Journal of Economic Behavior & Organization 84 (2012) 550–570

Contents lists available at SciVerse ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

Individual preferences, organization, and competition in a model of R&D incentive provision☆

Nicola Lacetera[a,*], Lorenzo Zirulia[b]

[a] University of Toronto, Canada and National Bureau of Economic Research, USA
[b] University of Bologna, KITeS, Bocconi University, Rimini Centre for Economic Analysis, Italy

ARTICLE INFO

Article history:
Received 30 March 2011
Received in revised form 2 July 2012
Accepted 5 September 2012
Available online 13 September 2012

Keywords:
Incentive provision
R&D activities
Economics of science
Product market competition

ABSTRACT

Understanding the organization of R&D activities requires the simultaneous consideration of scientific workers' talent and tastes, companies' organizational choices, and the characteristics of the relevant industry. We develop a model of the provision of incentives to corporate scientists, in an environment where (1) scientists engage in multiple activities when performing research; (2) knowledge is not perfectly appropriable; (3) scientists are responsive to both monetary and non-monetary incentives; and (4) firms compete on the product market. We show that both knowledge spillovers and market competition affect the incentives given to scientists, and these effects interact. First, high knowledge spillovers lead firms to soften incentives when product market competition is high, and to strengthen incentives when competition is low. Second, the relationship between the intensity of competition and the power of incentives is U-shaped, with the exact shape depending on the degree of knowledge spillovers. We also show that the performance-contingent pay for both applied and basic research increases with the non-pecuniary benefits that scientists obtain from research, while the fixed component decreases. We relate our findings to the existing empirical evidence, and also discuss their implications for management and public policy.

1. Introduction

The management of scientific workers and the design of effective incentives for them are considered key determinants of competitive success,[1] but present numerous challenges for companies. A major organizational decision concerns whether to provide high-powered incentives based on the scientists' performance, or to soften incentives instead and let the researchers' quest for reputation drive their effort. Another difficulty is how to measure performance in the first place, as research is a complex activity with no necessarily immediate returns (Holmstrom, 1989). A further set of issues regards how the characteristics of the markets where a company operates, and in particular the level of competition and knowledge appropriability,

☆ We are grateful to Ajay Agrawal, Kevin Boudreau, Ramon Casadesus-Masanell, Erika Färnstrand Damsgaard, Ramana Nanda, Heather Royer, Mark Schankerman, Justin Sydnor, Neil Aaron Thompson, Henry Sauermann and seminar participants at the 2010 Harvard Business School Strategy Conference, Boston University, Georgia Tech, the EARIE 2007 Meeting, the EEA 2008 Meeting, University of Bologna, KITeS Bocconi University, University of Naples Federico II and 2010 DRUID Conference for their comments and suggestions. Tina Chen provided excellent research assistance.

* Corresponding author. Tel.: +1 416 978 4423.
E-mail addresses: nicola.lacetera@utoronto.ca (N. Lacetera), lorenzo.zirulia@unibo.it (L. Zirulia).

[1] Andersson et al. (2009), Dennis (1987), Garnier (2008), Henderson and Cockburn (1994), Lamoreaux and Sokoloff (1999), Lerner and Wulf (2007), Sauermann and Cohen (2008), Zucker and Darby (1995).

0167-2681/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jebo.2012.09.001

affect the type and strength of incentives. Understanding how companies motivate scientific workers is of importance also for policy makers. Key industrial policy questions include how to design competition laws and intellectual property regimes that elicit incentives to innovate for firms, and therefore affect the types of incentives companies offer to their researchers, while not curbing the dissemination of knowledge.

In fact, these issues point to broader challenges for both scholars and practitioners. All major organizational problems require the considerations of multiple levels of analysis: individual characteristics such as talent and tastes (Sauermann et al., 2010; Stern, 2004); organizational capabilities and structure, including the incentive system (Henderson and Cockburn, 1994; Holmstrom, 1989; Holmstrom and Milgrom, 1994); and the characteristics of the relevant industry, in particular the competitive pressure (Porter, 1980; Raith, 2003; Schmidt, 1997; Turner et al., 2010). Although the importance of all of these dimensions is often recognized, research that tries to integrate them in one framework is limited.

