Academic Entrepreneurship: Bayh-Dole versus the "Professor's Privilege"

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Abstract

Should society encourage scientific researchers at universities to become entrepreneurs? Using data on U.S. university-employed scientists with a Ph.D. in STEM disciplines leaving their university to become entrepreneurs during 1993-2006 and similar data from Sweden we show evidence suggesting that owning your idea outright (the "Professor's Privilege") rather than sharing ownership with your university employer (the Bayh-Dole regime) is strongly positively associated with the rate of academic entrepreneurship but not with apparent economic gain for the entrepreneur. Further analysis show that in both countries there is too much entry into entrepreneurship, and selection from the bottom of the ability distribution among scientists. Targeted policies aimed at screening entrepreneurial decisions by younger, tenure-track academics may therefore produce more benefits for society than general incentives.

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Introduction

In 2010, a report from the National Academy of Sciences titled *Managing University Intellectual Property in the Public Interest* concluded that "…the system put in place by the Bayh-Dole Act, that is, university ownership of inventions from publicly funded research… is unquestionably more effective than its predecessor system... in making research advances available to the public." (NRC 2010, p. 61). A related and highly topical question, particularly among policymakers, is whether the Bayh-Dole regime is also more effective at stimulating academic entrepreneurship than the so-called "Professor's Privilege" regime. Whereas the former allocates ownership of inventions from publicly funded research to the university, it remains with the inventor in the latter, as has been the case for Sweden since 1949. An additional question is which of the regimes generates more successful and profitable new academic ventures.

Prior research at the national level has focussed on comparing rates of patenting among university employees within and across the U.S. and European countries.[1] The general conclusion seems to be that European academics are at least as active at patenting their research as their U.S. counterparts (Lissoni et al., 2008), and that introducing Bayh-Dole-type regimes in Denmark, Germany and Norway has typically been associated with significant decreases in patenting rates by academics (Czarnitzki et al., 2015; Hvide and Jones, 2015; Valentin and Lund-Jensen, 2007).

To our knowledge this is the first empirical paper where large scale data-bases are used to examine how different intellectual property (IP) right regimes influence the rate and success of academic entrepreneurship across different countries. We compare academic entrepreneurship in the U.S. post Bayh-Dole using a nationally representative sample of U.S. university-employed scientists with a Ph.D. from the Natural Sciences, Medicine and the Engineering (STEM) disciplines during the period 1993–2006, to similar data from a comprehensive national register of all Swedish university-employed scientists in the same disciplines. More precisely, we compare a)

[1] Previous studies have primarily examined how university-level policies affect academic entrepreneurship. Most of this wisdom has been based on case evidence documented by for example Hsu and Bernstein (1997) comparing MIT and Harvard, Mowery and Ziedonis (2001) examining founders of spin-offs from Lawrence Livermore labs, Feldman and Desrochers (2003; 2004) examining Johns Hopkins University, Kenney and Goe (2004) comparing U.C. Berkeley and Stanford, Roberts (1991) and Shane (2004) studying MIT entrepreneurs, and Perkmann et al (*forthcoming*) examining academic entrepreneurship at Imperial College, London. Few studies have, however, compared universities located across different institutional environments. As an exception, Kenney and Patton (2011) compare start-up rates in the local vicinity across six different universities whereof one located in Canada and the rest in the U.S. Further, Clarke (1998) and Wright et al., (2007) examine several European universities.

the fraction of academics who quit their employment to become full-time entrepreneurs, b) earnings from academic entrepreneurship relative to prior university wages, and finally, c) the business survival rate of academic entreprenenurs. Hence, we extend previous analyses in several ways. More generally, we have access to unique and comprehensive data enabling a more robust analysis regarding the effect of different IPR regimes on academic entrepreneurship. Second, our earnings data allow us to investigate whether the systems differ in their capability of sorting successful entrepreneurs.

We find that the biannual rate of academics turning entrepreneurs is low in both countries: 0.88% in the U.S. and 1.09% in Sweden, with the U.S. entry rate lagging behind Sweden by approximately 24%. However, a direct comparison between the entry rates of American and Swedish academics is not altogether appropriate since there are other obvious significant differences outside the IP right regimes that may also explain differences across the two countries. We therefore compute the *relative* entry rate in each country, defined as the entry rate by academics into entrepreneurship as a fraction of the entry rate by non-academics into entrepreneurship. We compare academics with individuals having a Ph.D. in the same disciplines but not employed by universities. The comparison group functions like a "control" group in that the non-university employed in both countries do not own the property rights of the ideas they develop at work, those right are *de jure* allocated to their employer. This provides a within-country benchmark.

Non-academic U.S. employees on the other hand clearly outperform their Swedish counterparts in terms of the rate of entrepreneurship. The biannual entry rate into entrepreneurship by Ph.D.s not employed by universities is 4.0% in the U.S., much higher than the 2.5% in Sweden.

Therefore, the entry rate of academics *relative* to their placebo group in each country is 22% in the U.S., while it is 44% in Sweden. That is, Swedish academics are twice as likely as their fellow U.S. peers to enter entrepreneurship, after controlling for the average entry rate in their respective countries. Since we control for everything that differs across the two countries in the denominator, we may conclude that giving academics the privilege to outright and fully own their IP (the Professor's Privilege) apparently is associated with a much higher willingness by academics to commercialize their IP and to leave their university to start a new business.

The differeneces in entry rates, however, do not show up when we look at earnings. We find that mean earnings deteriorate between 10% (Sweden) and 15% (the U.S.) when academics

switch from university employment to become full-time entrepreneurs.[2] Also, non-academics with similar Ph.D.s earn less by becoming entrepreneurs than staying employed, with U.S. entrepreneurs losing on average 16% per year compared to staying employed, while their Swedish counterparts lose 12% per year by becoming entrepreneurs. None of the earnings losses due to entrepreneurship are statistically or significantly different from each other, while all are statistically different from zero. Hence, while the IPR regimes between the two countries are different for academics, losses to becoming an entrepreneur are approximately similar, irrespective of whether the person owns his/her idea by default (Swedish academics) or whether his/her employer owns the idea. Thus, owning your idea outright rather than sharing ownership with your prior university imparts no apparent economic gain when commercializing the idea.

Previous research

The U.S., through the Bayh-Dole Act of 1980, pioneered a systemic change where IPRs, traditionally held by the granting agency, were transferred to universities provided that research had been granted federal funds. This drastic change in the IPR regime aimed at simplifying the relationships with granting agencies and also to increase American competitiveness through increased commercialization of university-based research (NRC, 2010). In Europe the Humboldt tradition remained, implying a strong focus on basic research and alleged limited links to the commercial sector, absence of targeted areas considered to be of particular strategic importance, and collegial governance. Similarly, the Professor's Privilege continued to be the prevailing rule among European countries.

A number of studies claim that the Bayh-Dole Act promoted a surge in innovation in the U.S. (OECD, 2003; Stevens, 2004; NRC, 2010).[3] Others are more skeptical, arguing that the Bayh-Dole act coincided with a number of other major policy changes, e.g. with regard to the tax

[2] These estimates are based on comparisons of all prior years of university wages to all posterior years of earnings from entrepreneurship for each individual, and then averaging these differences across those individuals making the transition in a regression framework, adjusted for inflation. Consecutive entrepreneurial spells are included. We use individual-fixed effects to omit potential pooling effects. People must have a Ph.D. in STEM, leave their prior university employer and have entrepreneurship as their primary source of income to be included in this study as academic entrepreneur. Part-time consulting and other minor entrepreneurial efforts (such as a second or third parallel venture but not the primary) are not included. The analysis therefore likely concerns significant entrepreneurial ventures where the potential business opportunities are large.

