

NETWORKS OF INVENTORS AND ACADEMICS IN FRANCE

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1. MOTIVATION AND RESEARCH QUESTIONS

University patents have been studied intensively over the past twenty years. Recent contributions from Europe have revealed that, no matter how small patent portfolios of European universities may be compared to those of their US counterparts, European academic scientists contribute greatly to inventions that are then patented by business companies and, to a lesser extent, by large public research organizations (Verspagen, 2006, Lissoni et al. 2008).

However, the role of academic scientists who contribute to patenting as inventors matters not only for the sheer number of the patents they produce, and their weight on total patents in a country and/or technological field. More important it is the relationship that academic scientists entertain with their co-inventors, many of whom come from industry or were students at the time when the patent was taken. More broadly, one may wish to investigate the academic inventors' standing in the overall technological community.

Such standing and the interaction with co-inventors may be revealing of how much information and knowledge academic inventors are in the position to pass on, or absorb from, technologists active in the invention process. Are academic inventors central to the communities of researchers contributing to the advancement of a given field? Is their presence necessary to connect people who would otherwise never exchange information and knowledge?

In this paper we build upon Balconi's et al. (2004) methodology in order to map the networks of inventors in France. We exploit the French section of the KEINS database complemented with the novel dataset on CNRS inventors collected following the KEINS methodology.

2. DATA

Data for building the networks of French inventors come from the EP-INV database produced at KITeS-Università Bocconi, which contains all the patent applications filed at the European Patent Office (EPO) since 1978, reclassified by applicant and inventor. An important subset of the EP-INV database is the KEINS database, which identifies "academic inventors" and provide information on their affiliation as well as (if available, depending on the country) on discipline, gender, date of last promotion, and date of birth. For the purposes of this and related papers, the French section of the KEINS database was complemented with information on CNRS inventors, also collected following the KEINS methodology.

Academic inventors are responsible for 2715 patent applications and CNRS researchers for 1715 applications, which amount respectively to 3.45% and 2.18% of all domestic patent applications at EPO. The most science-intensive fields (*Instruments, Chemicals & Materials, and Pharmaceuticals & Biotechnology*) are also those where public research is the most relevant for inventive activity. Inspection of the applicants' identity reveals that by and large academic patents are owned by business companies, rather than universities or other public research organizations.

3. NETWORKS OF INVENTORS AS SMALL WORLDS

Patent and inventor data lend themselves to be transformed into "affiliation networks" (also known as "two-mode" networks). The latter are bipartite graphs with two types of nodes: actors and events, where actors are linked to events in which they participate. In our case actors are the inventors and the events correspond to patent applications.

Affiliation networks, in turn, can be used for deriving corresponding "one-mode" networks in which actors are directly connected, based on the assumption that all actors affiliated to the same event are also in direct contact. Following the methodology outlined in Balconi et al. (2004) we projected the bipartite network of patents and inventors onto the set of inventors, under the assumption that all inventors of the same patent have direct links with each other.

Networks of inventors appear to be highly fragmented, as they are composed of a large number of distinct components. However, in the five technologies with a higher presence of academic and CNRS inventors we see that the largest component is much larger than all others, including the second largest one. This suggests some resemblance with networks of scientific collaborations, as measured by co-authorship of scientific papers, which in turn present some characteristics typical of "small-world" networks (Newman, 2001)

To investigate further in this direction, the paper produces two tests: a small-world ratio measure adapted to networks of inventors; and a "rewiring-based" test . The results of these tests suggest that four out of five of our inventor networks considered (one for each science-intensive technological field, and high presence of academic and CNRS inventors) have small world features.

4. ACADEMICS IN INVENTORS' SMALL WORLDS

We finally investigate whether it is precisely academic and CNRS inventors who provide the out-of-cluster connections that typically transform a regular graph into a small world.

We first we examine some measures of academic inventors' position (centrality) in the largest component of each technological field, with respect to all the inventors in the component. Then, we

identify cohesive subgroups and point at the importance of academic and CNRS inventors in providing a connection between them.

We find that, measured by average betweenness, closeness and degree centrality scores (respectively B_{CENT} , C_{CENT} and D_{CENT} , academic and CNRS inventors tend to occupy more central positions than the average inventor, both locally (D_{CENT}) and globally (B_{CENT} and C_{CENT}).

As for size of research teams, we find that the mean size of inventors' teams in science-intensive technologies (where academic patenting is more relevant), is larger than average, because inventions are more likely to result from a collective effort rather than from a solitary one. In addition, in all technological fields the size of academic teams tends to be larger than the average team size for the field. This may suggest that, even within science-intensive technologies, patents produced by academic teams are more science intensive than others, and this intensity shows up in the team size.

These results are proved to be compatible with the facts that academic and CNRS inventors move across teams more often than researchers in industry, who (for obvious contractual reasons) tend to keep working for long within the same teams, for the same company. That is, a disproportionate number of "mobile inventors" are academic and CNRS inventors.

5. CONCLUSIONS

The literature on social networks suggest that positions such as those taken by academic inventors in the networks examined here are indicative of an important role in the mediation and diffusion of information and knowledge. Breschi and Lissoni (2004), for example, make use of patent citations as indicators of knowledge diffusion and find that the distance between any two inventors in the same network greatly affects the probability of a citation link to exist between the two inventors' patents. To the extent that academic inventors, being central, are also relatively close to many other inventors in the network, one can expect their patents to be widely cited, and information therein widely diffused.

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