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Development trajectory and research themes of foresight

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ABSTRACT

This study integrates the edge-betweenness clustering technique and key-route main path analysis to analyse the ‘broad foresight’ literature. We retrieve the relevant papers from the Thomson Reuters Web of Science databases and construct the citation network among them. The edge-betweenness clustering identifies six research groups in the ‘broad foresight’ literature. Three major research groups and their major research themes are ‘technology foresight’, ‘futures studies’, and ‘technology forecasting’. The other three are ‘scenario analysis’, ‘future-oriented technology analysis (FTA)’, and ‘technology forecasting using data envelopment analysis (TFDEA)’. We apply main path analysis to explore the overall development trajectory and the linkage among different research groups. We believe that the results are valuable for those who are interested in comprehending the overall development picture of ‘broad foresight’. The approach used herein is also applicable to other fields.

1. Introduction

Technology foresight has been widely studied over the past decades, but the current literature lacks a systematic review work that covers such a large amount of foresight articles. Researchers of this topic also often ask about what to research when looking at foresight. We believe that this is a tough question to answer well. Thus, this paper aims at exploring the overall development trajectory and identifying the major research themes of the foresight literature.

There are several terminologies that are relevant to foresight, including futures studies, futures research, forecasting, la prospective, and anticipation. Hereafter, we name them together as ‘broad foresight’. Some researchers argue that they are different themes, such as Sardar (2010) who emphasized that the term used to describe the study of alternative futures is important. Valaskakis (2010) suggested that la prospective is not futurism, forecasting, or even foresight. The futures studies of different countries are coloured by cultural and environmental differences, yet some researchers think that they are similar, but are used under different time periods or in different countries. For example, Inayatullah (2010) argued that different theories and methodologies have their own purpose and applications, and hence it is not necessary to be either for or against a specific term. Godet (2010) claimed that despite cultural differences, the concepts of la prospective and strategic foresight are very similar. Linstone (2010) considered that the debate on the terminology is a rather jejune pursuit. The maturity of information technology has triggered the convergence of the relevant terminologies.

Many researchers have conducted reviews on a specific term of broad foresight. They separately have looked at the development of forecasting (Martino, 2003; Meade and Islam 2006), foresight (Martin 2010; Miles 2010), and futures studies (Kuosa 2011). Martino (2003) reviewed the methods applied in technological forecasting and presented some advances in methodology. Meade and Islam (2006) examined the modelling development on forecasting innovation diffusion and found that the main applications are on consumer durables and telecommunications. Martin (2010) provided an insider's perspective on the origins of the concept of foresight. He adopted a case study to examine the uses of the concept of ‘foresight’ in the U.S. and Canada, as well as a similar concept of ‘la prospective’ in France to understand the origins and early evolution of technology foresight. Miles (2010) indicated that technology foresight took off in the 1990s and is far more officially acceptable and legitimate now. Kuosa (2011) discussed the evolution of futures studies and identified two existing paradigms and the emergence of a new one. While these researchers have all offered valuable concepts of broad foresight from different perspectives, there is still no article in the literature, up to now, that has reviewed ‘broad foresight’ together, thus potentially missing some important insights among them. This study puts all the relevant terms together to probe for some insights into broad foresight.

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This study targets to answer the following questions. What is the development trajectory of 'broad foresight'? What are the major research themes of 'broad foresight'? What are the relationships or linkages among the major research groups of 'broad foresight'?

2. Methodologies

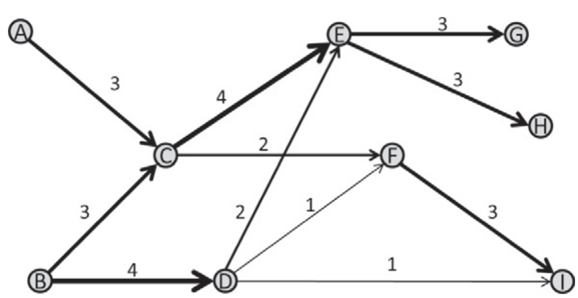
This study employs an integrated methodology, combining the edge-betweenness clustering technique and main path analysis, by retrieving the relevant papers and constructing the citation network among them. First, we use edge-betweenness clustering (Girvan and Newman 2002; Newman 2006) to the citation network in order to identify the major research groups and the citation linkage among them. Second, we apply the key-route main path analysis (Liu and Lu 2012) to explore the overall knowledge diffusion trajectory of the broad foresight literature and exhibit the relationship among the research groups. Third, we utilize the global main path analysis on the three medium-sized research groups to identify their development trajectories. We briefly describe the concept of main path analysis and edge-betweenness clustering below.

