

“Essays on Innovation, Productivity, and Talent Allocation”

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Abstract

This thesis contains three essays on innovation, productivity, and talent allocation. In Chapter 1, I use data on MIT bachelor’s graduates from 1980 to 2005 to study how short-term variations in economic conditions at the time of college graduation impact individuals’ long-term patent production. Chapter 2 examines the characteristics of financiers and the impact of the 2008 financial crisis on selection into finance, using data on MIT bachelor’s graduates from 2006 to 2010. Chapter 3 discusses the asset accumulation patterns of the Social Security Disability Insurance applicants and the implications on their labor force participation decisions.

Category: Economics: Labor Economics

Keywords: Patent production; innovation; business cycles; talent allocation; career choices

Executive Summary for

“Essays on Innovation, Productivity, and Talent Allocation”

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Overview

This thesis contains three essays on innovation, productivity, and talent allocation. In the first essay, I explore a novel channel through which short-term economic fluctuations affect the long-run innovative output of the U.S. economy: college graduates' initial career choices. Using a newly constructed data set on the patenting history of all individuals who obtained a bachelor's degree from the Massachusetts Institute of Technology (MIT) between 1980 and 2005, I find that cohorts graduating during economic booms produce significantly fewer patents over the subsequent two decades. Initial economic conditions do not affect inventors' long-term occupational affiliation, suggesting that the effect on patent production results primarily from differences in inventors' long-term level of inventive human capital. The decrease in patent output of cohorts graduating during booms is a result of lower inventive output from inventors with relatively low GPAs, and marginal patents receive fewer citations than average and median patents.

In the second essay, I study self-selection into the financial industry based on the observed academic talent and skills of recent bachelor's graduates from MIT. I present three key results. First, finance competes against science and engineering graduate programs for the very best talent from MIT. Second, there is positive sorting into graduate school, in that students pursuing a graduate degree have observably more academic talent and skills, which are highly valued

in the academic sector. Third, there is also positive sorting into finance. Finance does not value academic skills as much as graduate school, and as a result, students interested in finance are likely to develop a different set of skills which are unobserved here. Although the recent financial crisis as an exogenous shock has pushed some engineering and science majors out of finance and into graduate school, financiers and students entering graduate school are not substitutable in their skills, since they have followed different paths of skill development at MIT.

In the third essay, I examine the implications of asset accumulation on the labor force participation of Social Security Disability Insurance (SSDI) applicants, using data from the RAND Health and Retirement Study panel data. Despite having lower earnings, rejected SSDI applicants accumulate more assets immediately prior to their SSDI application and exhibit significantly lower attachment to the labor force. These findings are consistent with the hypothesis that a disability insurance program with imperfect screening encourages workers with high disutility of work to save more in the present and plan to apply for disability insurance in the future regardless of their future disability status. My results show that the current SSDI screening process effectively detects at least some of these individuals, but it does not deter a subset of workers from dropping out of the labor force and applying for disability insurance.

Chapter 1 - The Long-Term Impact of Business Cycles on Innovation: Evidence from the Massachusetts Institute of Technology

Allocating talent to innovative activity promotes a country's long-term economic growth (Baumol, 1990; Murphy et al., 1991). However, empirically we know little about what factors affect talented individuals' innovative output. Do short-term shocks to individuals' career choices have a long-term impact on innovation? Who is most affected? In this chapter, I provide empirical evidence to answer these questions by exploring one particular source of exogenous

variation: economic conditions at the time of college graduation. Using individual patent output as a measure of innovative activity, I estimate the causal impact of initial labor market conditions on the long-term patent production of a sample of highly skilled individuals: the alumni of the Massachusetts Institute of Technology (MIT).

To show how initial labor market conditions could affect an individual's long-term patent production, I develop a theoretical framework which indicates that by changing initial career choices, initial economic conditions could affect future patent production in two ways. First, if individuals acquire occupation-specific human capital on the job, initial market conditions could affect individuals' long-term occupational affiliations. Second, by altering graduates' career paths, initial economic conditions could affect their future level of human capital, even when there is no effect on long-term occupational affiliations. I examine the empirical implications of my model using a newly constructed longitudinal data set on the patenting history of everyone who received a bachelor's degree from MIT between 1980 and 2005. I match the alumni to the U.S. inventor database from Lai et al. (2011) based on names and locations. I then link the patent data to individual-level administrative records on demographics and academic performance at MIT to control for a rich set of characteristics in my empirical analysis.

I find that adverse labor market conditions at the time of college graduation lead to an increase in the future patent production of MIT alumni. A one-percentage-point increase in the national unemployment rate in the year of scheduled graduation increases the average graduate's annual patent output by around 5%, or approximately 2.5 patents per year for an average size cohort of 1000 graduates. The effect of initial economic conditions on patent production increases over time and is largest between 10 and 20 years after graduation, which are also graduates' peak inventive years. Meanwhile, economic

fluctuations have no measurable effect on the contemporaneous innovative output of graduates.

