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A regression analysis of researchers' social network metrics on their citation performance in a college of engineering

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ABSTRACT

Previous research shows that researchers' social network metrics obtained from a collaborative output network (e.g., joint publications or co-authorship network) impact their performance determined by g-index. We use a richer dataset to show that a scholar's performance should be considered with respect to position in multiple networks. Previous research using only the network of researchers' joint publications shows that a researcher's distinct connections to other researchers, a researcher's number of repeated collaborative outputs, and a researchers' redundant connections to a group of researchers who are themselves well-connected has a positive impact on the researchers' performance, while a researcher's tendency to connect with other researchers who are themselves well-connected (i.e., eigenvector centrality) had a negative impact on the researchers' performance. Our findings are similar except that we find that eigenvector centrality has a positive impact on the performance of scholars. Moreover, our results demonstrate that a researcher's tendency toward dense local neighborhoods and the researchers' demographic attributes such as gender should also be considered when investigating the impact of the social network metrics on the performance of researchers.

1. Introduction

It is important to determine who are the most influential researchers and invest in those researchers to both maximize the research outputs and to allocate funding effectively (Abbasi, Altmann, & Hossain, 2011; Jiang, 2008). Influential researchers can be determined by using social network metrics such as centrality metrics after mapping their collaborative output networks (e.g., joint publications, grant proposals, and patents) in which a tie between any two authors indicates collaboration on the making of a collaborative output. Hou, Kretschmer, and Zeyuan (2008) found that there was a positive correlation between being an influential researcher, (i.e., having a high degree centrality in the collaborative output network) and output of a researcher (i.e., number of publications). Defazio, Lockett, and Wright (2009) also found that there was high impact of being an influential researcher in the collaborative output network on output of a researcher. However, the quality of research outputs is as important as the quantity of the research outputs.

Hirsch (2005) proposed an index called the h-index in order to attempt to measure both the number of publications a researcher produced (i.e., quantity) and their impact on other publications (i.e., quality). Using the researchers' publications

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Table 1
Advantages of scientific collaboration.

Access to expertise for complex problems, new resources and, funding	Katz and Martin (1997), Melin (2000), Beaver (2001), Hara et al. (2003), Sonnenwald (2007), Bukvova (2010), National Science Board report (2012) and Hale (2012)
Increase in the participants' visibility and recognition	Katz and Martin (1997) and Beaver (2001)
Rapid solutions for more encompassing problems by creating a synergetic effect among participants	Melin and Persson (1996) and Beaver (2001)
Decrease in the risks and possible errors made, thereby increasing accuracy of research and quality of results due to multiple viewpoints	Beaver (2001) and Bukvova (2010)
Growth in advancement of scientific disciplines and cross-fertilization across scientific disciplines	Beaver (2001) and Cummings and Kiesler (2005)
Development of the science and technical human capital, e.g., participants' formal education and training, and their social relations and network ties with other scientists	Bozeman and Corley (2004)
Increase in the scientific productivity of individuals and their career growth	Fox (1983), Katz and Martin (1997), Bozeman and Corley (2004) and Lee and Bozeman (2005)

data in the information schools of five universities, Abbasi et al. (2011) investigated the impact of social network metrics (including different centrality metrics, average tie strength, and efficiency coefficient proposed by Burt (1992)) obtained from a researchers' co-authorship network on the their g-index (another form of h-index), and found out that degree centrality, average tie strength, and efficiency coefficient had a positive impact on the researchers' performance, while eigenvector centrality had a negative impact on the researchers' performance. Their study can be extended by considering the network metrics obtained from researchers' multiple networks. Thus, the purpose of our study is to test the findings of Abbasi et al. (2011) with the social network metrics obtained from researchers' multiple collaborative networks defined by joint publications, joint grant proposals, and joint patents as well as their communication network to understand the relationship between these social network metrics and the performance of researchers. Collecting researchers' ties for their informal conversational exchange (or informal communication) and collaborative outputs with other researchers within a college simultaneously makes this testing possible. We use h-index instead of the g-index because the researchers within the same field of study are compared (Bornmann & Daniel, 2009). In sum, this study seeks an answer to the following question: *what is the impact of social network metrics obtained from researchers' communication and collaborative output networks on their performance as measured by citations of their publications?*

2. Literature review and hypotheses

2.1. Researchers' communication and collaborative output networks

A science and technology (S&T) system comprises a wide range of activities such as fundamental science or scholarly activity, and applied research and developmental activities mainly concentrating on creating new products and processes (Moed, Glänzel, & Schmoch, 2004). It has become a driving force over the last 20 years for major economic growth and development and it is, therefore, an inseparable part of several national and regional innovation systems (Freeman & Soete, 2009; Moed et al., 2004). One of the important attributes contributing to the S&T system performance is scientific collaboration (Hara, Solomon, Kim, & Sonnenwald, 2003; Moed et al., 2004). Sonnenwald (2007) defined scientific collaboration as the interaction within a social context among two or more scientists in order to facilitate the completion of tasks with regard to a commonly or mutually shared goal. Thus, participants in the collaboration event integrate valuable knowledge from their respective domains to create new knowledge. Scientific collaboration provides several salient advantages as shown in Table 1. One of the important factors leading to advantages of scientific collaboration is the social dimension of scientific work such as informal conversational exchanges between colleagues (Bozeman & Corley, 2004; Katz & Martin, 1997), co-authorship relations (Glänzel & Schubert, 2004; Katz & Martin, 1997), jointly submitted grant proposals (Katz & Martin, 1997; Rigby, 2009), and co-patent applications (Balconi, Breschi, & Lissoni, 2004, Breschi & Lissoni, 2004, 2009; Meyer & Bhattacharya, 2004).

Co-authorship in scholarly publications is the most tangible and well-documented forms of scientific collaboration, and it is also a good indicator of the S&T system performance. Therefore, it is used widely in scientific collaboration studies (Glänzel & Schubert, 2004; Katz & Martin, 1997; Melin & Persson, 1996; Moed et al., 2004). For example, using social network analysis (SNA), Newman (2001a, 2001b, 2001c) and Barabasi et al. (2002) analyzed the structural properties of scientific collaboration patterns in large scale by depicting the network of researchers when two authors were considered linked if their names appeared in the same scientific journal. They found that co-authorship networks were small world networks in which most nodes (i.e., authors) could be reached from other nodes by a small number of steps. With a similar approach used in co-authorship network studies, some studies also analyzed the structure of co-inventor maps in the case that two patent applicants (i.e., co-authors) were linked if there was a patent application together by these two applicants; thus, a network of co-invention was constructed. However, analyzing co-inventor maps was not used as widely as analyzing co-authorship maps (Breschi & Lissoni, 2004). In addition, for the networks constructed from researchers' jointly submitted grant proposals,