[3] See also Mowery and Sampat (2005) and So et al. (2008). See Hellman (2007) for a theoretical model based on search costs why it may be motivated to transfer IPRs to the university. See also Siegel et al. (2003) and Debackere and Veugelers (2005).

regime, increased federal resources to university research and a more flexible investment policies for pension funds, all being instrumental in improving commercialization of university based research (David, 2007; Kenney and Patton, 2009; Lissoni et al., 2009; Litan et al., 2007). Rather, the Bayh-Dole system has been argued to foster a monopoly like system deterring the dissemination of knowledge and having marginal or insignificant effects on patenting (Crespi et al., 2006; Geuna and Nesta, 2006; Verspagen, 2006; Lissoni et al., 2009).

About a decade ago, and simultaneously as the effects of the Bayh-Dole Act became increasingly questioned in the U.S., a considerable number of countries had or were about to adopt a similar IPR regime (i.e. Germany, Denmark, Japan, Norway and China). These changes were primarily driven by policy makers beliefs' that Bayh-Dole regulation would increase competitiveness in their respective countries.[4] In Germany the number of university based inventions have, however, been shown to remain either unchanged (Von Proff et al. 2012) or decrease (Czarnitzki et al 2015), after a Bayh-Dole like system was imposed in 2002. Czarnitzki et al. (2015) use a difference-in-difference approach and estimate an overall treatment effect from revoking the Professor's Privilege at universities reducing the volume of university citation-weighed patents by 27% (19% un-weighted). According to Valentin and Lund-Jensen (2007), there was a 14 percent reduction in the share of Danish domestic academic inventors to patent applications made by Danish biotech firms, relative to Sweden over the four years 2001-2004 after IPRs were transferred to universities. In the most extreme case of Norway, there was an approximate 50% decline in the rate of new venture creation and patenting by university-based researchers after the reform and the quality of university start-ups and patents also appears to have declined (Hvide and Jones, 2015).

Even though the Bayh-Dole act has been imitated by several countries, some countries have chosen a different strategy. For instance, Italy introduced a Professor's Privilege system in 2001. And as mentioned above, in the case of Sweden the Professor's Privilege, which goes back to an exception in the 1949 Act on the Rights to Employee's Inventions, remains. Nevertheless,

[4] There has been a vivid and ongoing discussion concerning the effects of shifting IPRs to the universities. See Baldini et al., (*forthcoming*), Belenzon and Schankerman (2009), Thursby et al. (2001; 2009), Dechenaux et al. (2009), Greenburg (2007), Jacobsson and Lindholm-Dahlstrand (2003), Lach and Schankerman (2008), Thursby and Thursby (2010), to mention a few.

the Swedish IPR system has been heavily debated. After several years of investigation it wasdecided that it should be kept.[5]

To examine the alleged negative consequences of the effectiveness of the Bayh-Dole system, the National Research Council commissioned a National Academy of Sciences (NAS) review to examine how the new U.S. system impacted *technology licensing* from the universities (NRC, 2010). Just as in the Swedish case, albeit from an opposite position, the conclusion was to continue with the existing system. Based on observations over a 30 year period, the NAS study claimed that no empirical evidence could be provided that motivated a return to the old system. That did not imply that the present Bayh-Dole regulation was considered optimally designed, as the investigation resulted in six findings and 15 recommendations to improve the current system (Merrill and Mazza, 2010).

Research on the effectiveness of the Bayh-Dole system in terms of facilitating commercialization through licensing has grown rapidly in the last decade. Interestingly enough, the effect of the Bayh-Dole system on academic entrepreneurship and university-driven spin-offs as an alternative to technology transfer by existing firms, has received considerably less attention. One reason may simply be that licensing to established firms has constituted the dominant way of commercializing (Jensen and Showalter, 2011). Thus, the relatively extensive literature on academic entrepreneurship has barely touched upon the issue of how different IPRs regimes influence the choice between licensing to an established firm or setting up a new venture.[6] At the same time there has been a surge in interest among policy-makers regarding academic entrepreneurship.[7]

[5] See the investigation SOU 2005:95 and the Government Bill 2008/2009:50.

[6] For some more broad-based analyses of academic entrepreneurship see for example Louis et al., (1989), DeGregorio and Shane (2003), Goldfarb and Henrekson (2003), Powers and McDougall (2005), Lowe and Ziedonis (2006), Stuart and Ding (2006), Rothaermel et al. (2007), Siegel et al (2008) and Thursby et al. (2009). Theoretical contributions have been provided by e.g. Macho-Stadler et al. (2008), Conti (2009) and Jensen and Showalter (2011).

[7] See Breznits et al. (2008) and O'Shea et al. (2008). For instance, the U.S. has introduced a simpler and faster start-up license ("Carnegie License"), while Sweden has earmarked governmental funding to establish so called Innovation Offices at universities with a much broader mandate than just technology licensing. University-based incubators and accelerators have also multiplied dramatically over the last decade.

There are however a few notable exceptions of papers studying the effect of the IPR regime on academic entrepreneurship.[8] For example, Kenney and Patton (2011) conduct a comparative study of six universities whereof one operates under a Professor's Privilege regime (University of Waterloo, Canada) while the remaining five American universities are tied to the Bayh-Dole IPR system. Altogether the study comprises 515 university spin-offs between 1957 and 2009. The authors conclude that the Waterloo inventor ownership regime (Canadian Universities can freely choose how they want to allocate ownership rights) outperforms its U.S. counterpart in every dimension of academic entrepreneurship that is investigated (number of spin-offs, efficiency, rank, technology fields, etc.), with the possible exception of the largest U.S. universitiy (University of Wisconsin, Madison) in one or two of these dimensions.

In another related study Färnstrand-Darmsgaard and Thursby (2013), present a theoretical model based on the different IPR institutional set-ups in Sweden and the U.S. to analyze their effects on academic entrepreneurship. According to Färnstrand-Darmsgaard and Thursby the effectiveness of the respective system depends on the level of search costs, researcher preferences, and whether there are constant returns to scale in development effort. They conclude that the U.S. Bayh-Dole system is less conducive to entrepreneurship as compared to the Swedish Professor's Privilege system, whereas the average probability of commercialization success is higher in the U.S. The explanation for a higher probability of academic entrepreneurship in Sweden is that the inventor does not have to share possible future profit with the University. On the other hand, a technology licensing office at the university (TLO) have superior links to established firms and potential licensees and therefore better positioned to enable commercialization of inventions. That explains the higher probability for commercialization success in the U.S. in the model. TLOs have been in place for a longer time and developed stronger skills than their Swedish counterparts.[9]

In Färnstrand-Darmsgaard and Thursby's study, the advantages between the two systems may shift depending on the levels of the respective variable (search costs, inventor's preferences

[8] See Thursby and Thursby (2010) claiming that the Bayh-Dole act more generally has negatively impacted academic entrepreneurship. Among others, Kenney and Goe (2004), Shane (2004), Stuart and Ding (2006) and O'Shea et al. (2005) analyze different university characteristics that influences academic entrepreneurship, though not the effect of the national institutional regime. For surveys, see Kenney and Patton (2012) and Kenney (2013).

[9] Braunerhjelm (2008) shows that at the time of his survey, academic entrepreneurs in Sweden were either not aware of the TLO services offered by universities or, if aware, considered them inadequate.

and technology). Note that if a licensing option is chosen (by the inventor in Sweden and by the TLO in the U.S.), the probability of success (ceteris paribus) will be higher in Sweden, due to the agency problem present under the U.S. IPR regime, implying that the inventor exerts less effort in the U.S. Since invention often requires subsequent adjustment after being licensed, inventor effort plays an important role in securing commercial success (Braunerhjelm and Svensson, 2010).

