A local social network approach for research management

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ABSTRACT

Traditional methods to evaluate research performance focus on citation count, quality and quantity of research output by individual researchers. These measures overlook the roles an individual plays in research collaboration, which is critical in an institutional research management environment due to the inherent interdependency among research entities. In order to address the organizational research management needs, we propose a research social network approach to better analyze local collaboration networks. For this purpose, we develop a new "collaboration supportiveness" measure to quantify an individual researcher's collaboration ability. Insights derived from this research are very helpful for managers to effectively allocate resources, identify research priorities, promote collaboration, and grow research in directions aligned with the organizational strategies.

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1. Introduction

Academic institutions face tremendous pressure to expand their research outputs in the global competition for reputation. Effective research management is critical to institutional mission in developing a successful research strategy to build solid research programs, grow research activities, and align institutional priorities with funding agency criteria. It can also inform organizational level strategic decisions, ease reporting to external stakeholders such as funding councils, and help strengthen collaboration within and beyond the institution's boundaries. Today, institutional research repository has been put into agenda in many countries. For example, Symplectic is a publication-oriented system widely used in the universities in UK. The European Organization for International Research Information (www.eurocris.org) provides support for users in their recording, reporting and decision-making concerning the research process. In North America, many universities partner with Thomson Reuters to expand their global research presence.

Traditionally, research management function is performed by university research office which collects research outputs (e.g., papers, patents, etc.) from faculty via individual annual reports. The collected information is hosted by a university information system. As universities establish their own research repositories, institutional managers realize a number of challenges in measuring research impact and performing research assessment. First, the most widely used research metric is the journal impact factor (JIF) developed by the Institute for Scientific Information (ISI, now part of the Thomson Reuters group). The metric was originally intended as a tool for publishers to measure the impact of

individual journals. Due to the lack of other reliable measures, institutions tend to overly rely on JIF as a research measure. It is clear that the use of such single metric is insufficient to measure the impact of research. New metrics relevant to the specific institutional research contexts need to be developed.

Second, institutional research performance assessment usually only emphasizes on quality, quantity, and citations of published journal articles. These existing metrics largely treat individuals as independent contributors in the knowledge production and dissemination process. However, most research is collaborative in nature. There exist strong interdependencies among research projects involving a group of related researchers. The tie is even stronger for certain research topics and in certain research disciplines. It is necessary to develop alternative, reliable and objective methods for managing and measuring research performance not only individually, but in the context of local collaboration networks.

To address these challenges, we propose a research social network approach to perform research performance evaluation. In addition to the standard measure of productivity (e.g., quantity and quality of research), the new framework emphasizes on relevance and connectivity. Relevance refers to information such as keywords and research disciplines that put the research evaluation in the relevant context. Connectivity refers to the inherent interdependencies among researchers and research topics. We aim to transform traditional research management by incorporating a comprehensive analysis of the local collaboration communities. Our major contribution is to propose local collaboration network as a new tool to inform strategic, organizational, and managerial decision making.

For this purpose, we further develop a new measure called "collaboration supportiveness" to quantify the individual contribution in the local collaboration network. By smart exploitation of a local research

network in a university, we show that our method is very effective to discover rich patterns of collaboration and generate new insights. In comparison with the traditional collaboration network analyses such as citation network that essentially take a global view, we focus on more relevant, local social collaboration network from the perspective of institutional research management such as the research office.

Most social network applications in the literature only focus on either one type of subjects (e.g. authors) or single relationship (e.g. co-authorship) among subjects. However, the joint analysis of authors and topics can provide more information for better research group identification than separated networks. In this study we not only consider the traditional network analysis on the research collaboration, but also the links between researchers and topics based on two-mode network analysis methods. To the best of our knowledge, this research is the first to employ two-mode network to perform joint analysis of researchers and topics in the context of research collaboration.

We developed a research online information system to effectively collect, disseminate, and regulate research outputs. The available services are classified into three types of users: institutional administrators, researchers, and public users. The system supports both tactical and strategic management functions at different levels. In this study, we focus on the information and management function from the institutional administrators' perspective. Our analyses help answer the following questions: what is an individual's social position and specific roles he/she plays in the collaboration network? How many and which groups are the most cohesive collaboration research groups in the department/college/ university? What are the key research areas within the department or across the disciplines? Who belong to the core group of researchers to connect different research topics? Do there exist centers of excellence in terms of productivity? What are the new collaboration opportunities? Better understanding of these questions will enable information-rich collaboration, effective decision-making and successful management of research.