In this paper, we develop a model to show that not only all of these dimensions affect the determination of incentives to company scientists, but that these different factors interact in interesting ways. The model is developed in Section 2, and includes four key aspects. First, scientists engage in multiple, different activities (Cockburn et al., 1999). Second, the outcome of research activities, knowledge, is only imperfectly appropriable (Arrow, 1962; Spence, 1984). Third, scientists are responsive to the provision of monetary incentives, but they also care about non-material outcomes, such as their reputation among peers (Dasgupta and David, 1994; Merton, 1973). Fourth, the provision of incentives to scientists, and to all workers in general, is likely to depend on the conditions that a firm faces in the product market, such as the intensity of competition (Raith, 2003; Schmidt, 1997).

In the model, two firms compete in an industry by offering differentiated products, and design incentives for their scientists (simplified to be a single agent per firm) to invest in cost-reducing research. Scientists engage in two types of efforts. The first kind of effort – which we call applied (or proprietary) research – does not provide non-pecuniary benefits to the scientists and does not generate knowledge spillovers to the rival firm; the second kind of effort – we call it basic (or open) research – provides non-pecuniary benefits to scientists but spills over to the rival firm. The firm's owners offer a wage contract to the scientists contingent on observable outcomes. The outcomes can include, for example, patents and scientific articles.

In Section 3 we discuss the results of the model, characterizing the optimal incentive contract for the scientists. The first set of results highlight how the provision of incentives for basic and applied research depends not only on the intensity of competition and the degree of knowledge spillovers, but also crucially on the *interaction* between these two environmental conditions. High knowledge spillovers do not necessarily reduce the incentives to perform research: if competition is low, then firms provide high-powered incentives for both basic and applied research, since their dominant position in the product market reduces the negative effects of spillovers while allowing firms to enjoy each other's produced knowledge. With high competition, not only do we derive that incentives for basic research effort decrease as spillovers become more pervasive; we also show that it is optimal to mute incentives for applied research effort, even if it does not generate spillovers. In turn, the impact of product market competition on the strength and direction of R&D incentives depends on the degree of knowledge spillovers. If knowledge spillovers are low, firms provide the strongest incentives for basic and applied research both when they face very little competition (since cost reduction through R&D has a bigger absolute impact on profits), and when competition is very high (for competitive pressure makes any small cost reduction a proportionally large one, because profits are lower). Thus, the relationship between the intensity of competition and the power of incentives to scientists is U-shaped. In contrast, when there are high levels of spillovers, the strength of incentives is decreasing in the intensity of competition. A further implication of these findings is that incentives for basic and applied research are complementary only if either the level of product market competition or the degree of spillovers is low.

The second set of results concern the impact of a scientist's non-monetary motivation to perform basic research, or taste for science, on her pay scheme. The response of scientists to steeper incentives is stronger when they also have high intrinsic motives to perform basic research. As a consequence, companies optimally provide stronger incentives to intrinsically motivated scientists, both for basic research and applied research, even if the latter does not generate non-monetary benefits to the scientists. We show, in contrast, that a trade-off can occur between the fixed component of pay and non-monetary rewards.

An implication for empirical research is that studies of the determinants of incentives to scientists need to account for such environmental conditions as the degree of product market competition and of appropriability of knowledge, and need to analyze separately different components of wages, e.g. fixed and contingent pays, as they might respond differently to certain individual or environmental changes. We also interpret a number of existing empirical studies in light of our findings.

The model in this paper is, to our knowledge, the first one to analyze the effects of product market characteristics on incentives for effort (in research activities) where effort is multi-dimensional and the agents have preferences or tastes for certain activities. The building blocks of the model here have been established by an extensive literature. There is, in particular, a vast literature investigating the relationship between competition and managerial efficiency (e.g., Raith, 2003; Schmidt, 1997) and between competition and innovation (among the most recent contributions, see Sacco and Schmutzler, 2011; Schmutzler, 2010; Vives, 2008). Baggs and de Bettignies (2007), moreover, link these two streams of literature by developing a model where they isolate the agency effect of competition from the direct pressure effect, which is present independent of agency costs. Some papers consider also the presence of knowledge spillovers in R&D investments (Qiu, 1997;