To summarize, the evidence remains inconclusive as to which IPR regime is most conducive to commercialization of academic research, albeit the empirical facts seem to favour a Professor's Privilege system. The evidence is even scarcer with respect to how academic entrepreneurship is affected, but also here an emerging literature suggests that the Professor's Privilege is likely to be more advantageous.

Data and Estimation Methodology

Data Generation Process and Data Definitions

For the U.S. we use a representative sample covering individuals with a Ph.D. in the Natural Sciences, Medicines or Engineering (STEM) disciplines covering the period 1993-2006. We employ the restricted-use Survey of Doctorate Recipients (SDR) dataset collected by the NSF for the years 1993, 1995, 1997, 1999, 2001, 2003 and 2006. SDR gathers information from individuals who have obtained a doctoral degree in a science, engineering or health field. The SDR is conducted every 2 years (although the 2006 survey was conducted 2.5 years after the previous 2003 one) and is a longitudinal survey that follows recipients of research doctorates from U.S. institutions until age 76. At each observation point freshly minted doctorate recipients are added to the survey while some previously followed individuals drop (because of age or other reasons). There are a significant number of individuals who have been followed over the whole period of 14 years (at 2-2.5 years intervals) and also individuals who have been followed for just part of this period.[10] These surveys are integrated into the U.S. Scientists and Engineers Statistical Data System (SESTAT), which is a database specially designed for drawing inferences about the total population of scientists and engineers, with appropriate account taken of the

[10] See http://www.nsf.gov/statistics/srvydoctorateworkfor a detailed description of the target populations and other technical information about the Survey of Doctorate Recipients.

different population sizes across the three surveys by adding the special variable provided to the restricted-use data called "SESTAT integrated weights."[11] We use the SESTAT integrated weights to allow us to recover population numbers and report these population numbers throughout.

The Swedish register on all employed individuals working in the country was matched with register data from their employers by their social security number. From this matched employer-employee data set we extract all 39,705 individuals with a Ph.D. degree in STEM who at some point during 1999–2008 were employed in Sweden.[12] In addition, we merge annual data on research funding and staff at Swedish universities from the Swedish National Agency for Higher Education.[13]

Entrepreneurship Definition

Our identification of entrepreneurship for U.S. (and Swedish) faculty and university employees follows established practice in the literature using SESTAT data (see Braguinsky et al., 2012; Elfenbein et al., 2010) by defining entrepreneurs as cases where an individual with a Ph.D. in the STEM disciplines switched to principal employment in his/her own business, professional practice or farm after previously reporting his/her principal employment in a 4-year college, university, medical school or a university research institute. We distinguish between entrepreneurs that were previously employed as ranked faculty (full, associate and assistant professors) and all other employees (including adjunct faculty, postdocs and administrative personnel). Non-university employed entrepreneurs are defined similarly as those with a Ph.D. in the STEM disciplines who switched to principal employment in his/her own business, professional practice or farm after previously reporting his/her principal employment in other employment types (that is, not in a 4-year college, university, medical school or a university research institute and not in own business, professional practice or farm).

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[11] See http://www.nsf.gov/statistics/sestat/weighting.cfm for a detailed discussion of the weighting strategy.

[12] We sample the same Ph.D. disciplines in Sweden as in the U.S. In Natural Science we include the natural sciences, mathematics, computer science and agricultural science.

[13] The Swedish Secrecy Act protects access to the data from Statistics Sweden, but researchers affiliated with a Swedish research institution can apply for access to this data from Statistics Sweden, www.scb.se, Phone: 08-506 948 01, Mail: SCB, Box 24300, 104 51 STOCKHOLM.

Statistics Sweden defines an individual as a full-time entrepreneur if he/she owns a registered sole proprietorship or closely held corporation in a given year *and* his/her total income from this company (labor and capital income) is 1.6 times greater than labor income from employment in the single next greatest source of labor income and the person works at least 1/3 of his/her time in that business. The adjustment is based on a separate labor survey performed by Statistics Sweden, which suggests that entrepreneurs work 1.6 more hours than the employed for every krona/dollar earned. Using this definition we extract 341 individuals with a Ph.D. in the STEM disciplines leaving Swedish universities to become entrepreneurs during 2000–2008. To augment the study with more observations we consider as entrepreneurs those individuals who leave a position in academia to work full-time for a company with 10 or less employees founded in the year they left academia even when a direct ownership link to the firm could not be observed. Using this definition we extract 163 additional entrepreneurs. Several studies using the Danish matched employer-employee dataset have employed a similar definition of entrepreneurship (e.g. Nanda and Sorensen, 2010; Sorensen, 2007). Considerable regularities have been established using this definition of entrepreneurship and we consider us to be on safe ground using this additional sample.[14]

It should be noted that we employ a very strict definition of entrepreneurship. It is not enough to own a business while still working for the university to be classified by us as entrepreneur. The person has to switch to *principal employment* in his/her own business. This study therefore excludes part-time efforts such as consulting, and informal or formal advisory roles. Entrepreneurial efforts are likely to be substantial as this is their main source of income, and we are likely to draw entrepreneurial projects that represents considerable upside opportunities.[15] We include consecutive entrepreneurial spells but exclude part-time work in potential parallel ventures which are not providing the *principal employment.*

[14] These studies assume that an individual who leaves a job and becomes an employee with at least a management position (as defined by occupational codes) in a newly registered firm is an entrepreneur. We presume that employees with Ph.D. degrees leaving universities to join a newly registered firm with 10 or less employees are relatively important employees such that imposing additional occupational code constraint to define them as entrepreneurs is not necessary. We perform sensitivity analysis including and excluding these individuals in analysis and further analyze the extent to which they share profits in the new firm and found qualitatively similar results.

[15] It is for example unlikely that academics would leave a steady and reasonably well paying job for another with highly uncertain rewards for the purpose of tax arbitrage. Academics have plenty of time to operate small consulting

Non-university employed entrepreneurs are defined similarly as those 1,360 individuals with a Ph.D. in the STEM disciplines leaving employment at any type of organisation other than a university to become entrepreneurs during 2000–2008. In parallel to the identification process described above, we consider as entrepreneurs those individuals who leave a position not in academia to work full-time for a company with 10 or less employees founded in the year they left prior employment even when a direct ownership link to the new firm could not be observed. Using this definition we extract 586 additional entrepreneurs.

Income Mesurement

In line with the established practice in the literature (Braguinsky et al., 2012; Elfenbein et al., 2010), U.S. earnings are taken from the answers to survey questions about the basic annual salary (before deductions and excluding bonuses, overtime or additional compensation for summertime teaching or research) as of the week April 15 of the year the individuals were surveyed (see http://www.nsf.gov/statistics/srvydoctoratework/#qs).

Data on Swedish annual wage income are collected from the Swedish tax register. While it is possible to collect data also on non-wage income, such as interest earned on savings and public stocks, dividends from and sale of entrepreneurial businesses, we decided to exclude these data to be more directly comparable to the U.S. data. For a study of academic entrepreneurial earnings which include non-wage income, see Åstebro et al. (2013). It turns out that the returns to academic entrepreneurship are not affected by including these non-wage data.

Additional Variables for the U.S. and Sweden

We include socio-demographics of the individual and data about the university at which the individual is (or recently was) employed and the region where the individual works (based on the address of the employer). We have typical background characteristics such as their labor market history, gender and marital status and we also have data on whether they were foreign born or not. For labor market experience we measure the number of years since obtaining the Ph.D. We also include a measure of the number of years worked at the most recent university.

businesses earning a part-time side income into which they both can shift some private consumption to pre-tax expenses and enjoy lower tax rates thus increasing disposable income as an academic. The opportunity to reduce taxes is thus already present for academics without needing to become a full-time entrepreneur.