Overall, our system builds a more transparent research environment and gains more visibility in terms of the roles research centers and departments play in various research activities. This can help the research office in its internal resource allocation, balance the different demands of basic versus applied research, individual versus collaborative research, and identify research priorities or respond to national priorities. In addition, the decision support system can help make recommendations for institutions and policymakers, such as designing incentive mechanisms to award outstanding researchers, train human capital, and grow research capacity.

The rest of the paper is organized as follows. Section 2 briefly reviews the related work on research social network analysis methods and applications. Section 3 describes our research framework, details the management functions, key features, and the corresponding network analysis methods. We provide detailed analyses in Sections 4 and 5. Concluding remarks are presented in Section 6.

2. Related literature

In this section, we first focus our attention on popular techniques used in social network analysis. We then review three major types of applications: paper-centered, author-centered, and topic-centered network analysis.

2.1. Social network analysis methods

Social network analysis, originally gained its popularity in social and behavior sciences, involves understanding the linkages among social entities and the implications of these linkages. With the rapid development of formal analyzing techniques, it has become an attractive tool for a variety of fields, such as economics [24,26], marketing [36], knowledge management [19], industrial engineering [1,18], etc. Academic collaboration network is an important type of social network that receives

growing interests in recent years [2,11–13,29]. Such analyses provide important insights to drive the development and structure of the specific academic disciplines [27].

In the social network analysis, *mode* refers to distinct kind of social entities (or actors) in the network. We can categorize networks by how many modes the network has. Co-authorship network is an example of one-mode network in which researchers are defined as a single type of entities. Two-mode networks focus on two distinct types of entities. For instance, the conference participation network consists of researchers and conferences. A bipartite graph can be constructed to express researchers' participation in different conferences [37].

The social network can also be distinguished by its global or local influence, depending on whether there are focal entities in the network [37]. A local network consists of focal entities (i.e., egos) with whom a set of actors have ties. It is also called ego-centered network. If all entities in the network are treated equally, the network is a global network.

Existing social network analysis techniques focus on a number of important measurements about the network structure. *Centrality* is an indication of the social power of a node based on how well it connects the network. In general, there are three types of centrality measures: degree centrality, betweenness centrality, and closeness centrality. *Degree* of a node is the number of direct connections a node has in a network. *Betweenness* of a node is the number of shortest paths between other node pairs that pass through that node in a network. This measure gives a higher value for nodes that bridge clusters. It implies that, if more people depend on a person to make connections with other people, then more power that person has. *Closeness* of a node is the inverse of the sum of all shortest distances between that node and other nodes. It indicates the extent to which an individual is near all other individuals in a network directly or indirectly.

In bibliometrics, social network analysis techniques are often used to explore the collaboration patterns within certain disciplines. Researchers, papers, and keywords are most frequently used subjects. They are connected by relationships such as co-authorship, citation relationship, co-occurrence etc. According to the type of analyzed subjects, the related research output analysis can be mainly categorized into three classes: paper-centered analysis, author-centered analysis, and topics-centered analysis.

2.2. Paper-centered analysis

Paper-centered analysis usually uses publications or journals as major subjects. It focuses on citation or co-citation relationship. Citation analysis is one of the most widely used methods of bibliometrics [34]. When one research work cites another, a relationship, citation-from or citation-to, is established. This relationship could be extended to between authors, between journals, between fields, between institutions, or even between countries. For example, the Social Science Citation Index (SSCI) and the Science Citation Index (SCI) are designed to trace citations and indicate the importance and impact of the research papers and journals. The well-known link-based ranking algorithms such as PageRank [33] have been used in the citation network to more accurately measure research quality [9]. Building upon the PageRank algorithm, Google Scholar is a very popular automated citation indexing tool that analyzes citations in large-scale.

Citation analysis can be used to quantify the influence of a single researcher. The best-known measures so far include h-index [16], in which both the number of publications and the number of citations per publication are taken into account, and g-index [10], which is calculated based on the distribution of citations received by a given researcher's publications. The h-index and g-index are highly correlated. These measures are used to evaluate an individual scholar's productivity and impact of the published work [32].

Citation analysis is also a means of determining "classic" publications. Walstrom et al. [35] conduct citation analysis on 118,364 references from 3752 articles published in top IS journals from 1986 to 1995.