and the theoretical model they not only found results did not contradict one another but also complemented the phenomena in study.

Garcia and Jager (2011) resolve to demonstrate by choosing five papers incorporating a model and simulation methodology into a real market issue regarding a certain diffusion of innovation, that once the models are grounded with real up to date information, the outcomes of the models mimic the real social dynamic. For example, Gonzalez-Avella, Cosenza, Klemm, Eguluz and San Miguel (2007), examine two models that indicate how direct and indirect mass media influence in cultural dynamic in order to create cultural diffusion in society; where Shibanai, Yasuno and Ishiguro (2001), who are also interested in the effect mass media has, approach it from a different angle by using two simulations which study how mass media influences others with common and uncommon traits. Even though both investigations approach the matter with different variables, throughout modeling and simulation both conclude that mass media does diffuse to have a direct effect on giving a support for a local minority.

However, modeling and simulation in innovation diffusion is not only used to prove or contradict a theory but also to discover variables that were not taking into account in the system in the first place. Whilst Watts and Dodds (2007) applied computer simulations to get a better grip of a beyond doubt, decades long marketing and diffusion research belief that stated influentials are an indispensable piece of the formation of public opinion, the model's results highlight that the huge influential wave is not driven by special skills the influential may have, but is the result of easily influenced individuals influencing other easy-to-influence people.

Networks, collaborations and communities

Argyris and Schön (1996) state that a learning organization is one that is permanently changing its interpretation of the environment, this attribute is a must in the survival of an organization considering innovation is, as Pourdehnad, Maani and Sedehi (2002) imply, an outcome of interactive adaptive networks; It is a complex systems that evolves and has dynamic interactions with internal and external variables, it has multiple objectives, it is constantly adapting to an environment, does not develop around a central control mechanism and is in continuous and inevitable change. Hence researchers have learned to use knowledge collaboration to better nourish models with information which allow a more realistic tool in order for innovation processes to be held and understood.

Researchers like Millington and Wainwright (2016) take different existing models and use a comparative approach to innovate by using each contribution as a piece of a puzzle; by examining how well different models fit the same set of empirical data and reproducing whole new models (Janssen, 2009); Zou and Yilmaz (2010) develop a computational model contemplating knowledge gathered from three different types of communities that allowed them to understand structural and behavioral conditions in communities of science. Similar simulation experiments such as the one developed by Gilbert, Ahrweiler and Pyka (2010), also highlight the impact of knowledge sharing communities in innovation, demonstrating through their model's results the importance of finding new know-hows from outside the organization, agreeing with Gay and Dousset (2005), who stated that technology and knowledge necessary for innovation usually lies outside a firm's core competence; Gilbert, Ahrweiler, and Pyka (2001) use an agent-based model of knowledge-intensive innovation networks, to simulate the resulting effects on innovation performance and size of the industry; Jiang and Hao (2011) develop a game model that evaluates

the status of association stability under the effect of different learning abilities, concluding that networking in knowledge is crucial to technological cooperation and innovation.

Nevertheless, in innovation there is still a valid doubt when studying how far must collaborations go in order to preserve its novelty, efficiency and cost- effectiveness. Almirall and Casadesus-Masanell (2010) use a simulation model to consider the benefits of discovery of new combinations of product features versus the costs of suboptimal coordination. Since investment decisions about innovation projects are typically updated over time considering the uncertainty involved in predicting markets (Dawid, H, 2006), their model guides the way to determine if an intermediate of opened and closed innovation is what generates optimal results. Alexander and Van Knippenberg (2014) develop an orientation model highlighting certain team's abilities identifying roles of leaders and reflexive team processes, concluding collaboration is a key factor in achieving innovation success.

Now, contemplating the prior mentioned models and simulations that show how networks, collaborations and communities are a key factors for innovation, researchers have also considered real life cases to evidence the theories' results are accurate: Cooper and Bruno (1997) study how most startups formed by a single entrepreneur tend to have less chance of succeeding the first four years in a market than others founded by groups collaborating with necessary feedback to survive the market; Thurston (1986) and Feeser and Willard (1989), suggested that outcome created by a team is regularly superior to one created by a single entrepreneur and that instability of this group leads to jeopardizing a firm's performance; Doutriaux (1992) implies that a network is a sustained comparative advantage because it impacts on the general orientation and strategy of the organization. Chandler and Hanks (1998) study how a firm's growth is enhanced by select team members that offer unique functional diversity to the organization.

Validation of models and simulation

Throughout the extend of this article evidence of models and simulation applied to innovation have shown to have outstanding results on the approach of the fields complexity; Nonetheless, regarding model building, simulation and validation, other concrete approaches are additionally proposed bearing in mind the parameters of methodology when applying a model, stablishing there is still room for improvement in these tools.

Werker and Brenner (2004) describe as "quite an adventure into the known" the specification of parameters set with which to run simulations, considering it is hardly justifiable why to choose a certain parameter and not another. Duffy (2006) emphasizes on how even though the findings of agent-based models are often in agreement with human subject experiments, modeling still offers too many degrees of freedom when following a methodology. Squazzoni (2010) quotes "A first critical point is the lack of a common methodological standard on how to build, describe, analyze, evaluate and replicate".

Conclusions

The Valley of Death metaphor, often explains how many innovations fail on the way from the workshop to the market (Weyant, 2011). It is reported that the implementation phase is regarded as the most difficult phase of a change management program (Pfeifer, Schmitt and Voigt, 2005), the struggle of this proliferates when it involves innovation. Thus, the biggest challenge for decision makers is to obtain the best awareness of the innovation constituents and how their conducts and performances are correlated and integrated to affect other components within, which ultimately impact the system as a whole reducing the decision uncertainty.

In order to efficaciously act upon innovation, modeling and simulation emanate as an insight delivering tool by visioning impacts and permutations of variables over time, identifying through various methodologies unintended effects, contributing with a comprehensive approach of how the autonomous various uncertainties (Garcia, 2005., Gilbert, Jager, Deffuant, and Adjali, 2007). Throughout the categorization made in this literature review it is established that even though modeling and simulation have not concluded a common methodology (which is necessary in order to be a much helpful tool as reference points for more generalized topics), inter-reliant elements are shared in the mentioned categories evidencing that throughout innovation diffusion and collaboration networks models and simulations are better fed allowing the innovation process which ultimately become a complexity challenge (Audretsch, 1995., Rycroft and Kash, 1999) to be better held and understood.

Acknowledgements

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