Dummy variables are used to capture the field where the person received his/her Ph.D. degree and year effects. To capture the quality of the university we use the 1993 National Research Council (NRC) ratings of doctorate programmes to assign ratings to the universities and colleges that entrepreneurs originated from in the case of the U.S.,[16] or the research funding per employee in millions of Swedish kronor in the case of Sweden.

Data are organized as an unbalanced panel, entry and exit can occur any time. We exclude individual-year observations whenever an entrepreneur switches back to the wage sector. Altogether we have 61,828 year-person observations for the U.S. and 87,740 year-person observations from Sweden.

Descriptive Statistics

Table 1 reports variables, means and standard deviations for the U.S. and Swedish datasets on academics. To economize on space we only display data for individuals with prior employment in universities. Column 1 includes all university-employed individuals with a Ph.D. degree in the STEM disciplines during 1993–2006 for the U.S. and 1999–2008 for Sweden. Column 2 includes those defined in the same way, but who quit their employment at the university and became full-time entrepreneurs some time during 1995–2006 for the U.S. and 2000–2009 for Sweden. Column 3 reports data for those never leaving academia. For the Swedish data we note that with the exception "Married/ Cohabitating", all differences in means between those ever becoming entrepreneurs and those never becoming entrepreneurs are all statistically significant at the 1% level. For the U.S. data, the only statistically and economically significant difference between those ever becoming entrepreneurs and those never becoming entrepreneurs is in the fraction of individuals with Ph.D. degrees in Medicine.

Insert Table 1 about here

[16] The NRC rating of a college or university was calculated as the average of NRC ratings of its doctorate programmes if it had NRC-rated doctorate programmes, otherwise, the rating was set equal to zero. See Golderberger et al. (1995); also http://www.stat.tamu.edu/~jnewton/nrc_rankings/nrc1.html

Figure 1 provides graphical representation of earnings for academic entrepreneurs and non-entrepreneurs. Figure 1A shows that earnings for U.S. and Swedish academic entrepreneurs are typically much lower than earnings for their peers staying in academia—the blue earnings distribution is shifted more to the left. This earnings difference depends on two factors as illustrated in the next two figures. First, those who later become entrepreneurs earn less than their peers prior to moving, as illustrated in Figure 1B, and this lesser performance in academia tends to persist in entrepreneurship. Second, those who become entrepreneurs tend to earn less after moving than they did before entrepreneurship, as illustrated in Figure 1C, indicating that the act of entrepreneurship reduces income.

Insert Figure 1 about here

Estimation methodology

Utilizing the full sample of academics and running the analysis independently for the U.S. and Sweden (merging the datasets was not possible due to restrictions in data use by the NSF and Statistics Sweden), we first estimate individuals' propensity to leave academic employment for entrepreneurship using a panel-data linear probability random effects ordinary least squares estimator.

$$P(E_{it}) = \alpha + \beta X_{it} + \tau_t + \varepsilon_{it}$$

where E_{it} is employment status at time *t* for individual *i* (=1 if entrepreneur, = 0 if employed in academia), X_{it} is a vector of (potentially time-varying) covariates that may determine entrepreneurship, τ_t are time-fixed effects, and ε_{it} is an i.i.d. error term.

We next study the returns to entrepreneurship, estimating Mincer-type wage equations. The estimating equation is the earnings model

$$y_{it} = \alpha + E_{it}(\beta + \delta X_{it}) + \theta_i + \tau_t + \varepsilon_{it}$$

where y_{it} is the natural logarithm of earnings[17], θ_i are person-fixed effects that do not vary over time, and the remaining notation is as before. The model is first estimated without the inclusion of θ_i, using a random effects estimator and with covariates *not* interacted with the entrepreneurship dummy. However, as the choice of entrepreneurship might be a function of expected returns and unobserved (for the econometrician) characteristics such as a permanent disposition and inclination for entrepreneurial activity, such estimates can be considered to suffer from bias. To address this problem, we use a fixed effects difference regression approach, where we only analyze the difference in earnings for those that become entrepreneurs. We thus estimate the difference in income between entrepreneurship and employment for a given individual. Identification is based on the individuals who are observed to change employment status once. We assume that time-variant unobservable circumstances are random in the sense that they are not correlated with the covariates in the equation. Our estimation strategy generates the treatment effect on the treated.

Results

The results together with robustness tests will be presented in Tables 2-5. Since we will report on different aspects of academic entrepreneurship – probability of becoming an entrepreneur, earnings, and in relation to non-academic entrepreneurs – and also vary the estimation techniques, our main findings are summarized in Table 6.

Regression results describing who becomes an entrepreneur

A key question is who becomes an entrepreneur. Results are presented in Column 0 in Table 2, revealing some similarities as well as differences in the patterns of academic entrepreneurship between the two countries. With respect to similarities, the probability of becoming an entrepreneur is increasing in the years since the Ph.D. was obtained but decreasing in the number of years at the last employer in both countries. Both results represent typical life-cycle patterns observed in many other studies of entrepreneurship. Similarly, being of a foreign nationality is shown to be negatively associated with academic entrepreneurship. However, there is more academic entrepreneurship in the medical and engineering fields (in comparison to natural sciences) in the U.S., whereas entrepreneurship is more prevalent among the natural sciences in Sweden.

[17] For those owning a sole proprietorship, net earnings from business operations and wages are reported jointly to the Swedish tax authorities -- "wages" can then on occasion be negative. Observations with negative earnings are re-coded to zero in the logarithmic measure of earnings. Earnings are index adjusted with the consumer price index.

Notably, in the U.S. there is a lower probability of becoming an entrepreneur for academics employed at the best universities (Table 2, Column 0), while, at the same time, wages are higher for those working at top universities (Table 2, Column 2). In addition, those not on tenure track (research assistants, post-docs and alike) are more likely to become entrepreneurs than tenure-track professors. In the U.S., it thus appears that there is negative selection into entrepreneurship—faculty at top U.S. universities and with more prestigious positions are more likely to stay employed and earn higher wages. For Sweden the opposite results are reported—the best (research) universities produce more entrepreneurs but appear to pay their employees less than lower ranked universities. To examine this claim we ran a separate regression of university salary against university quality while controlling for individual-fixed effects (not shown but available on request). This regression confirmed that for a given person, a one standard deviation increase in employer university quality is associated with a 2.8% decrease in salary. Our interpretation is that the lower ranked and relatively new Swedish universities with lower R&D spending ratios have to pay more than the old established universities with higher R&D spending ratios to attract a given faculty member.

Overall, there appears to be a clear negative selection into entrepreneurship in both the U.S. and Sweden. Table 2, Column 0 shows that Swedes with higher wages as academics are less likely to become entrepreneurs. In addition, when the tenure track and university quality variables are both removed for the U.S. regression (as both variables likely are positively correlated with wages), previous wage is shown to have a statistically significant negative influence on the probability to become entrepreneur also for U.S. academics (Table 4, Column 0).[18]

Insert Table 2 about here

Insert Table 3 about here

Regression results describing the financial returns to becoming an entrepreneur

[18] Note that in both regressions we control for labor market experience and years of service at the latest employer, which are both strong predictors of wage. After these controls, what remains as determinants of wage is typically associated with individual ability both in teaching and research.

