THE DETERMINANTS OF INNOVATIVE ACTIVITY: EVIDENCE FROM A SILICON VALLEY FIRM

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Introduction

I am a labor economist with a strong interest in incentives in firms. I use data from inside organizations to shed light on the determinants of organizational performance. My dissertation uses data from a leading firm in the trucking industry to analyze contracts used in providing general training to new workers.

I propose to study the individual-level determinants of innovation, partnering with a large anonymous Silicon Valley firm employing thousands of programmers and scientists. A large advantage of working with the data is that workers at the firm have produced thousands of patents. Work analyzing individual-level determinants of innovation represents an exciting growth area in the economics of innovation (see e.g. Kerr, 2008; Jones, 2009; and Shu, 2011).

It will be a multi-year project and is thus ideally suited toward a postdoctoral position. The project will lead to several papers, two of which are described below.

Stock Options and Innovation

Innovation is an important driver of prosperity and growth. Understanding how innovation is affected by different institutions including laws, norms, and contracts is thus of critical importance. However, there is limited research on whether firms' use of different incentive contracts affects innovation.[1] This project analyzes how stock option contracts, used by many high-tech firms including the firm being studied, affect innovation.

Firms frequently use stock options to attempt to increase worker retention (Oyer, 2004). Changing worker retention may affect innovation. If innovation benefits from the accumulation of firm-specific knowledge or from learning from peers, retention incentives may increase innovation. Alternatively, if having a steady stream of ideas requires a fluid and rapidly changing set of employees, then retention incentives may decrease innovation.[2]

The first part of the paper will analyze descriptively how innovation and productivity change with worker tenure. In addition to patenting, the data contain information such as the number of lines of computer code written, promotions, and subjective performance ratings. It may also be possible to use information on whether other workers are using a given workers' computer code and on email communication between workers.

In the second part of the paper, I will analyze how exogenous variation in the value of stock options affects innovation. Workers entering the firm at different times will have stock options worth significantly different amounts due to whether the stock price increased or decreased after their start.

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[1] For exceptions, see Manso (2011) and Ederer and Manso (2011). Some work in psychology (e.g. Kohn, 1993; Amabile, 1996) suggests that higher-powered incentives may inhibit innovation.

[2] Stock options may also affect innovation if stock options have a direct incentive effect.

That is, some workers will be giving up very valuable stock options if they quit whereas other workers would not. To gain further identifying power, I will exploit several changes over time to required stock option vesting periods. For example, one reform lowered the required vesting period for a subset of employees, but not for most employees, thereby allowing for a difference-in-difference design.

In the third part of the paper, I will use a variant of the structural model of turnover developed in my job market paper (Hoffman, 2011), which expands on the canonical turnover model of Jovanovic (1979). Workers are initially uncertain about their job match and decide whether or not to quit based on learning about their match. Innovation follows the tenure-specific process estimated in the first part of the paper. Using the simulated structural model, I will explore counterfactually how different stock option contracts affect firm profits and the level of innovation. When there are important externalities to innovation (Nelson, 1959; Arrow, 1962), firms' use of stock options may not be socially efficient.[3]

Peer Effects in Innovative Activity

Is innovation contagious? Economists dating back to Marshall (1890) have argued for the importance of human capital externalities. Scientists often emphasize the cumulative nature of innovation, with knowledge begetting knowledge.[4] Externalities from idea sharing play an important role in theories of growth (Lucas, 1988) and in theories of cities (Moretti, 2004).

Despite the importance of the issue, identifying the impact of peers on innovation is difficult. Star inventors may sort into working together or a common environmental influence (e.g. an increase in research funding at a university) may influence the output of peer inventors. A number of papers have made important strides despite these endogeneity concerns. Jaffe, Trajtenberg, and Henderson (1993) document geographic localization in patent citations. Azoulay, Wang and Zivin (2010) identify peer effects using the death of superstar scientists. Waldinger (2010) uses the dismissal of Jewish scientists in universities in Nazi Germany as an exogenous shifter of peer groups.

To analyze peer effects in innovation, this paper will exploit the very frequent reassignment of workers to different teams. Knowledge workers at the firm work on many projects simultaneously, constantly being exposed to different groups of workers. I will test whether being exposed to a worker who has a higher propensity of patenting increases an individual's propensity of patenting on different projects.

An advantage of using personnel data to study peer effects in innovation is that it may allow for a superior understanding of the mechanisms at play. In a study on grocery checker productivity, Mas and Moretti (2009) show that spatial proximity is an important determinant of peer effects. I will build on their insight to examine whether peer effects are stronger for individuals who are closer together physically. In addition, using information on fellow worker code usage and email records, it may be possible to illuminate whether increased communication among workers is reflected in peer effects. Finally, by analyzing information in the data on project completion and the number of lines of code written, it may be possible to explore whether there are spillovers from individuals who patent into non-patenting behavior in other workers.

[3] The issues at stake for stock options may be similar to those for non-compete agreements, which have been argued to stifle innovation by decreasing mobility (e.g. Marx, Strumsky, and Fleming, 2009).

[4] Recall Newton's famous statement: "If I have seen further it is only by standing on the shoulders of giants."