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Comparing public and scientific discourse in the context of innovation systems

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ABSTRACT

Innovation as a systemic process is not only driven by science and technology but has diverse sources. While there are (numeric) indicators to map S&T developments such as patents, publications or standards, new indicators are required to map other areas of the innovation system. In this regard, one option is the examination of news reporting. News is a recognized channel for innovation diffusion and plays an important role in informing society. To contrast changes and developments in science and society, specifically the link between both is addressed in this article by comparing the content of news articles and scientific publications. Thus, the aim of this article is to first argue the benefit of integrating the media in the innovation system debate because of its recognized role in innovation diffusion and to develop a methodology to automatically compare scientific and media discourses. To process the volume of textual data according to a common analytical scheme, a text mining framework has been developed. The results offer valuable input for examining the present state of themes and technologies and, thereby, support future planning activities.

1. Introduction

Insights in innovation systems and their dynamics and architecture are relevant for future planning due to the close link between foresight, policy planning, and the performance of innovation systems (Alkemade et al., 2007). Therefore, an in-depth analysis of current developments is crucial for capturing the state-of-the-art as a starting point to build future assumptions and strategies. For the long-term observation of thematic and technical developments, an analysis should not only address one area of the innovation system (i.e., science) but should consider further parts (i.e., society).

Innovation as a systemic process is not only driven by science and technology but has diverse sources. While there are (numeric) indicators to map S&T developments such as patents, publications or standards, new indicators are required to map other areas of the innovation system. In this regard, one option is the examination of news reporting to map societal discourse. News is a recognized channel for innovation diffusion and plays an important role in informing society. Based on the current literature on innovation systems, this article proceeds with the assumption of media being a central actor, enabling a public sphere where innovation discourses can take place. Thus, apart from its role in science, policy, and the economy, media should be considered in terms of its societal functions and role in the spread of innovation.

To contrast changes and developments in science and society, specifically the link between the two is addressed in this article by comparing the content of news articles and scientific publications. Publication data is a commonly used source for examining scientific progress (e.g., Leydesdorff and Milojević, 2015). This work will explore if it is possible to (automatically) recognize changes and focus in reporting of both, science and news. This potentially enables inferences on the state of a technology or its societal acceptance for the comparison of subsystems. To process the volume of textual data according to a common analytical scheme, a text mining framework has been developed. Currently, there is no methodology for the (automatic) comparison of news articles and scientific publications but theoretical discussions (e.g., Franzen et al., 2012).

Thus, the aim of this article is to first argue the benefit of integrating the media in the innovation system debate because of its recognized role in innovation diffusion and introducing an adapted innovation system model as conceptual framework. Then a method is developed to automatically compare scientific and media discourses based on *textual data*. It is examined if differences in the discourse can be measured and mapped based on news articles and scientific publication abstracts. Therefore, a framework based on text mining is developed. This might illustrate the spread and diffusion of concepts and the chronological order of events. To test and illustrate the methodology, three topics driven by different angles are used—*cloud computing*, *artificial photosynthesis*, and *vegan diet*. The differences in these three cases may highlight the strengths and weaknesses of the methodology.

This article starts with a description of the basic building blocks, i.e., innovation system, foresight, and the (societal) role of the media

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(Section 2). Then, Section 3 describes the framework of analysis while Section 4 introduces the three case studies. In Section 5, the results are discussed and final conclusions are drawn.

2. Foundations

This chapter points out the meaning of innovation, foresight, and innovation systems, with a focus on mass media and its impact on innovation and change.

2.1. Innovation system and foresight

Innovation and change are an outcome of systemic interaction. This non-linear process includes many feedback loops and is considered in its national (Freeman, 1987), regional (Cooke, 2001), sectoral (Malerba, 2002), and technological contexts (Bergek et al., 2008). Definitions of innovation systems highlight how the interplay of institutions influences technology and innovation (Freeman, 1987) and innovation systems are described as "*[…] all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovations* (Edquist, 1997)". These definitions emphasize the role of diffusion and interaction; therefore, the dynamics of these systems are most important. Among others, Hekkert et al. (2007) describe functions of innovation systems to measure system performance and dynamic interactions. These functions, such as *knowledge diffusion* or *market formation*, are important in assessing the performance of the system. On the other hand, understanding innovation systems and their dynamics and architecture is most relevant for future planning activities due to the close association between foresight, policy planning, and the performance of innovation systems (Alkemade et al., 2007). In this article, foresight is defined as a structured discourse about possible and plausible futures involving the relevant stakeholders. One of the basic assumptions underlying foresight is that the future is not predictable. However, thinking about possible future developments and related consequences may influence the present decisions that affect our future. Therefore, an in-depth analysis of current (technological) developments and their spread and societal acceptance is crucial. In principle, future technology analysis (FTA) and foresight can assist in reorienting and improving innovation systems and bringing together different stakeholders and actors (e.g., Martin and Johnston, 1999).