When one simply compares the difference (in logs) between regression-estimated entrepreneurs and non-entrepreneurial earnings, U.S. entrepreneurs earn 19% less and Swedish entrepreneurs earn 10% less than the average wage-working academic (Table 2, Column 1). Once we control for several background characteristics to capture differences across people who become and do not become entrepreneurs, we note that the mean entrepreneurial earnings for comparable individuals are 24% less in U.S. and 15% less in Sweden than academic wage workers (Table 2, Column 2). These baseline coefficients reflect returns to entrepreneurship for an omitted category, which in Table 2, Column 2, consists of an individual with a Ph.D. degree from the Natural Sciences, female, not married, with zero years of work experience and not on tenure track. In several cases wages/earnings differ considerably across different groups of academics. For example, both Americans and Swedes with a Ph.D. in Medicine earn approximately 19% more than those with a Ph.D. in the Natural Sciences. And, for each year of labor market experience, earnings increase by between 2.8% and 2.9% in both countries, while staying at your employer reduces earnings by 0.3% each year in the U.S. but increases earnings by 0.6% per year in Sweden. These numbers are plausible and demonstrate that in Sweden academic wages are strongly tied to tenure, but in the U.S. wage increases are primarily a result of moving between universities.

It may be that there are still pooling effects reflecting differences in unobservable variables that may cause the differences in earnings between entrepreneurs and wage workers. For example, we noted that the worst performing academics tend to become entrepreneurs in both countries. If we do not fully control for these differences, it may just be that we are observing lower entrepreneurial earnings than wages because it is the low-performing individuals who predominantly become entrepreneurs. In Columns 3 and 4 (in Table 2) we therefore compare wages before becoming an entrepreneur to earnings after becoming an entrepreneur only for switchers in an individual fixed effects regression framework. The number of observations is naturally drastically reduced because there is only a small fraction of academics who become entrepreneurs. For Sweden, we have data on all academics who switch to full-time entrepreneurship, but there are only approximately 16,000 academics in Sweden, so the number of academics observed making the transition is therefore not large. Since the U.S. data is based on a survey, the surveyed group is also not large.

Column 3 confirms that if we look only at the change in earnings for academics who become entrepreneurs, the mean change is a decrease of approximately 15% in the U.S. and a decrease of

approximately 10% in Sweden. We then experiment with interacting covariates with the entrepreneurship dummy in Column 4. The interactions allow us to explore how the overall change in earnings may be driven by a particular group of people. Note that these results are not directly comparable to those reported in Column 3. First, we only look at those who switches so there are no pooling effect, and, second, coefficients for covariates reflect *interactions* with the entrepreneurship dummy.

Column 4 reveals that in both countries increased work experience makes becoming an entrepreneur less profitable, however, only in the U.S. is the coefficient significant and relatively large (a 4% annual reduction in relative earnings).[19] Finally, we note a very interesting effect of being foreign born: in Sweden it is associated with making much less as an entrepreneur than staying in academia (-34%), while in the U.S. it is associated with making much more as an entrepreneur than staying in academia (49%).[20] Since the foreign born represent large fractions of the overall populations of switchers (14% in Sweden and 22% in the U.S.), they do have a sizeable effect on the estimated mean return to becoming an entrepreneur. The baseline return to becoming an entrepreneur is still negative, but it is now rather imprecisely measured due to the combined effect of the small number of individuals we can observe making the transitions to entrepreneurship, and the number of covariates which we introduce, both reducing precision in coefficient estimates.

Robustness Analysis

In this subsection we conduct comparative analysis on the returns to entreprenurship for academics and those not originating from university employment. We also test whether controlling for year dummies changes any results and further discuss some special analysis of the U.S. data. Estimating models always contains individual-fixed effects, and so we compare wages before becoming an entrepreneur to earnings after becoming an entrepreneur and then average these in a regression framework.

[19] One might also interpret this result as that the opportunity cost to leaving academia increases a lot with academic experience in the U.S.

[20] It should be noted that many foreign-born academics start their careers on work visas in the U.S., which prevents them from leaving their employers freely. Once they obtain permanent residence, however, they are free to leave and start their own businesses. High returns to foreign-born U.S. academic entrepreneurs may thus, at least partially, reflect the “suppressed opportunity” for such individuals while in academia.

Results presented in Table 3 indicate that the returns to becoming an entrepreneur are similar irrespective if one originates from university or non-university employment, and irrespective of whether one controls for year dummies or not, with estimates typically landing between -10% to -15%. Results in columns 1 and 2 are exactly those reported also in Column 3 of Table 2, and these results are, together with those reported in columns 5 and 6 of Table 3, re-displayed in Table 6 which contains the summary of main findings.[21]

The U.S. earnings data further showed that those not on tenure track are among the worst-performing entrepreneurs and they are also the most likely to become entrepreneurs. Going back to Table 2, Column 2, we observed that the coefficient for being on tenure track is 0.311 and highly significant, indicating that those on tenure track on average earn 31% more than those which are not on tenure track.[22] We also observed from Column 0 in Table 2 that those individuals not on tenure track are two percentage points more likely to become entrepreneurs than those on tenure track. (Similar data on tenure track status were unfortunately not available from Sweden.)[23] In the fixed effects regression reported in Column 4 of Table 2 we find instead a much smaller positive effect of being on tenure track, about a 4.8% increase in earnings from switching to become an entrepreneur. The coefficient is however imprecisely measured. Nevertheless, the large difference in the coefficient for tenure track academics in affecting earnings between the random and fixed effects regressions indicates that there is selection from the bottom of the ability distribution into academic entrepreneurship. Those which are more likely to have low pre-entry earnings are more likely to be on non-tenure track positions.

An additional noteworthy result in the U.S. data is that older academics, as measured by years since obtaining their Ph.D., have the worst performing entrepreneurial projects in relation to their prior earnings, while younger academics on average generate higher earnings when becoming

[21] Test of differences in z-values across the differently estimated earnings are not significant at conventional levels. For example, the difference in entrepreneurial earnings vs wage earnings between individuals originating from Swedish universities vs Swedish non-universities is z=-0.62 (n.s.), whereas the same difference for the U.S. case is z=-0.23 (n.s.). Comparing instead the difference in entrepreneurial earnings vs wage earnings between individuals originating from Swedish universities vs U.S. universities, one obtains z=-0.43 (n.s.), while the same comparison across the two countries for previously non-university employed is z=-1.22 (n.s.).

[22] Those not on tenure track positions still have Ph.D.'s in STEM and are a collection of administrative personnel, lab assistants and post-docs.

[23] Unlike their U.S. counterparts, Swedish universities had in general not implemented formal tenure track systems during the observation period. While we did not have access to individual-level data on employment contracts, data from complementary sources indicates that in the aggregate, approximately 84% of all Swedish academic positions held by PhDs were of a permanent nature during the period (Swedish Higher Education Authority, 2014).

entrepreneurs compared to their prior earnings in academia. The coefficient for work experience (years since Ph.D.) displayed in Table 2, Column 4, and in a slightly different specification in Table 4, Column 3, shows a reduction in relative earnings from entrepreneurship of between 3.5% to 4% per year of work experience at entry. To further illustrate the negative correlation between work experience and entrepreneurial earnings, in auxiliary analysis we split the sample by age below and above 40 years old.

The results from this auxiliary regression, again unique for the U.S., are displayed in Table 5. As shown, switching to becoming an entrepreneur below the age of 40 involves an earnings increase of between 17% and 29% (these coefficients are somewhat imprecisely measured due to the smaller number of observations), while for those over age 40 the average earnings penalty is between -34% and -37%. We might interpret this result as that the opportunity cost to leaving academia to become an entrepreneur increases a lot with academic experience in the U.S. An alternative interpretation is that older academics have worse entrepreneurial ideas than younger academics.[24]

Insert Table 3 about here

Insert Table 4 about here

Insert Table 5 about here

Data (not tabulated) also show that a large fraction of academic entrepreneurs quit within a short time period. After two years, 46% of Swedish academic entrepreneurs have given up while a slightly smaller fraction of U.S. academic entrepreneurs have quit (about 40%). Both figures represent considerably larger failure rates when compared to Ph.D.'s not employed at universities

[24] Two papers suggest that age and creativity are negatively related. In Braguinsky et al (2012), a key aspect of their theoretical model is the interaction between the ability of individuals to evaluate the prospects of ideas and their inherent ability to develop them. The ability to evaluate ideas increases with knowledge-related experience, which leads to the predictions that entry rates in entrepreneurship increase with experience, while individuals with high levels of inherent ability will enter entrepreneurship at younger ages and on average will be more successful. We find support for these predictions for our sample of U.S. academic entrepreneurs. Acemoglu et al (2014) develops a model with similar predictions. In analysis of patent data they establish a very robust cross-sectional negative correlation between CEO (or top management) age and several measures of firrm-level creative innovation.

and entering entrepreneurship. For example, only 32% of Swedish non-academic entrepreneurs quit after two years. Interestingly, about 61% of Swedish academics who give up their entrepreneurial ambitions return to academia, while only a third of Americans do. These data indicate a relatively liquid labor market in both countries, with a lesser penalty for becoming an entrepreneur in Sweden than in the U.S.

