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ScienceDirect
Research Policy 36 (2007) 1128–1142
research policy
www.elsevier.com/locate/respol

"Stacking" and "picking" inventions: The patenting behavior of European inventors

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Received 13 February 2006; received in revised form 28 February 2007; accepted 4 July 2007
Available online 12 September 2007

Abstract

By using a sample of 793 inventors drawn from the PatVal-EU dataset, this paper explores three aspects of patent production at the individual inventor level: (1) the number of EPO patents that the inventors produce; (2) the average value of their inventions; (3) the production of the most valuable patents. By jointly estimating the three equations we find that the inventors' level of education, employment in a large firm, and involvement in large-scale research projects positively correlate with *quantity*. Yet, apart from the size of the research project, none of these factors *directly* influence the expected *value* of the inventions. They do, however, have an *indirect* influence, as we find that the number of patents explains the probability of producing a technological hit (the maximum value). Also, there is no regression to the mean in the invention process at an individual level, as the number of inventions that an inventor produces is not correlated with the average value.

Keywords: Inventor; Productivity; Number of patents; Patent value

1. Introduction

Invention and human capital are key factors for the growth of firms and for economic growth more generally. Yet, little is known about the key actors in this process – the industrial inventors – and the determinants of their productivity.

Traditional contributions focus on scientists and use scientific publications as a measure of their research output (for an overview, see Stephan, 1996). They show that the distribution of the scientists' productivity is skewed (Lotka, 1926; De Solla Price, 1963; Allison and Stewart, 1974; Turner and Mairesse, in press), and that age and vintage matter, with scientists becoming less productive as they get older (Oster and Hamermesh, 1998; Levin and Stephan, 1991; Cole, 1979). This holds after controlling for individual fixed effects that proxy for differences in motivation and ability. Our knowledge about industrial inventors is sparser. The difficulty to obtain information about individual inventors has prevented previous research from performing systematic empirical studies on this matter. The existing evidence is based on small samples, specific industries and firms (e.g., Narin and Breitzman, 1995; Ernst et al., 2000; Tijssen, 2002).

By relying on novel and detailed information from a large sample of European inventors (PatVal-EU, 2005), our paper explores the determinants of the *quantity* and *value* of the patents that they produce. In fact, inventors' productivity may take various forms. While the number of patents that they develop is one form, the inventors often acquire visibility for the technological

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doi:10.1016/j.respol.2007.07.009

and economic importance of their inventions, and sometimes their reputation depends on one or several, major achievements (Jones, 2005). This calls for an indicator of the technological and economic importance of the inventions. We start by using the number of citations that the patents have received within 5 years of their publication date (i.e., forward citations). Alternatively, by combining different patent indicators, we extract a composite index – i.e., a common component – that proxies for the technological and economic importance of the inventions, as in Lanjouw and Schankerman (2004). We then measure inventors' research output as follows:

1. Number of patents that the inventors contributed to inventing and that were applied for at the European Patent Office (EPO) in the period 1988–1998.
2. Average value of these inventions as measured by the average number of forward citations across each inventor's patents, and alternatively, by the average common component indicator.
3. Maximum value of the patents invented by the individual inventor, i.e., the inventor's patent with the largest number of forward citations, and alternatively, with the highest level of the common component indicator.

The empirical investigation uses a sample of 793 European inventors. Information on individual characteristics is drawn from the PatVal-EU survey that interviewed the inventors of 9017 EPO patents with a priority date in the years 1993–1997. Information on all the patents that the 793 individuals contributed to inventing and that were applied for at the EPO in 1988–1998 is collected from the EPO database. We jointly estimate three equations at the inventor level with (1)–(3) above as dependent variables. Our covariates are individual, firm, industry, and country characteristics. To identify the effect of the number of patents on the expected average and maximum value of the inventions we exploit information contained in the variance–covariance matrix of the residuals of the system of three equations.

The paper is organized as follows. We first provide an overview of the background literature in Section 2. Then we present the data, describe the estimation procedure, and show the results of the empirical tests (Sections 3–5). Section 6 summarizes the results and draws some conclusive remarks.

2. Background literature

The determinants of research productivity over a researcher's life cycle have been studied in the economic literature as well as in other disciplines. Pioneering work by Lotka (1926) shows that research productivity is concentrated among only a few individuals, regardless of the scientific field. Other authors confirm these findings and explain them with differences in the distribution of ability among scientists, and with the allocation of recognition and resources to the most productive individuals that make them even more productive – the "Matthew Effect" – whereby an initial success entails increasing productivity and reputation (Merton, 1968; Allison and Stewart, 1974; Cole, 1979; David, 1994).

Yet other authors show that age matters in many disciplines with older scientists becoming less productive (Dalton and Thompson, 1971; Goldberg and Shenhav, 1984). Levin and Stephan (1991), for example, examine the research productivity of scientists over their life cycle in six scientific areas, and find that it declines over time. Oster and Hamermesh (1998) follow the careers of 208 economists in the economic departments of 17 top research institutions who received PhD degrees between 1959 and 1983. They provide evidence that publishing diminishes with age. They also demonstrate the presence of persistent heterogeneity among individuals: the most productive economists early in their careers keep producing high-value research (though at a lower rate) as they become older. In a cross-section analysis of American scientists, Cole (1979) finds that age is concavely related to the quantity and quality of their productivity. Turner and Mairesse (in press) explore the differences in productivity among French condensed matter physicists between 1986 and 1997 in terms of the number and impact of their publications. They find a strong impact of individual and institutional characteristics. For the same sample of scientists, Hall et al. (2005) try to disentangle the impact of cohort, age, and period effects on researcher productivity.

Existing evidence about industrial inventors is much more limited compared to academic scientists, and it is based on small-scale samples, and specific industries and firms. Narin and Breitzman (1995) tested Lotka's inverse square law of productivity on a sample of inventors in the R&D departments of four companies in the semiconductor industry. Similarly, Ernst et al. (2000) studied the research productivity of inventors in 43 German companies, both in terms of quantity and value of their patents (see also Ernst, 1998 for a study at the firm level).[1] This literature confirms that the distribution of

[1] From a different point of view, Breschi et al. (2007) investigate the relationship between publishing and patenting by Italian academic inventors and find a strong and positive relationship between the two research outputs.