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An empirical enquiry into co-patent networks and their stars: The case of cardiac pacemaker technology

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ABSTRACT

Scientific research concerning R&D staff structures has already been based on networks as they are mapped by co-patent data. The present paper combines the method of patent analysis with network analysis techniques and shows by means of a patent sample from cardiac pacemaker technology, that the different communication functions a star inventor accomplishes in their network are mirrored not only by quantity, but also by quality of patents. The mere patent quantity has a significant positive impact on the size of an inventors' personal network and the number of inventors they can directly pass information to. But more importantly, there is significant empirical evidence that high technical specialisation has a positive impact on an inventor's potential to mediate between others as well as on the efficacy to reach them on short notice. For the latter, likewise the number of citations received is a positive predictor. Thus, we characterise stars as industrious, well-known technical specialists and contradict the general assumption that generalists would be the ideal gatekeeper in an R&D network.

1. Introduction

Co-patent networks are reflections of existing knowledge flows between companies, R&D departments or inventors. These networks display stars, who are important actors in their field of technology. Their early detection and development can be considered as main issues for HR management in R&D. However, the characteristics of stars within the surroundings of their co-patent networks have not yet been fully explored. Against this background, the present work engages in matching instruments of network analysis with patent analysis techniques. It seeks to determine patent predictors of star inventors in co-patent networks. The focal point is to answer the question if and to what extent patent quality characteristics mirror the different roles stars take in their network: their basic functions being the maintenance of large personal networks, the mediatorship between individuals and the ability to reach everybody on short notice. Patent research here insinuates that patent quality will furnish appropriate predictors that distinguish common inventors from stars. Especially the frequently employed predictor citations received, as well as the technical range inventors cover, and their ability to bridge geographical distances should explain the stardom of an inventor.

In the following paragraphs, Section 2 at first creates the theoretical framework of the present work. Section 3 introduces the methodical approach, whereas Section 4 presents an empirical example from the cardiac pacemaker technology. Section 5 gives a summarising conclusion. The results of this work help understanding the evolution of prominence in some inventors that we call stars within a technology field. By identifying the driving forces, HR management in R&D can support their selection processes by looking for specific characteristics of the candidates. Knowing which factors explain the emergence of the much sought for 'network capital', facilitates personnel selection, early development of inventors and appropriate team composition. The study thereby attempts to make a contribution to the empirical foundation of essential communication characteristics of R&D networks and their inventors.

2. Theoretical framework

2.1. Relevance and success factors of collaboration

Collaboration in R&D appears in many different forms. It can be formally arranged in teams or projects and it may likewise happen informally through unscheduled, random contacts or get-togethers. Collaboration takes place in order to work on scientific discoveries as well as to conduct clinical trials, beta testing or to realise the transfer of knowledge and resources between researchers. A minimum of two individuals working together can thereby be understood as collaboration (Mindruta, 2008). In

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this context, it is widely agreed that the increase of technical complexity and the challenges of globalised markets necessitate the extensive use of collaboration especially in R&D (Wuchty et al., 2007; Zhenzhong and Yender, 2008). This growing importance is underlined in patent statistics by the increasing number of inventors on patent documents. Considering for example patent applications at the German Patent Office in the last decade, the number of inventors has risen from 1.96 inventors per patent application (1995) to 2.32 within the next ten years (DPMA, 2005). Similar results could be obtained for American patents at the United States Patent Office, USPTO (Zhengzhong and Yender, 2008; Wuchty et al., 2007) as well as concerning patents of European and Asian countries (Hussler and Rondé, 2007; Zhenzhong and Yender, 2008). The main advantages of collaborative work are possible synergies and cross-fertilisation, as well as the natural increase of creativity and cross-thinking between collaborators (He et al., 2009).

There are different factors that facilitate or promote the collaboration of companies or inventors.

First and foremost, scientific popularity, visibility and recognition are promoting factors for the emergence of collaboration and professional excellence. Outstanding reputation will lead to increased willingness of others to collaborate. Companies as well as inventors attract valuable collaboration partners more easily, the better their reputation presents itself and the better known in their technological community they actually are (Merton, 1968). Companies that for example support collaboration between industry and academia may especially attain image effects based on academic involvement and thus make themselves more attractive for future company alliances or as future employers. More than that, company collaborations with academic researchers usually entail higher quality than company to company collaborations (Balconi et al., 2004; Mindruta, 2008).