Conclusions

Our main results summarized in Table 6 are briefly reviewed here before moving on to discuss policy implications. We find that the entry rate of academics *relative* to a control group in each country is 22% in the U.S., while it is 44% in Sweden. That is, Swedish academics are twice as likely as their fellow U.S. peers to enter entrepreneurship, after controlling for the average entry rate in their respective countries. Since we control for everything that differs across the two countries in the denominator, we may conclude that giving academics the privilege to outright and fully own their IP (the Professor's Privilege) apparently is associated with a much higher willingness by academics to commercialize their IP and to leave their university to start a new business.

However, we further conclude that mean earnings deteriorate between 10% (Sweden) and 15% (the U.S.) when academics become entrepreneurs. These estimates are based on comparisons of prior university wages to posterior earnings from entrepreneurship for each individual, and then averaging these differences across those individuals making the transition in a regression framework. These earnings losses due to entrepreneurship are not statistically significantly different from each other, and they are not statistically different from the earning losses for people with similar Ph.D. degrees not originating from universities. All estimates are however statistically different from zero. Hence, while the IPR regimes between the two countries are different for academics, losses to becoming an entrepreneur are approximately similar, irrespective of whether the person owns his/her idea by default (Swedish academics) or whether his/her employer owns the idea. Thus, owning your idea outright rather than sharing ownership with your prior university imparts no apparent economic gain when commercializing the idea.

Insert Table 6 about here

Our policy conclusions must be guarded. We do not have more than two countries to compare across, and our analysis is further hamstrung by the requirement by the data source providers to run the analysis within each country, without the ability to pool the data. We furthermore cannot link entrepreneurship directly with ownership of IP at the individual level, we can only make comparions at the aggregate across groups. We further cannot separate between those which are forced to leave as they do not make tenure and those choosing to leave because of other reasons. However, it should be noted that most academics not getting tenure at one university can still stay an academic should they so prefer by simply switching to another university. Finally, we focus on significant entrepreneurial efforts where the academic takes the plunge and leave their prior employer, and exclude those who do it on a part-time basis, practise consulting, or give free advice to others who take the risks.[25] Despite these restrictions, we are able to compare to a control group in both countries, making the cross-country comparions subject to less bias from omitted variables and more trustworthy for policy inference.

The results suggests that should one want to increase the entry rate into entpreneurship in the U.S., an obvious policy change would be to allocate a greater share of ownership of the IP to its creators in academia. But it is not clear from our analysis how much more IP rights should be allocated to academics to substantially increase academic entrepreneurship rates in the U.S. A complete changeover to the Professor's Privilege may not be warranted in the U.S. as there are some benefits to mixed ownership (Hvide and Jones, 2015), although their model points to that the academic should have a majority share.

Nevertheless, from a private perspective there is over-entry by academics into entrepreneurship in both countries as these efforts do not pay off for the individuals, on average. Since entrepreneurial earnings are associated with significantly higher income risk than wages, with approximately a three times higher standard deviation, the risk-adjusted returns to academic entrepreneurs look even worse than those computed in this article. Nevertheless, the returns appear to be similar for non-academics who do not have the benefits of fully owning the IP that they might

[25] For a comparison of full-time and part-time U.S. academic entrepreneurs see Markman et al., (2008). For an analysis of Swedish part-time entrepreneurship see Folta et al. (2010). In Sweden there are large tax-planning benefits to run a non-profitable business where consulting and other occasional earnings are declared. Indeed, average non-salary income for Swedish part-time entrepreneurs with a full-time wage job were -57,500 SEK or approximately U.S. -$7,200 in 1994 (Folta et al., 2010, Table 3). We wanted to the extent possible to avoid including such tax-planning vehicles in this study and therefore focus on full-time entrepreneurial efforts.

have worked on at their prior employer, as do exit rates. Overall, these figures indicate either that those who become entrepreneurs are economically biased, or have a preference for becoming entrepreneurs that compensates them for their economic losses.

Both in the U.S. and in Sweden, a number of policy instruments to encourage all university employees to become entrepreneurs have been adopted. For example, university technology licensing offices and accelerators built are often partially funded by federal funds, and university regulation has been redrafted to allow universities to take equity in start-ups. We assume these policies are based on the idea that these projects will generate large social rates of return even if they are privately unprofitable, on average. And, if the projects indeed have large social surpluses, then there is an argument to compensate academics for the rather large losses they are apparently making when trying to commercialize their IP.

However, our results suggest that there seems to be too much emphasis on general stimulus of academics since in both countries there is selection from the bottom of the ability distribution. In the U.S., non tenure-track employees, and those with lower wages pre-entry, are more likely to become entrepreneurs, but earn less than tenure track Professors after becoming entrepreneurs. Also, older academics have the worst performing entrepreneurial projects in relation to their prior earnings, while younger academics on average generate higher earnings when becoming entrepreneurs compared to their prior earnings in academia. We also find high failure rates of academic entrepreneurial projects when compared to Ph.D.'s not employed at universities and entering entrepreneurship. But we also find difference in the labor market dynamics in Sweden than in the U.S.: about 61% of Swedish academics who give up their entrepreneurial ambitions return to academia, while only a third of Americans do.

While these results must be taken as preliminary they would tend to indicate some directions for more effective policy. Unless there are some market failures for older professors when becoming entrepreneurs (we think this is rather unlikely), we argue that more targeted policies aimed at screening entrepreneurial decisions by younger, tenure-track academics may produce more benefits for society than general incentives for all academics, as can a system that provides for seamless return to academia in case entrepreneurial projects do not pan out. Irrespective of the institutional set-up, university-based researchers may serve new ventures better if they are more

loosely affiliated as co-owners or advisors, rather than being encouraged to become full time entrepreneurs (Braunerhjelm and Svensson, 2010).

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Table 1: Key descriptive statistics.

