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RAI Revista de Administração e Inovação 13 (2016) 78–88

http://www.revistas.usp.br/rai

Actor centrality in Network Projects and scientific performance: an exploratory study

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Received 29 July 2015; accepted 31 March 2016
Available online 13 May 2016

Abstract

This study analyzed the relationship between actor centrality of Network Projects and scientific productivity performance using a method known as Social Network Analysis. Social Network Analysis and its respective properties are able to analyze actors' positions in the structure and existing social interactions in networks. Thus, this method generates indicators to understand the format of collaborative structures of projects and their respective performances in scientific productivity. In order to carry out this proposal, models for multimodal analysis were used, taking into consideration different centrality measures. The behavior of centrality metrics has proven to be significantly different for analyses. Furthermore, the correlations between these metrics and scientific productivity performance have shown to be important in achieving project goals. This shows that the more centrality there is, the greater the chance the project has to achieve its goals.

Keywords: Social Network Analysis; Centrality; Network Projects; Scientific productivity

Introduction

Social Network Analysis (SNA) is based on methods derived from graph theory (Kilduff & Tsai, 2003, p. 38) and can organize structures and interactions from actors and represent them in a graph. SNA also generates individual indicators from actors or even groups and networks as a whole. These indicators can associate the nature of the structures and relations from the network to phenomena, such as power, knowledge transmission, information flow, etc. (Marteleto, 2001, p. 72). According to Freeman (1979) SNA is a theoretical approach of a multidisciplinary nature, such as sociology, anthropology, mathematics, statistics and computing.

According to Borgatti and Everett (1997), SNA studies attributes of pairs of individuals (or dyads), sub-groups or networks whereas in traditional social science the focus is on attributes of individuals. SNA examines structural and relational aspects in dyads, sub-groups and relationship networking (Sacomano Neto & Truzzi, 2009) and is also known as a meso level of analysis method. Borgatti and Everett (1997, p. 243) also highlight the importance of "pairs of individuals" in SNA, which they call *dyadic attributes*, instead of focusing on the individual itself.

As it is an approach that focuses on positioning as a technique for network studies, Borgatti (2009, p. 901) state that the fundamental axiom of SNA lies in the concept of structures, relative to the actors' positions. According to these researchers, the actor (node), the results and the characteristics of a network depend on this positioning (Borgatti, 2009, p. 902). The level in which the structure (or positioning) determines the importance of an actor (node) in a network is called centrality.

Specifically regarding collaborative environments of R&D performance, the occurrence of multiple forms of productive and technological cooperation is a recurrent theme in different approaches of Industrial Economics (Britto, 2002). These studies address the agglutination of skills and greater exchange of information with the R&D process (Britto, 2002). However,

Peer Review under the responsibility of Departamento de Administração, Faculdade de Economia, Administração e Contabilidade da Universidade de São Paulo – FEA/USP.

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http://dx.doi.org/10.1016/j.rai.2016.03.002

little is seen concerning how these collaborative environments influence the productivity of R&D structures (Mote, 2005).

In this study, we attempt to find elements that enable us to clarify the dynamics of collaborative environments. In the R&D environment at Embrapa (*Empresa Brasileira de Pesquisa Agropecuária* – The Brazilian Agricultural Research Corporation), there are ways of organizing scientific research that encourage cooperative relationships to meet this demand, which are called Network Projects (NP).

This is bureaucratic because it involves normative and social formalization (Características, 2004), with individuals in leadership roles, characterizing the structure as interorganizational relations. In any R&D environment at Embrapa, there are actor dynamics and responsibilities for the benefit of research developed by social networks.

Each Network Project (NP) is based on a macroprogram, a management tool that conducts the operation of the company's R&D program to obtain results that attain the technical goals. Each project consists of Research Units (RU) comprising the framework of institutions that are responsible for the activities. These activities are organized logically in a structure called Action Plan (AP) to obtain specific results expected by the project. This study specifically investigates Macroprogram 2, a portfolio that includes projects with network structures.

Embrapa has an R&D management model, according to which research projects use various actors to produce results to reach technical goals. Thus, the projects are supported by the multi-institutional and multidisciplinary approach of the actors involved. These projects generate numerous research networks with various actors, nodes and links. However, there are no systematic assessments of these networks in the company using SNA. Network measures for R&D need to be constructed so as to provide a more appropriate reading of the relationship between project structure and results, thus, shedding light on how network relations, specifically connection designs, have impacted the effectiveness of the company's research results.

The main question to be addressed in the study is the following: "Does actor centrality of Network Projects at Embrapa influence scientific productivity?" This has implications concerning SNA measures: project structure centrality. There is no knowledge about how the centrality measures of Network Projects at Embrapa can influence the scientific productivity of the networks.

Borgatti (2009, p. 901) highlight that the key to SNA is to understand the structural characteristics, the actors' positions and dyadic properties. In this study, this structural term is limited to relations, focusing on the actors' positions. As an extension of the main question, the following question arises: "Do adjacent interactions of the actors involved in the network influence the performance of the Network Project (NP) and these actors' scientific productivity?"

The participants in a network may or may not have connections with other actors. When they do exist, this connectivity may be direct (also called adjacent) or even indirect.

Sometimes some actors may take on intermediary positions, exercising relative control within the universe of a whole project. Considering this, the following question arises: "Is there a relationship between the intermediation of the actors and R&D performance in terms of these actors' scientific productivity?"

According to Cross and Parker (2004, p. 34), peripheral actors are those that have few connections. For these authors, this position may reflect the degree of motivation of the individual or even the little time they participate. These individuals may have a relative degree of independence in choosing (Cross & Parker, 2004, p. 34). This distance for the rest of the network can also denote a greater availability of suitable paths of information flow (Stephenson & Zelen, 1989). Along the same line of reasoning, the more available paths there are to access other individuals, the more central this actor is. To address this issue, the following question arises: "Does a greater availability of paths to enable access to other individuals influence these actors' performance of scientific productivity?"

According to Rossoni, Hocayen-da-Silva, and Ferreira Júnior (2008, p. 35), the underlying assumption is that knowledge is constituted by the social environment and influenced by peers who make up an arrangement. Considering this, not only are relations observed, but also the structure which affects scientific literature. Mizruchi (2006) has the same understanding, whereby research in social networks attempts to assess the structure of the relations. Along these lines, the main objective of this study is to analyze the relationship between actor centrality of the Network Projects at Embrapa and the performance of the project in terms of scientific productivity. The propositions of the study are as follows:

- the greater the Degree Centrality (DC) of the actors involved in the projects, the greater the performance in scientific production. This hypothesis is based on the ability of actors, who have more adjacent relationships, having access to a larger number of individuals and, hence, a greater multidisciplinary structure;
- intermediary actors perform better in scientific production projects as they ensure access to the circulation of relevant information to the network; and
- the closer the actors are, the better the scientific production project performance is, as they are more available to access other actors in the network. It is considered, therefore, that the actors who are more likely to transfer and receive information from the whole project are those who have the largest number of paths in the network.

It should be mentioned that the actors in this study are the Research Units (RU) and the Action Plans (AP) of the Network Projects.

According to Wasserman and Koehley (1994), Hanneman and Riddle (2005) and Borgatti (2009), there are various centrality metrics used. Three measures are recurrent in studies assessing centrality (Hanneman & Riddle, 2005) and are also addressed in this study: Degree Centrality, Betweenness Centrality and Closeness Centrality. This study took the following into consideration: Degree Centrality which is based on adjacent relationships; Betweenness Centrality which reflects the intermediation level of the structure; and Harmonic Centrality that