Aligning innovation system functions with FTA, the contribution of FTA (related to innovation policy) lays in "*[…] providing safe spaces for new ideas to emerge and existing knowledge to be combined in novel ways* (Cagnin et al., 2012)". This leads to a better understanding of future challenges and broadening of the knowledge base in decision making. Therefore, foresight may also serve as a framework for analysis. Apart from the debate on contributions of foresight to the analysis of the innovation system, the argument to consider foresight as a systemic process is strengthened. As Andersen and Andersen (2014) point out, foresight requires a systemic understanding because, otherwise, the impact of foresight is limited due to its weak conceptual understanding. So the context (innovation system) and the current dynamics should be taken into consideration for meaningful foresight.

2.2. Integrating media in the innovation system debate

While it is commonly agreed that innovation needs to be viewed systemic, the society as a framework or media as a distribution channel are no explicit elements of prominent definitions of innovation systems (Waldherr, 2008, 2012). For this reason, this article discusses the role of the media as diffusion channel and positions them in the innovation system debate.

The media contributes to our knowledge about the world (e.g., Luhmann, 2009). Thereby mass media has certain functions in society (e.g., Burkart, 2002). The most crucial one is the *information function*, which relates to neutral knowledge transfer as well as to influencing the formation of public opinion. The media distributes selected information to which it adds its own interpretation or version of truth (e.g., Kabalak et al., 2008). In addition, the media has a *critique and control function* in democratic societies, for scientific results as well (Franzen et al., 2012). Therefore, media mirrors public discourse and its evolution to a certain degree (see Stauffacher et al., 2015 for a comparable case).

As a matter of fact, media discourse may influence innovation processes (e.g., Waldherr, 2008). For instance, by reporting about new innovations and technologies, the media can influence and attract attention. Additionally, the media can influence public opinion by commenting on innovation (critique function of media). Furthermore, media has a recognized role in innovation diffusion (Rogers, 1995; Schenk, 2012; Karnowski, 2013). However, the literature on innovation systems does not acknowledge media's role as an intermediary between different actors, its functions in society, or its meaning for the spread of innovation. This article attempts to analyze and map the dynamics and processes of diffusion introduces an adapted model.

Waldherr (2012) argues that mass media is an important intermediary in the triangle of politics, economy, and research (see Fig. 2-1). Mass media enables public communication, while society is seen as the overall framework with three subsystems: economy, politics, and science. The link between media and the political system comprises political factors that influence the media. Further on, there is an exchange of money and attention between media and the economy, while media reputation is primarily relevant for firms. Additionally, economic actors learn about changing societal norms, values, and interests through media. And science needs public attention to build legitimacy and reputation.

Although this model is on a high aggregation level, it illustrates the core dependencies very well. Therefore, this model serves as a conceptual framework for the methodological part and the interrelation between societal and scientific discourse is analyzed in more detail in this work. So this article examines if it is possible to automatically compare news articles and publication abstracts and develops a method for this purpose. These two data sources are of comparable language and text quality and will therefore be used for a principal investigation. Of course, if the results show to be useful, the method can be developed further and further data can be integrated in future work.

3. Methodology: comparing datasets

Focus of the following section is to introduce a method that is able to automatically compare scientific and public discourse. A manual approach is too time consuming due to the size of the data sets. The method builds on scientific publications and news reporting. This section begins with a description of the preliminaries of publication analysis and media analysis as methodological base for this work, after which the analysis framework is introduced.

3.1. Publication analysis

Scientific publications describe the output of scientific work, thus providing a means to measure and assess scientific activity and performance. The statistical analysis of the publication data related to a specific theme or technology reveals insights on aspects such as trends, developments, and new research directions (see Leydesdorff and Milojević, 2015 for an overview). Publication analysis generally uses different data fields (e.g., year of publication, keywords, and abstracts) depending on the research interest. This work carries out text mining on the abstracts of the publications as summaries of the articles. This decision reduces the cleaning effort that is higher for full articles. Moreover, the text length of the abstract is comparable to the second type of data source—news articles.

Text mining is frequently used in publication analysis (Cunningham et al., 2006; Kostoff, 2012). This includes applications analyzing title, abstracts, and keywords (e.g., Glänzel, 2012) but also full texts (e.g., Glenisson et al., 2005). Concerning mapping of (technological)