	Column 1		Column 2		Column 3	
	Sample averages		Sample split by ever-entrepreneur=1		Sample split by ever-entrepreneur=0	
Dependent variables	US	Sweden	US	Sweden	US	Sweden
Percentage entrepreneurs	0.009 (0.093)	0.013 (0.115)	0.493 (0.500)	0.422 (0.494)	0	0
Log(wage income)(t)	11.18 (0.623)	12.9 (0.545)	10.93 (1.034)	12.70 (0.813)	11.19 (0.613)	12.9 (0.533)
Pr(exit)|entrepreneur=1			0.400 (0.490)	0.490 (0.500)		
Independent variables						
Natural Sciences=1	0.771 (0.420)	0.402 (0.490)	0.743 (0.437)	0.360 (0.480)	0.771 (0.420)	0.403 (0.491)
Medicine=1	0.067 (0.251)	0.269 (0.443)	0.101 (0.301)	0.223 (0.417)	0.067 (0.250)	0.270 (0.444)
Engineering=1	0.162 (0.368)	0.313 (0.464)	0.156 (0.363)	0.410 (0.492)	0.162 (0.368)	0.310 (0.462)
Foreign born=1	0.240 (0.427)	0.196 (0.397)	0.215 (0.411)	0.145 (0.352)	0.241 (0.428)	0.198 (0.398)
Male=1	0.758 (0.428)	0.697 (0.460)	0.675 (0.468)	0.755 (0.430)	0.760 (0.427)	0.695 (0.460)
Married/cohab=1	0.794 (0.404)	0.690 (0.462)	0.745 (0.436)	0.702 (0.457)	0.795 (0.404)	0.690 (0.463)
Years since obtaining Ph.D.	13.56 (9.22)	9.67 (8.47)	13.41 (8.33)	8.24 (6.90)	13.56 (9.24)	9.72 (8.51)
Years at last employer	9.27 (8.50)	9.10 (7.32)	5.61 (6.32)	4.65 (5.67)	9.35 (8.52)	9.25 (7.32)
Tenure track=1	0.713 (0.453)	N/A	0.439 (0.496)	N/A	0.717 (0.450)	N/A
University quality (1)	3.049 (0.847)	N/A	2.982 (0.880)	N/A	3.050 (0.846)	N/A
University quality (2)	N/A	1.31 (0.667)	N/A	1.27 (0.671)	N/A	1.31 (0.667)
Number of observations	61,828	86,950	1,045	2,739	60,755	84,211

Source: Authors' estimates using the NSF and Statistics Sweden data. N**otes**: Earnings adjusted with consumer price index. University quality (1) = NRC score. University quality (2) = R&D (in millions of Swedish kronor) / number of employees. The number of observations for the U.S. data is the total number of observations. Because U.S. data are based on a survey, there are some missing data on various metrics (particularly on salaries and on years with previous employer). The number of observations in each row may therefore be fewer than the total reported in the last row.

Table 2. Regression results for university-employed Ph.D.s

	Column 0		Column 1		Column 2		Column 3		Covariates for Column 4	Column 4	
Estimation model	Xtreg, re		Xtreg, re		Xtreg, re		Xtreg, fe			Xtreg, fe	
Dependent var.	*Pr(entrepreneur=1)(t)*		*Log(earnings)(t)*		*Log(earnings)(t)*		*Log(earnings)(t)*			*Log(earnings)(t)*	
Country	US	Sweden	US	Sweden	US	Sweden	US	Sweden		US	Sweden
Entrepreneur=1			-0.192*** (0.071)	-0.102** (0.041)	-0.242*** (0.087)	-0.153*** (0.041)	-0.151** (0.077)	-0.097** (0.043)	*Entrepreneur*	-0.333 (0.574)	-0.031 (0.131)
Medicine=1	0.008** (0.004)	-0.006*** (0.002)	-	-	0.181*** (0.014)	0.186*** (0.009)	-	-	*Entrepreneur* Medicine*	0.381 (0.274)	-0.110 (0.123)
Engineering=1	0.009*** (0.003)	-0.009*** (0.002)	-	-	0.184*** (0.010)	0.092*** (0.007)	-	-	*Entrepreneur* Engineering*	0.260 (0.269)	-0.102 (0.090)
Foreign born=1	-0.004** (0.002)	-0.004*** (0.002)	-	-	-0.041*** (0.009)	-0.054*** (0.008)	-	-	*Entrepreneur* Foreign born*	0.493** (0.207)	-0.343** (0.160)
Male=1	-0.004* (0.002)	-0.000 (0.002)	-	-	0.112*** (0.009)	0.199*** (0.07)	-	-	*Entrepreneur* Male*	0.071 (0.247)	-0.092 (0.097)
Married/cohab=1	0.001 (0.002)	0.003** (0.001)	-	-	0.042*** (0.008)	-0.034*** (0.006)	-	-	*Entrepreneur* Married*	0.149 (0.206)	-0.009 (0.097)
Years since obtaining Ph.D.	0.002*** (0.000)	0.003*** (0.000)	-	-	0.028*** (0.001)	0.029*** (0.001)	-	-	*Entrepreneur* Years since Ph.D.*	-0.040*** (0.012)	-0.006 (0.006)
Years at last employer	-0.002*** (0.000)	-0.005*** (0.00)	-	-	-0.003*** (0.001)	0.007*** (0.001)	-	-	*Entrepreneur* Years at last employer*	0.018 (0.019)	0.022 (0.023)
Tenure track=1	-0.021*** (0.003)	N/A	-	-	0.311*** (0.009)	N/A	-	-	*Entrepreneur* Tenure track*	0.048 (0.235)	N/A
Log(wage income)(t-1)	-0.002 (0.002)	-0.008*** (0.002)	-	-	-	-	-	-	*Entrepreneur* Log prior inc.*	-	-
University quality	-0.003*** (0.001)	0.003*** (0.001)	-	-	0.059*** (0.005)	-0.037*** (0.003)	-	-	*Entrepreneur* Univ. quality*	0.101 (0.162)	0.068 (0.064)
Number of observations (individuals)	29,652 (10,919)	68,179	61,384 (22,388)	86,870 (18,832)	36,518 (14,417)	86,870 (18,832)	1,016 (307)	2,677 (504)		605 (217)	2,677 (504)

Source: Authors' estimates using NSF and Statistics Sweden data. **Notes**: ***.001, **< .01; *<0.05. Standard errors clustered on individual. Earnings adjusted with consumer price index. Reference group in the intercept: Natural Sciences, born in Sweden/U.S., female, single, tenure track=0: [post-docs, research assistants, or administrators employed at universities]. U.S. university quality measured by the NRC score, Swedish by R&D funding / employee. The reduction in number of observations from Column 1 to Column 2 in the U.S. data is due to missing data on years with previous employer, tenure track status and university quality. If estimated on the same sample, the coefficient on the entrepreneurship dummy in Column 3 is nevertheless -0.175** (0.088), indicating that differences in samples due to missing data are not driving results. Since the controls for years with previous employer, tenure track status and university quality are not significant in Column 4, but result in the loss of many observations, it seems reasonable to drop these controls. Results without these variables are presented in Table 4 and look more sensible, although most coefficients are still not significant and the magnitudes of point estimates and standard errors are large.

Table 3. The returns to academic and non-academic entrepreneurship

Column	1	2	3	4	5	6	7	8
Country	US	Sweden	US	Sweden	US	Sweden	US	Sweden
Prior employment	Univ.	Univ.	Univ.	Univ.	Not Univ.	Not Univ.	Not Univ.	Not Univ.
Entrepreneur=1	-0.151** (0.077)	-0.097** (0.043)	-0.137 (0.095)	-.123*** (0.045)	-0.160** (0.027)	-.121*** (0.017)	-0.182** (0.031)	-.159*** (0.019)
Year Dummies	No	No	Yes	Yes	No	No	Yes	Yes
Number of individuals	307	504	307	504	1,650	1,943	1,650	1,943

Notes: ***<0.001; **< .01; *<0.05. Earnings adjusted with consumer price index. Estimation model is always a fixed effects panel-data regression with standard errors clustered on the individual and with log of earnings at *t* as the dependent variable.

