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Title and Abstract

Title

The role of scientific and market knowledge in the inventive process: evidence from a survey of industrial inventors

Abstract

This paper investigates the role of external knowledge in the patenting activity of inventors that work inside firms, i.e. industrial inventors. It does so with the aim of showing that inventors who follow an 'open innovation paradigm' (Chesbrough, 2003) in their knowledge sourcing strategies by combining the use of different sources of knowledge, i.e. scientific and market sources, display a better performance than those who do not. The creation of innovation inside firms is based on the recombination of new and existing knowledge inside organisations. In fact, it is nowadays well established that knowledge that is internal to the firms, though being essential, is not sufficient (see e.g. Allen & Cohen, 1969; Allen, 1977; Arora & Gambardella 1990; Cassiman & Veugelers, 2006 and 2007; Chesbrough, 2003; Tijssen, 2002; Utterback, 1971). In order to successfully produce innovation and stay competitive on the market, firms need to tap into knowledge that rests outside their boundaries. External-to-the-firm knowledge is supplied by a wide range of actors with different characteristics – hence providing different types of knowledge – that make up the innovation network in which firms are embedded (Etzkowitz, 2003). In particular, it is possible to distinguish scientific knowledge, supplied by scientific actors, such as universities and research centres, and technical knowledge, supplied by market actors – and for this reason referred to as market knowledge – such as other competitor firms, suppliers, clients and customers (Von Hippel, 1988). Scientific knowledge is usually disconnected form the market and its purpose is to foster technological progress by producing new knowledge and technology (Etzkowitz, 2003; Fleming & Sorenson, 2004), whereas market knowledge is more applicative, aims at addressing specific users' problems and is, by definition, market-oriented (Cohen, Nelson, & Walsh, 2002). Because of these characteristics, scientific knowledge is seen as fundamental for the idea-generation phase of the innovation process, whereas market knowledge is essential for the technical realisation of a given innovation (see e.g. Aghion, et al., 2008; Frenz & Ietto-Gillies, 2009; Hagedoorn, 1993; Tijssen, 2002; Utterback, 1971).

The empirical evidence on the knowledge sourcing strategies of firms and how such strategies relate to the innovative outcome is vast, though not fully conclusive yet. Both complementarity and substitutability between internal

and external knowledge, as well as between different types of external knowledge, have been found, depending on a number of different factors, including firms' characteristics and the proxy used to measure the knowledge type and/or source (see e.g. Arora & Gambardella 1990 and 1994; Cassiman & Veugelers, 2006 and 2007; Frenz & Ietto-Gillies, 2009). This can be suggestive of the need to get a closer look at the role of knowledge by exploiting a finer unit of analysis, such as the individuals inside the firms. Indeed, more recently – with new and better data at individual level – the empirical evidence has looked at the role of knowledge for the individual who is responsible of the innovative process, i.e. the inventor. A number of papers that use the information provided by patents and by surveys of inventors (both inventors employed by academia and by firms) shed new light on the factors that influence the inventor's patenting activity, including individual characteristics, such as education and age, as well as job mobility and the existence of knowledge exchange with other organisations (see e.g. Giuri & al, 2007; Hoisl, 2007; Mariani & Romanelli, 2007; Pasquini et al, 2012; Schneider, 2009). However, the comparison of the contribution of different sources of knowledge has not been widely studied yet, hence leaving some unanswered questions.

This paper will focus on the individual who is primarily responsible for the inventive activity inside the firm, namely, the patent inventor. Innovation is indeed not simply the product of firms and organisations, since it ultimately requires individual creativity. In addition, patents are commonly recognised as creative output (Huber, 1998; Meyer, 2002) and therefore they may represent the right innovative outcome to look at. The aim of this paper is to show that scientific and market knowledge sources are complementary for the patenting performance of industrial inventors. I will test the hypothesis that the joint use of scientific and market knowledge has a higher impact on the inventor's performance than the separate use of each of the two knowledge sources. In other words, in line with the open innovation paradigm (Chesbrough, 2003), I expect that inventors drawing upon a higher number of knowledge sources – therefore having an "open" search strategy – display better performances than inventors who do not. In addition, the role of individual, patent and employer's factors will be studied.

The novelty of the present study lies, in first place, in the focus on the individual innovator as unit of analysis, instead of the firm, which is the most used unit of analysis for these types of studies. In addition, this paper exploits an original data source that combines the results of a very recent survey of industrial inventors carried out in three European regions with patent data from the European Patent Office (EPO). The aim of this survey is to explore the inventive process of industrial inventors in order to provide new insights about the demand of knowledge expressed by the actors directly involved in the innovative process. Whereas previous literature has mainly relied on proxies for the linkages of inventors to knowledge sources, this survey data is likely to provide a better indicator since inventors were explicitly asked questions on the use of knowledge sources in the inventive process.

In the empirical analysis, inventors' quantity and quality measures will be estimated as a function of the inventor's knowledge sourcing strategies, controlling for individual-level characteristics as well as patent- and firm-level determinants. This is also known as the productivity (or direct)

approach (Cassiman & Veugelers, 2006) and will be estimated with ordinary least squares with robust standard errors. This approach has been widely used in the management literature to analyse the relevance of knowledge flows for firms and is, to the best of the author's knowledge, one of the first attempts to apply it at the inventor's level. Four knowledge sourcing strategies (independent variables) will be measured from the inventors' responses to one question of the survey: (1) using only scientific knowledge, (2) using only market knowledge, (3) using both scientific and market knowledge, (4) using none of them. The absolute number of patent applications (both granted and non-granted patents) will be used to quantify the inventor's patenting activity, whereas two different measures will be used to investigate the quality of the inventor's patents (dependent variables). From the count of citations received by each patent (forward citations), the average number of citations across each inventor's patents will be calculated, along with the number of citations received by the most cited patent (i.e. the best invention). Furthermore, as a robustness check, an alternative measure of quality will be created by weighting the forward citation counts of each patent for the average number of citations received by patents in the same technological class. Individual-level control variables include inventor's gender, age, education level, job mobility and job position inside the firm; at patent level, the share of foreign patents and co-inventing behaviour are controlled for, along with firm fixed effects to account for firm unobservable characteristics and a control for multinational enterprises.

The findings show that there is a significant and positive relation between both quantity and quality of inventors' patenting activity and the joint use of scientific and market knowledge, supporting the hypothesis that inventors merge the technological potential of scientific knowledge with the market potential of market knowledge to produce more and better inventions. These findings are stronger for inventors' productivity (quantity) than for their quality. In particular, the sole use of knowledge from market sources is significantly related to the quality of inventors in some of the estimations, showing that inventors' quality may benefit from inter-firms relations only. On the other hand, the separate use of scientific sources of knowledge does not seem to have any relation with inventor's performance. Furthermore, mobile inventors seem to benefit more than non-mobile ones from external knowledge, most likely because of their greater openness towards external-to-the-firm organisations. The robustness check further shows that, when accounting for the uneven distribution of forward citations across different patent technological classes, the findings are consistent with the baseline estimations. The findings of this paper are interesting because tracing a positive link between the use of external knowledge form different sources and the inventive process inside firms is relevant for research as well as for policy - considering that knowledge exchange across organisations is at the core of innovation and development policies in most regions and countries.