There are two possible explanations for these findings, which are not mutually exclusive. First, more graduates may become inventors as a result of graduating in a worse economy (changes at the extensive margin). Second, inventors who graduate in a worse economy may be more productive (changes at the intensive margin). Comparing the patent production of the 1980-1995 cohorts during their first 15 years after graduation, I find no evidence for changes at the extensive margin. Inventors from recession cohorts are not ex ante more likely to patent, where I use their cumulative grade point average (GPA) at MIT as a measure of their inventive ability at the time of graduation.¹ Thus, graduates who become inventors would most likely patent regardless of initial labor market conditions, but graduating in a worse economy increases the number of patents they produce.

The increase in patent production due to graduating in adverse labor market conditions comes primarily from science majors working in non-software-engineering sectors, such as the chemical, drug, and medical industries. Initial economic conditions have no significant effect on the distribution of the inventors' long-term sector. Furthermore, graduating in a worse economy has a significantly negative effect on the time that an inventor takes to produce their first patent. Taken together, these results suggest that the accumulation of human capital is likely the main channel through which initial labor market conditions affect long-term patent production. The most plausible explanation is that inventors from recession cohorts either start working in patent producing sectors sooner or are more likely to go to graduate school, though my data does not allow me to determine the relative importance of these two channels. I

¹ I normalize the GPA by major and cohort. The normalized GPA significantly predicts future patent production.

show that initial conditions affect the patent production of inventors with relatively low GPAs. Consistent with the finding that the relatively less inventive individuals produce marginal patents, those patents also receive slightly fewer citations than the average and median patents in my sample.² These results suggest that there exists positive sorting into patent production, where the most talented inventors produce the same patents regardless of their graduating economic conditions.

An influential line of work shows that, because innovation generates positive spillovers, innovators receive inadequate compensation relative to their contribution to society (Arrow, 1962). Since wages do not perfectly measure inventors' marginal product of labor, the growing literature that examines the effect of graduating economic conditions on private returns does not have clear implications for social welfare. For example, graduating in adverse labor market conditions has a negative long-term impact on the earnings of college graduates (Kahn, 2010; Oreopoulos et al., 2012), the career development of aspiring investment bankers (Oyer, 2008), and the productivity of economists (Oyer, 2006). In contrast, this paper is one of the first to focus on an outcome that generates potentially large social externalities. My results suggest that a thorough analysis of the impact of adverse labor market conditions on welfare should account for the potential social gains of the increased innovative output.

Chapter 2 - Self-Selection into Finance and Implications for Talent Allocation

The financial sector has become one of the most popular destinations for elite college graduates, which is not surprising given the lucrative prospects of a job in finance. Oyer (2008) shows that for Stanford MBA graduates, the expected difference in cumulative income between investment bankers and non-financiers

² It is important to note that the marginal patents still receive more citations than the average and median of all U.S. utility patents.

is millions of dollars during the first 20 years after graduation; Kaplan and Rauh (2010) find that in 2004 the top 25 hedge fund managers together earned more than all of the CEOs of Standard & Poor's 500 companies combined.

To some, it is disconcerting that the high wages in finance might lure young talent away from sectors where they could have produced more value to society. While the existing literature has focused more on whether the recent rise in financial wages represents booming productivity or increasing opportunities in rent seeking, little empirical evidence exists on the talent selection into finance.

A central question remains unanswered: would financiers have become productive engineers, scientists, or entrepreneurs in a counterfactual world with fewer opportunities in finance? The recent financial crisis, which exogenously and dramatically decreased the availability of entry-level jobs in finance, creates a perfect natural experiment to study the question. Using data on MIT bachelor's graduates between 2006 and 2010, I report three new findings in this paper. First, when finance is no longer a viable job option, the most likely alternative careers depend on the graduates' majors. Those with engineering and science degrees are likely to go to graduate programs in engineering and science instead, whereas the economics and management majors would work for non-financial, non-consulting firms. Second, limiting the number of entry-level jobs in finance in the case of a financial crisis does not make the sector less attractive to graduates but, rather, makes it more selective; the average base salaries in finance rose post crisis. In other words, marginal financiers who dropped out of finance because of the crisis have significantly lower base salaries than average financiers. Finally, to the students with the highest academic talent and skills coming out of MIT, graduate school is still more attractive than finance regardless of market conditions.

These results are consistent with the predictions of a Roy-style selection model where finance values different skills than the engineering and science sectors. Using measures of academic skills and talent, I also provide suggestive evidence that students interested in different sectors make an effort to develop different skills during college. Students who aspire to go to graduate school are likely to focus on developing specific academic skills and their efforts are reflected in their GPAs. In contrast, students who are interested in finance may spend time practicing skills that are not captured by GPAs (e.g., social skills such as networking and communication). As a result, the two populations do not appear substitutable in their skills when they graduate from MIT.