2.1. Main path analysis

Hummon and Doreian (1989) introduced main path analysis by proposing a procedure to identify the major development trajectory of a specific scientific field. The procedure for main path analysis is as follows. First, it constructs the citation network among the relevant papers of a scientific field. Second, it calculates the 'traversal count' for each link of the citation network. Third, it searches the main path according to the traversal counts. Many researchers have applied main path analysis to bibliographic citation data or patent citation data to explore the scientific or technological development trajectories (Lucio-Arias and Leydesdorff 2008; Moore et al. 2006).

Fig. 1 illustrates a simple example of a citation network to describe the concept of main path analysis. Each node represents a paper, and the link between two nodes indicates the citation relationship. A source node is a node that is cited but does not cite any other node in the network. A sink node is a node that cites other node(s) but is not cited. When one exhausts all the searches from all the source nodes to all the sink nodes, the search path count (SPC) of each link is defined as the total number of times the link is traversed.

The traditional main path is a 'local search', because it begins the search from all the source nodes and selects the link(s) with the largest SPC value for the next search until a sink node is reached. In Fig. 1, link B–D is selected first and then D–E, E–G, and E–H are chosen sequentially. The local main paths are B–D–E–G and B–D–E–H. One can find that the accumulated SPC value of the local main paths is 9 and is lower than that of paths A–C–E–G, A–C–E–H, B–C–E–G, and B–C–E–H. The accumulated SPC value of the latter ones is 10. It means that the traditional main path analysis has the shortcoming of missing some significant paths. Liu and Lu (2012) supplemented this by proposing several new types of main paths, including global and key-route main paths. The global main path is defined as the path with the largest accumulated SPC value. Here, A–C–E–G, A–C–E–H, B–C–E–G, and B–C–E–H are the global main paths generated under the definition.



Note: The thicker the line is, the higher the SPC index.

Fig. 1. A simple citation network with the SPC index.

Neither the local main path nor the global main paths include all the links with the largest SPC. The key-route main path is introduced to overcome this issue. The key-route main path is formed as follows: identify the links with the largest SPC as the key-route(s); trace backward from the start node of the key-route and forward from the end node of the key-route until a source or a sink node is reached; combine all the key-route(s), the generated forward searching paths, and the backward searching paths to compose the key-route main path. In Fig. 1, the key-route main paths are A–C–E–G, A–C–E–H, B–C–E–G, B–C–E–H, B–D–E–G, and B–D–E–H.

Combining the local, global, and key-route main path analyses, one can view the development trajectories from different perspectives. These new types of main paths have been applied to various fields and are demonstrated to be quite useful in understanding the whole picture of a theoretical or technological development (Liu et al. 2013a, 2013b; Lu and Liu 2013). Among these main paths, the key-route main path is able to exhibit the convergence and divergence phenomenon of a scientific development and is so far the most widely adopted main path.

2.2. Edge-betweenness clustering

Girvan and Newman (2002) proposed an edge-betweenness clustering technique to group networks. The betweenness of an edge is the number of the shortest paths between pairs of vertices that run along it. Edge-betweenness can be used to split a citation network into several groups. Fig. 2 illustrates the concept of edge-betweenness clustering. When links a, b, c, and d are removed, three groups are clearly identified. In a network, two nodes can be considered similar, or structurally equivalent, if they have identical links with all the other nodes. Under the context of this study, that means two articles pursue similar topics if they not only cite the same set of literature, but also are cited by another identical set of literature. Based on this assumption, Newman and Girvan (2004) demonstrated that edge-betweenness clustering is a feasible and useful approach to group a large-scale citation network (Newman 2004).

Newman (2006) further recommended the concept of modularity to decide the optimal structure of a network. The modularity is defined as 'the number of edges (links) falling within groups minus the expected number in an equivalent network with edges placed at random'. The optimal division of a network is the one with the largest network modularity. The procedure of edge-betweenness clustering is as follows. First, calculate the betweenness for all links of the citation network.

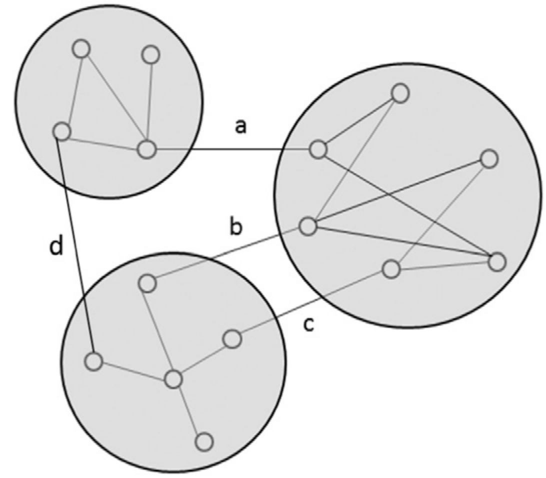


Fig. 2. Illustration of edge-betweenness clustering.