In addition, the degree of specialisation as well as the need for complimentary knowledge influence the inclination to collaborate (Balconi et al., 2004; Mairesse and Turner, 2005). The higher a company's specialisation and the subsequent need for partners with different technological backgrounds, the more will they seek contact to their counterparts. In this context even geographical distances matter less, the more specialised and demanding the sought for knowledge is (Hussler and Rondé, 2007). The technical fit is most important, since the search for collaborators is not random, but a strategic process. In this process partners sort themselves by attributes which are relevant for the respective innovation (Mindruta, 2008).

Third, geographic proximity plays an important role. Researchers naturally have a higher propensity to collaborate when working in the same laboratory or in the same region than if they were further apart. Knowledge exchange becomes easier once the inventors face no or only marginal spatial barriers. It can therefore be important for companies, to locate in regions where there are similar or complementary technological specialisations to their own, from which they can benefit. Likewise should inventors and research departments who are to collaborate on a regular basis, not be separated by large geographical distances. This holds for company to company collaborations as well as for collaborations within a company (Hussler and Rondé, 2007; Mairesse and Turner, 2005; Zucker et al., 2006).

2.2. Characteristics of co-patent networks

Co-patenting can be understood as a visible result of inventive collaboration in R&D and signifies that an inventor is listed on a patent not on his or her own, but with at least one other inventor. Collaboration in this sense is the tracking of work relations, or even more precise, information channels, along which information has flown in the process of patenting an invention. Literature distinguishes co-patent networks and co-publication networks. While the former focus on inventors and their patents, the latter are dedicated to researchers and scientists who publish their work in scientific literature. Co-patenting is held more relevant for industry researchers, i.e. applied research, whereas publications are more prominent among academia. The examination of these collaboration activities helps the mapping of ties within technology fields and depicts knowledge maps that could hardly be traced outside a company or institution but with publicly available patent or publication data (Balconi et al., 2004; Hussler and Rondé, 2007; Mina et al., 2007).

Despite the objection that patents are by definition static and possibly incomplete criteria to measure knowledge flows (since there may be many non-patentable work results), they offer the next best solution when company internal information about communication, work or social structures between individuals is absent. This will be regularly the case when external researchers examine collaboration structures in R&D, when companies monitor competitors or if within a company relevant communication information remains undisclosed or incomplete. Patents mirror the results of collaboration that appears always within a social context. In the process of inventing, the social links an inventor has influence their decisions substantially. Social interaction like leadership effects and peer effects in their research group play an important role concerning collaboration structures and disclosure of knowledge (Bercovitz and Feldman, 2004). The method of extracting information from patent statistics thus cannot be doubted generally; the variety of patent studies is reference for that. On the contrary, there is even empirical evidence that structures around inventors examined by patent statistics are largely identical with structures revealed by expert surveys in R&D. In a study by VITT for instance, members of R&D departments name in interviews the same inventors as key inventors in their technology field, who could before be identified externally by patent statistics (Vitt, 1998).

As regards the characteristics of co-patent networks, they generally show high fragmentation at the beginning of their emergence, but become increasingly connected and less fragmented over time. They consist of different components in which every inventor can be reached by another (i.e. there the graph in one component is connected), but the components are not connected among each other. The more components there are, the more fragmented is the co-patent network. A component minimum depicts collaboration links resulting from 1 patent. In this case a co-patent network would consist of as many components as there are patents. A component at most covers all patents and inventors of a technology field, which will however practically rather not be the case. Still there is empirical proof that the main component covers the majority of actors, only a minority is usually disconnected or part of the smaller components (Barabási et al., 2002; Cotta and Merelo, 2007; Heinze, 2006; Liu et al., 2005; Newman, 2001, 2004). Components are thereby defined as subsets of actors who are connected to each other, but not with the rest of the network. The main component is the largest of these subsets (Wasserman and Faust, 2007).

While there are only few pioneers in the introductory stage of an industry, many inventors enter the network in the growth stage and thenceforth (Haupt et al., 2007). Network theory shows in this context, that during the evolution of a network new links are added according to two basic principles: time and preferential attachment. Thus, the 'oldest' inventors have a good chance to be the centres of their respective co-patent network. Likewise the inventors with many links benefit from a great chance to generate