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SIMULATION OF CANADIAN NANOTECHNOLOGY INNOVATION NETWORK

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ABSTRACT

This work aims to investigate the role of individual scientists and their collaborations in enhancing the innovative performance of the Canadian nanotechnology innovation network. The study uses real data that consists of all the journal articles in nanotechnology field published within 1980-2012 by the authors affiliated to Canadian institutions, which were collected from Scopus database. The scientific networks have been created based on the co-authorship of the articles and an agent-based simulation model has been developed to study the innovation networks in their dynamic context. This research argues that the individual performance of authors with different network properties distinctively affect the overall efficiency and structure of the network.

1 INTRODUCTION

Due to the collective knowledge sharing among researchers within scientific collaboration network, innovative ideas are exchanged and new knowledge is generated. In such networks the knowledge is created and transmitted by socially connected individuals whose collaborations shape the links of the networks. Recently, simulation attempts have been carried out to analyze the performance of the innovation networks at the firm level while the individual level has not been explored in the literature yet. Moreover, considering that the existing studies have not used a real world data as input into their models, whereas our simulation model is fully based on the observed behavior of the scientists in the Canadian nanotechnology knowledge production network, this work represents a unique approach and a great contribution to the network simulation research. The objective of this paper is to investigate the role of individual scientists and their collaborations in enhancing the innovative performance of the Canadian nanotechnology innovation network. Agent-based modeling using Netlogo is applied to simulate the scientific collaborations and evaluate the knowledge dynamics in the co-authorship network of the Canadian nanotechnology scientists. The model has been developed based on the topology structure of the network and the information about research activities for each co-author and his/her collaborators.

2 DATA COLLECTION AND PRE-PROCESSING

The analyzed dataset has been extracted from the SCOPUS database using specialized keywords related only to nanotechnology. Only the papers where at least one of the co-authors has a Canadian affiliation were extracted. To visualize the Canadian nanotechnology innovation network and represent the co-authorship relationships among scientists we have implemented social network analysis using Pajek software. Various network indicators were calculated in order to describe the structure of the network. We have defined and characterized separate profiles for scientists by considering number of network measurements such as; betweenness centrality, degree centrality, weighted degree and so on. Research activities information about each co-author, such as his/her publications count, co-authorships count and h-index, are then used as inputs for data mining procedure to detect the patterns of different actors' behavior.

As a complementary approach we run a survey sent to active researchers having scientific collaborations in Scopus in order to investigate some personal preferences to be considered while selecting the partners for conducting a research project. All of this data is then fed into the simulation model that represents the collaboration activities of Canadian nanotechnology scientists.

3 SIMULATION EXPERIMENTS

Agent-based models (ABM) are commonly used in dynamic adaptive systems to analyze individual actors, describe human behavior and to observe the effects of the agents' interaction among themselves and with their environment considering various factors. ABM is considered as an effective tool in simulating the flows of scientific knowledge within collaborations and in exploring the learning of agents from partners and collaborators. It has been used in several studies related to social networks such as modeling dynamically changed networks, capturing different types of agents and their behaviors (Berryman and Angus 2010), exploring the diffusion of innovation and adoption dynamics (Bonabeau 2002), and addressing the complexity of knowledge production processes in a manner not captured by more traditional research approaches (Gilbert, Ahrweiler and Pyka 2010).

The basic units of our proposed model are a set of agents or nodes representing the scientists, where two nodes are connected by a link if these two scientists have coauthored at least one article together. The nodes are characterized by various properties including affiliation, research performance indicators and network measures reflecting different roles for the scientists. Each of these roles is defined by a certain set of actions that describe their behavior in the context of collaboration. An agent can perform one of the following actions: either he/she can quit the network, repeat the collaboration with the same partner or find a new collaborator. Moreover, new agents in different roles are being added while model is running and others may have their properties changed. Several scenarios are simulated, such as the presence and absence of scientists with different roles, increasing or decreasing their number in the network as well as changing their properties and roles. Combinations of these actions are then explored in order to determine their impact on the network structure and its efficiency in terms of scientific production.

4 CONCLUSION

This study is an attempt to investigate different roles of individual scientists in the overall performance of the innovation network using agent-based modeling. It is the first simulation model of innovation networks developed based on the real data. Moreover, the uniqueness of this research also consists in combining multiple methodologies, i.e. bibliometric analysis, social network analysis and data mining techniques complemented by the authors' feedback collected from the questionnaire. Simulation experiments employed for various scenarios effectively examined the behavior of agents under several conditions and enabled us to highlight a set of factors that affected both the structure and performance of the network.

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