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Analysis of scientific collaboration patterns in the co-authorship network of Simulation–Optimization of supply chains

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ABSTRACT

In the 1970s, a co-authorship network in the field of Simulation Optimization of supply chains was established, supported by local associations. Then, the development of this network was favored by the foundation of new co-authorships and the consolidation of already existing. The purpose of this study is to analyze the structure, collaboration patterns and the time-evolution of the co-authorship network of Simulation Optimization of supply chains. Data are based upon 202 peer-reviewed contributions published from 1970 to August 2012 in relevant journals indexed in the ISI/Web of Science database and International Conferences. The analysis is conducted using exploratory social network analysis technique. Results indicate that the development of knowledge in Simulation Optimization of supply chains has been carried out mainly by 353 authors from 35 countries. Also, there have been proposed over forty Simulation Optimization methods by different authors however the most usual is response surface methodology, followed by gradient based search method and genetic algorithms. In addition, applications of Simulation Optimization methods and techniques are found mainly in areas as health care, management, transport, airline, telecommunications, aerospace, and financial. Although research in Simulation Optimization of supply chains has received much attention by the simulation community, its application in key industries continues to be still small, limiting its support in decision-making.

1. Introduction

Simulation Optimization is a structured approach that is useful to determine optimal settings for input parameters associated with a simulation model. In this case, the optimality is measured by a (steady-state or transient) function of output variables [1]. As suggested by Fu [2], the general optimization problem consists of finding a setting of controllable parameters that minimizes a given objective function, i.e.

$$\min J(\theta) \quad \theta \in \Theta \tag{1}$$

where $\theta \in \Theta$ represents the vector of input variables, $J(\theta)$ is the objective function, and Θ is the constraint set, which may be either explicitly or implicitly defined. The assumption in the Simulation Optimization setting is that $J(\theta)$ is not available directly, but must be estimated via simulation [2].

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The key difficulty in Simulation Optimization involves a trade-off between allocating computational resources for searching $\theta \in \Theta$ *versus* conducting additional simulation replications for better estimating the performance of current promising solutions [3]. Since the 1970s several Simulation Optimization techniques have been proposed for finding optimal settings for input parameters of a simulation model. Some of these methods have been very sophisticated while others have been naïve just generating several input values at random and running the simulation model at each of these input values. None of Simulation Optimization techniques is sure to work for all problems, but each one has characteristics which make it useful for certain types of problems [4]. Extensive reviews and surveys about Simulation Optimization methods and techniques have been carried out by different authors and can be found in [5–14,3,15,16]. However, at present little attention in the literature has been paid to the co-authorship network of Simulation Optimization and its time-evolution and very little has been written about main applications of Simulation Optimization techniques in industry.

Peer-reviewed contributions are considered an important source of information that let us to identify the development of knowledge in a specific field, and pinpoint how research is organized and structured [17]. In this direction, specific research questions addressed by this study are: how do authors of peer-reviewed articles in the field of Simulation Optimization of supply chains collaborate? How is structured the co-authorship network of Simulation Optimization of supply chain? Which Simulation Optimization methods have been proposed by researchers? And last but not least, which industries have been supported by Simulation Optimization methods? In line with this, the aim of this study is to analyze the structure, collaboration patterns and the time-evolution of the co-authorship network of Simulation Optimization of supply chains. In order to achieve this aim 202 peer-reviewed articles were selected using the purposive sampling method, which is defined in Section 2. Based on the information about authors, we developed the co-authorship network and analyze its structural properties and time-evolution using exploratory social network analysis technique. This technique has the advantage of determine at global level structural features of a network, detecting its patterns. Then Simulation Optimization methods were classified based on their application areas. This classification is of relevance because provides guidance for industrials, academics and practitioners in optimization method selection. After that, industries that have been supported by Simulation Optimization methods in making decisions processes were listed. Although theoretical Simulation Optimization methods are numerous, key industrial areas of application are still small. We highlight this gap and recommend how to increase the application of Simulation Optimization methods in real-world problems solutions.

The remainder of this paper is organized as follows. In Section 2, the data collection method is presented. The exploratory social network analysis technique is described in Section 3. The co-authorship network of Simulation Optimization of supply chains is characterized in Section 4. The structure and time-evolution of the co-authorship network of Simulation Optimization of supply chains is analyzed in Section 5. Main conclusions and future research are drawn in Section 6.

2. The data collection

We collected 202 peer-reviewed contributions in Simulation Optimization of supply chains from relevant journals indexed in the ISI/Web of Science database and International Conferences. These contributions were selected based on purposive sampling method. This method is also referred to as qualitative sampling that involves certain units or cases based on a specific purpose rather than randomly [18]. Three broad categories of purposive sampling techniques are well known: sampling to achieve a representativeness or comparability, sampling special or unique cases, and sequential sampling [18]. In this study, peer-reviewed contributions were sampled based on the first category of the purposive sampling techniques to achieve a representativeness of the application of Simulation Optimization in supply chain field. The criterion to filter a contribution was the inclusion of the phrase "simulation optimization" in its title but with its application in supply chain field. The period of publication taken in account was from 1970s to August 2012. As the first contribution was published in the 1970s, additional queries regarding five periods were placed in data as follows: Period I, 1970–1979; Period II, 1980–1989; Period III, 1990–1999; Period IV, 2000–2009; and Period V, 2010–2012. As it is noted from Table 1, for each period peer-reviewed contributions were quantified as well as International Journals and Conferences, authors and their countries. The tendency in the number of peer-reviewed contributions published over five periods already mentioned, suggests the attracting increasing interest from the simulation community in Simulation Optimization field since the last decades.

The distribution of peer-reviewed contributions based on the number of co-authors is summarized in Table 2. Two-authored contributions represent the biggest proportion with 41% of the total. In contrast to this, the single-authored contributions represent only 15%.

Table 1
Dissemination of peer-reviewed contributions of Simulation Optimization of supply chains.

Period Years	I 1970–1979	II 1980–1989	III 1990–1999	IV 2000–2009	V 2010–2012
Authors	10	20	32	232	100
Peer-reviewed contributions	5	15	20	118	44
Int. Journals/Conference	1	2	1	23	17
Countries	1	2	2	29	18