By providing evidence on self-selection, this chapter builds toward an understanding of the welfare implications of the growing financial sector in the U.S. My results are likely informative for other top engineering and science undergraduate programs, since the skill distributions are similar. However, it is important to note the differences between MIT bachelor's graduates and the average science and engineering population. First, MIT is likely to attract students who are best suited for engineering and science in terms of both their talents and tastes. Thus, even though a marginal financier from MIT may not have been the most productive engineer or scientist from MIT, she may still be more talented than the broader population. Furthermore, most of the MIT graduates have at least some engineering and science skills. While the marginal return to engineering and science skills for someone with no such skills may be high, there are no variations in my sample to identify the effect. An important direction for future research would be to generalize the methodology developed in this paper to study a more representative sample of engineering and science students in the U.S.

Chapter 3 - Asset Accumulation and Labor Force Participation of Disability Insurance Applicants

Social Security Disability Insurance (SSDI), designed to protect the working population from the risk of total disability, is one of the largest income transfer programs in the United States. In December 2010, the program paid 9.6 billion U.S. dollars in benefits to over 9.4 million people, including 8.2 million disabled workers (Social Security Administration (SSA), 2010). To qualify for SSDI, a worker must be younger than the full retirement age and have worked enough in recent years.³ In addition, the worker must pass a screening for "total disability," which the SSA defines as the inability to work due to medical conditions that are expected to result in death or to last for at least one year. Since the program intends to cover workers with long-term disabilities, few beneficiaries exit voluntarily by becoming employed again. The two main reasons for leaving SSDI are reaching the full retirement age⁴ and death, which together account for 86% of the exits in 2004 (Autor and Duggan, 2006). Thus, mistakenly accepting work-capable individuals into disability insurance could generate unnecessary financial burdens to taxpayers as well as productivity losses to society. However, the current SSDI application review process is imperfect because it relies on a mixture of objective and subjective criteria intended to evaluate an applicant's medical impairments and ability to work. Certain medical conditions, such as back pain and depression, are difficult to verify, making the award decision more susceptible to personal judgment.

Previous empirical studies show that disability insurance could discourage work in two ways. First, receiving disability benefits may cause the recipients to stay away from the labor force even as they regain their health and become work-capable again. Second, an imperfectly-screened disability insurance program may induce work-capable individuals to drop out of the labor force in the present to apply for disability insurance, especially when they

³ The exact length and timing requirements for employment vary by person and are specified by the SSA.

⁴ The disability benefits become retirement benefits at the full retirement age.

face adverse labor market conditions. However, a third, dynamic type of work disincentive effect has only been considered in the theoretical literature. Under an imperfectly-screened disability insurance program, some individuals may *plan* to exit the labor force *in the future* and apply for disability insurance then, regardless of their future state of health (Golosov and Tsyvinski, 2006). This path is preferable to leaving the labor force right away since it gives the individuals time to adjust their savings accordingly. Thus, disability insurance affects not only current but also future labor supply. Without accounting for this third, inter-temporal channel, the current empirical literature focusing on the contemporaneous impact of disability insurance on labor force participation may underestimate the magnitude of the total work disincentive effect. In this paper,

I develop a two-period model similar to that of Diamond and Mirrlees (1978) and Golosov and Tsyvinski (2006), and show that certain individuals maximize utility by planning for their future disability insurance application in advance. The decision to do so depends on their health as well as how much they dislike working. Since leaving the labor force lowers the expected future income, the individuals who plan for their disability application accumulate more assets than they otherwise would if they only apply for disability insurance when they become disabled. I use the RAND Health and Retirement Study (HRS) panel data to present empirical support for the model. The results from my quantile regressions show that, conditional on observed characteristics--including income, labor force participation, and health status--rejected applicants have significantly more liquid financial assets than accepted applicants at the time of their disability insurance application. Both the magnitude and the statistical significance of the effect increase in applicants' asset levels. Furthermore, rejected and accepted applicants have very similar levels of assets several years before their application, suggesting that the divergence at the time of the disability insurance application is unlikely to have been driven by any unobserved

differences in the applicants' inherent tendency to save. Consistent with the model, I also find evidence that rejected applicants display significantly lower attachment to the labor force prior to their application, implying that they may have less desire to work than accepted applicants. Although rejected and accepted applicants self-report similar levels of health at the time of application, accepted applicants are significantly less healthy than rejected applicants in the few years after application. Taken together, these results suggest that some rejected applicants have accumulated their assets in a way consistent with the planning story. However, the current screening system can detect at least some of these work-capable applicants, even without relying on assets as a criterion.⁵ Thus, it is unclear whether imposing an asset-based criterion on top of the current system, as suggested by Golosov and Tsyvinski (2006), would increase the efficacy of screening.

⁵ At the same time, it is not effective enough to deter their applications.

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