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Organization of innovation and capital markets



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ABSTRACT

This paper develops a theory of the firm scope where not only research but also ordinary production employees can generate inventions. Separating research from production (“specialization”) solves the two-tier agency problem of inducing simultaneously research effort and managerial truthful-reporting but is costly when capital markets are imperfect. Improvements in capital markets, therefore, promote specialization, allowing a greater number of specialized firms to be established and also enabling them to undertake innovative projects with larger potential outcomes. Moreover, this capital market improvement effect is stronger for innovative activities that are less capital-intensive and that have weaker synergies with existing production activities. The model can help us understand the explosion of small company innovation in the U.S. since late 1970s and the contribution of venture capital to this change.

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1. Introduction

We know that innovative activities occur inside different organizational forms but we do not know precisely what motivates these choices and how these choices affect the productivity of innovation. Moreover, the choice of organizational form changes over time, presumably as a result of the need to effectively cope with the ever-changing challenges of the business environment. During the past few decades, for example, there has been a dramatic shift in the importance of small-scale firms

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in innovation in the U.S.: The National Science Foundation (NSF) data show that the share of R&D performed by small firms (defined as firms with less than 500 employees) has increased steadily from below 5% in 1980 to nearly 20% in 2001 and stabilized around that level afterwards. Furthermore, the shift towards small firms in innovation is more pronounced in some sectors than it is in others: The share of biotechnology R&D performed by small firms increased from under 3% in 1984 to roughly 40% in 2003. Understanding the forces that determine when innovation is undertaken by small companies and when by large corporations is of great interest to academics and policymakers alike.

In this paper, I investigate how imperfections in capital markets affect and are related to the organization of innovation. To this end, I compare two organizational arrangements for innovative activity. Under *integration*, R&D is carried out in a firm together with ordinary production activity, whereas under *specialization* (or *non-integration*), R&D is isolated from production activity. In making this comparison, I depart from most studies in the literature by explicitly taking into account the fact that an innovative venture typically requires the collaboration of (at least) three types of players: Suppliers of funds, agents who use those funds on the suppliers' behalf, and agents who carry out the actual innovative task. As I will explain shortly, the involvement of three different players can give rise to a *multi-tier agency problem*, the severity of which may critically depend on the organizational form.

The formal question I am after in this paper can then be formulated as follows: What are the costs and benefits of specialization (or integration) in research environments with multi-tier agency problems? And, how are imperfections in capital markets related to these costs and benefits and hence to the choice of organizational form?

To answer this question, I develop a theoretical model in which development of new technologies and products requires the collaboration of investors, managers, and workers. Workers are either research workers (*scientists*) who must exert costly effort to obtain with some probability a valuable invention or ordinary production workers (*production engineers*) who perform routine production activities. Moreover, scientists are either *talented* or *untalented*, and only a talented scientist has a positive probability of making an invention. On the other hand, a stand-in investor acts on behalf of all investors. This investor has funds but lacks the ability to separate talented scientists from untalented ones. She therefore employs a manager, who with costly effort, can undertake this task on her behalf. Both the manager's and scientists' efforts are their private information; and this gives rise to a two-tier moral hazard problem for the investor.

I make two additional assumptions in the model which fully characterizes the economic environment. The first is that production engineers may independently discover, by pure luck, with some probability an invention which is a substitute of the invention that could be obtained by the researcher. I further assume that this probability is greater when engineers are able to communicate more frequently with scientists. That is, I allow for the possibility of technological synergies or complementarities between research and ordinary production activities. The second and final assumption I make is that the investor can observe only the aggregate output of a manager and his team. A manager, on the other hand, can observe both the aggregate output and the individual outputs for the activities under his supervision thanks to his direct involvement with his employees.

This theoretical setup allows me to study the costs and benefits of different organizational forms for innovation, that is, integration and specialization. Abstracting initially from financial imperfections and technological synergies between research and ordinary activities, I focus on the extent of agency problems generated by each of these organizational forms while undertaking innovation. My first main result is that specialization is characterized by less severe two-tier agency problems than integration and is hence optimal. To understand why, suppose that a manager is responsible for both research and ordinary production (integration). As the investor must give the manager proper incentives to hire a talented scientist and also ensure that the scientist works hard, it is crucial that she writes contracts contingent on *truthful* reports of the manager. The friction, however, is that the investor can only observe the aggregate output from research and ordinary production, but not the individual output from each activity. So, the investor knows that an invention has occurred (when in fact one has occurred) but she does not know whether it occurred because the scientist was successful or because the engineer was lucky. This gives the manager incentive to distort reporting of productivity across activities, making it difficult for the investor to tailor the manager's compensation to the scientist's

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