Table 4. Alternative regression results for university-employed Ph.D.s on U.S. data

	Column 0	Column 1	Column 2	Covariate for Column 3	Column 3
Estimation model	Xtreg, re	Xtreg, re	Xtreg, fe		Xtreg, fe
Dependent variable	*Pr(entr.=1)*	*Log(earnings)*	*Log(earnings)*		*Log(earnings)*
Entrepreneur=1		-0.180*** (0.070)	-0.146* (0.075)	*Entrepreneur*	-0.188 (0.189)
Medicine=1	0.005* (0.003)			*Entrepreneur *Medicine*	0.175 (0.196)
Engineering=1	0.004** (0.002)			*Entrepreneur * Engineering*	0.128 (0.183)
Foreign born=1	-0.001 (0.002)			*Entrepreneur *Foreign*	0.421*** (0.138)
Male=1	-0.005** (0.002)			*Entrepreneur *Male*	0.282 (0.174)
Married/cohab=1	0.000 (0.002)			*Entrepreneur *Married*	0.327** (0.161)
Years since obtaining Ph.D.	0.002*** (0.000)			*Entrepreneur *Years since Ph.D.*	-0.035*** (0.009)
Years at last employer	-0.002*** (0.000)			*Entrepreneur *Years at last employer*	No
Tenure track=1	No			*Entrepreneur *Tenure track*	No
Log(wage income)(t-1)	-0.005*** (0.002)			*Entrepreneur *Log prior inc*	-
University quality	No			*Entrepreneur *Univ. quality*	No
Number of observations	40,700 (15,177)	61,398 (22,388)	1,058 (307)		1,016 (307)

Source: Authors' estimates using NSF data. **Notes.** Earnings adjusted with consumer price index. Standard errors are clustered on the individual. Compared to Table 2, the estimation in Column 0 drop tenure track and university quality and in Column 3 we also drop years at last employer.

Table 5. Earnings of U.S. academic entrepreneurs split by age group.

Column	1	2	3	4
Age	40 or less		Over 40	
Prior employment	University	University	University	University
Entrepreneur=1	0.290** (0.121)	0.171 (0.129)	-0.366*** (0.106)	-0.345** (0.141)
Year Dummies	No	Yes	No	Yes
Number of individuals	382	382	684	684

Notes: ***<0.001; **< .01; *<0.05. Estimation model is always fixed effects panel-data regression with standard errors clustered on the individual and with log of earnings at *t* as the dependent variable. Earnings adjusted with consumer price index.

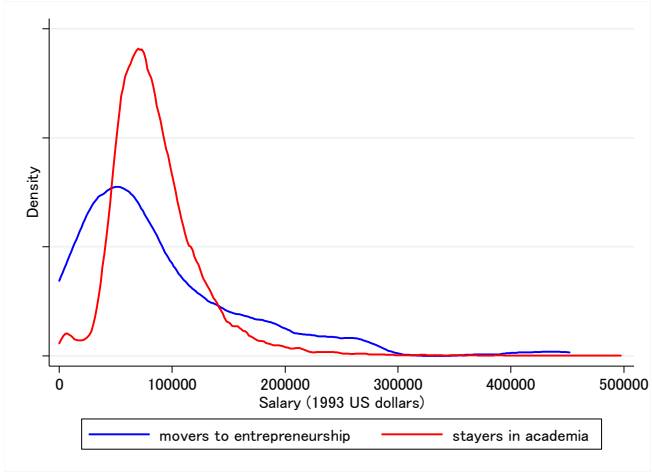
Table 6. Summary of Main findings. A summary of comparison of the differences in the rates of entrepreneurship and earnings improvements for prior academics and non-academics becoming entrepreneurs between the U.S. (1993–2006) and Sweden (1999–2008).

		University-employed Ph.D.	Non-university employed Ph.D.	Relative Entry Rate
U.S.	Bi-annual entrepreneurship rate	0.9%	4.0%	22%
	Earnings difference from switching to entrepreneurship	-15.1%	-16.0%	
Sweden	Bi-annual entrepreneurship rate	1.1%	2.5%	44%
	Earnings difference from switching to entrepreneurship	-9.7%	-12.1%	

Source: Authors' estimates using NSF data and Statistics Sweden data.

Figure 1.

Figure 1A. Probability density functions of earnings for those moving to entrepreneurship from academia (blue line) and wages for those staying in academia (red line) (1993 US dollars and 2008 Swedish krona).



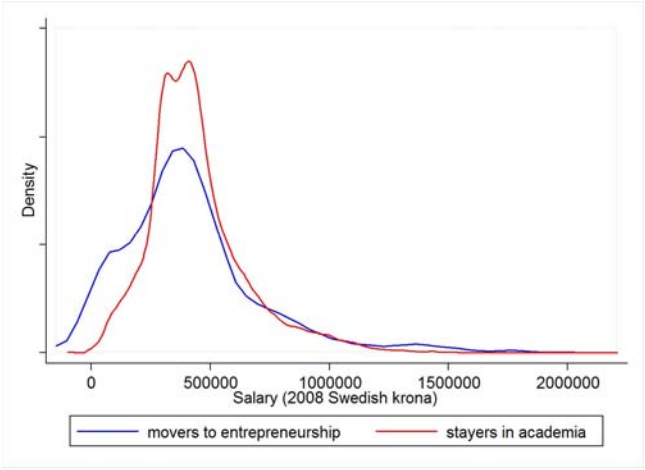
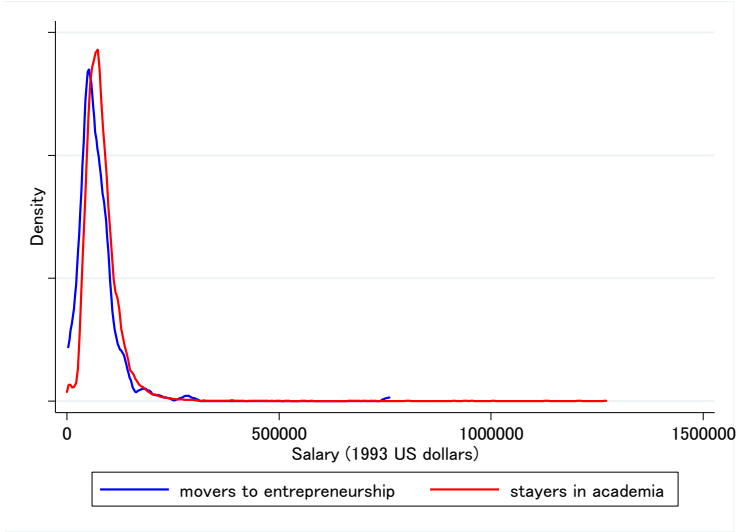


Figure 1B. Probability density functions of wages prior to moving for those moving to entrepreneurship from academia (blue line) and wages for those staying in academia (red line) (1993 US dollars and 2008 Swedish krona).



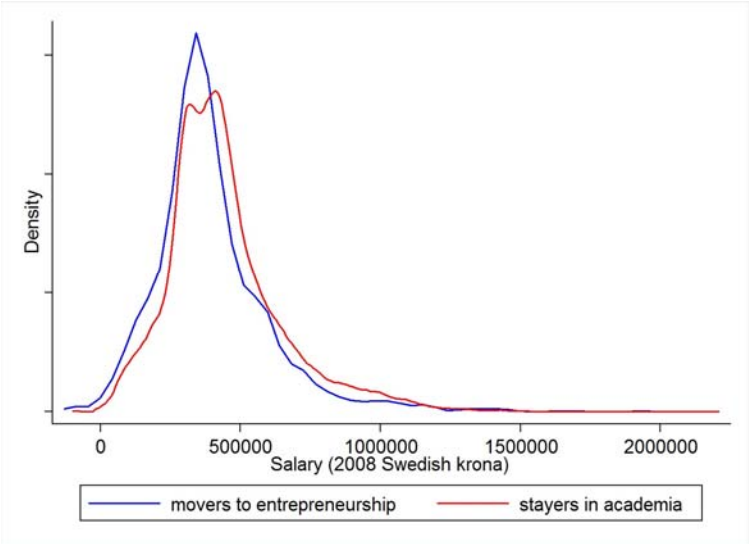


Figure 1C. Probability density functions of wages prior to moving (blue line) and earnings after moving (red line) for those moving to entrepreneurship from academia (1993 US dollars and 2008 Swedish krona).