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Academic Entrepreneurship:

Bayh-Dole versus the "Professor's Privilege"

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Abstract

We explore whether the Bayh-Dole intellectual property regime is associated with more, and more valuable, academic entrepreneurship than the "Professor's Privilege" regime. Using data on US PhDs in the natural sciences, engineering, and medicine fields who became entrepreneurs in 1993–2006 and similar data from Sweden, we show that, in both countries, the entry rate into entrepreneurship is lower for those originating in academia than for those originating in non-university employment and that the relative rate of academic entrepreneurship is slightly lower in the US than in Sweden. We also find that the mean economic gains from becoming an entrepreneur are negative, both for PhDs originating in academia and non-university employment in both countries. Further analysis indicates that, in both countries, selection occurs from the bottom of the ability distribution among academics. The results suggest that policies aimed at screening entrepreneurial decisions by younger, tenure-track academics may be more effective than general incentives to increase academic entrepreneurship.

JEL Classification: L26, J20, N32

Keywords: Academic entrepreneurship, innovation, royalty sharing, Bayh-Dole, Professor's Privilege

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Introduction

Students of economic change care about the optimal allocation of ownership and control rights for maximizing invention. Focusing on the case of university invention, the allocation of control and ownership rights in this sector, and its impact on technology licensing to established firms, a 2010 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" (Merrill and Mazza, 2010, p. 61). Despite this emphatic conclusion, research comparing rates of patenting among university employees within and across the US and European countries presents a more mixed judgment. Some evidence indicates that European academics working in Professor's Privilege regimes are at least as active at patenting their research as their US counterparts (Lissoni et al., 2008). Moreover, replacing the Professor's Privilege with Bayh-Dole-type regimes in Germany, Finland, Norway, and Denmark has been associated with significant decreases in patenting rates by academics (Czarnitzki et al., 2015; Ejermo and Toivanen, 2018; Hvide and Jones, 2015; Valentin and Lund-Jensen, 2007). These alternate data might instead lead to the conclusion that patenting levels by academics are higher under a different allocation of control and ownership rights than under the Bayh-Dole act.

But we also care about university employees' production of innovation, not just invention. The allocation of property and control rights at universities are likely to matter for those outcomes as well. The Bayh-Dole regime was designed to solve difficult administrative issues associated with transferring the title for inventions to private firms and was invoked primarily to stimulate the transfer of inventions to established commercial firms. Its impact on academic

entrepreneurship was probably not fully considered at the time. Nevertheless, today department heads, rectors, deans, chancellors, education ministers, and others are all concerned with improving and increasing the commercialization of inventions by faculty through academic entrepreneurship. This paper therefore focuses on the relationship between the allocation of invention property/control rights and academic entrepreneurship, where university employees leave their university to engage in commercializing their inventions—the act of innovation.

Because control and property rights rests fully with the inventor under the Professor's Privilege, the economic incentive to commercialize university inventions (in any form) would a priori seem higher under the Professor's Privilege than the Bayh-Dole regime. But Bayh-Dole regimes may offer incentives for universities to get more active to stimulate innovation in ways that may either offset or complement the private incentive for commercializing inventions by university inventors. And in cases where university inventors are motivated by non-economic incentives, such as ego or scientific status, the university may need to take a more active role for university inventions to see daylight outside its laboratories. The question motivating our research is simply whether, today, and considering all potential effects, the Bayh-Dole regime is associated with more, and more valuable, academic entrepreneurship than the "Professor's Privilege."

As the cases of Germany, Finland and Norway illustrate, studying the effects of changing an intellectual property (IP) regime within a country offers a relatively "clean" opportunity to analyze how IP regimes affect academic entrepreneurship. However, the method is inherently restricted to short-term effects. If reforms take time to implement and optimize, e.g., due to institutional inertia, then short-term effects may not appropriately reflect a new IP regime's fundamental impact. In addition, causal effects are more difficult to infer when outcomes appear far in the future. In view of such concerns, important complementary insights into how IP regimes

affect academic entrepreneurship might be gained by comparing mature versions of the Bayh-Dole and the Professor's Privilege regimes. In this paper, we offer a careful comparison of two such cases: the US and Sweden. In particular, for each case we undertake within-country analyses of entrepreneurial entry and the private returns to entrepreneurship, where academic entrepreneurs are compared to similar entrepreneurs originating in the non-university sector.

To our knowledge, this is the first empirical paper that uses two large datasets to construct comparative case studies aimed at examining how different IP regimes are associated with the rate and economic success of academic entrepreneurship. Further, we investigate whether the systems differ in their ability to sort successful entrepreneurs.

Bayh-Dole Act vs. Professors' Privilege: Background[1]

Through the Bayh-Dole Act (BDA) of 1980, the US pioneered a systemic change in which IPR, traditionally held by the granting agency, was transferred to universities if that research had been conducted using federal funds. This change in the IPR regime was aimed to simplify relationships with granting agencies and to increase American competitiveness through increased licensing of university-based research (Merrill and Mazza, 2010). In Europe, the Humboldt tradition remained, with a strong focus on basic research and limited links to the commercial sector, the absence of targeted areas considered of particular strategic importance, and collegial governance. Similarly, the Professors' Privilege (PP) continued to prevail in European countries.

These two IPR systems have two major conditions that are different. First, under the BDA, control rights are held by the university, not by the inventor. The Act allowed universities

[1] We only review research on academic entrepreneurship that relates to the design of the IPR regime. For general literature surveys on academic entrepreneurship, see Åstebro and Bazzazian (2011), Djokovic and Souitaris (2008), Perkmann et al. (2013), Rotharmael et al. (2007), and Siegel and Wright (2015).

to retain title to federally funded inventions, in return for which they must file patent applications and collaborate with businesses to promote commercial use of the inventions they elect to own (Jensen and Thursby, 2001). In the PP, the roles are reversed: the inventor has exclusive rights her invention. Second, under BDA, by default (de jure) the university has full ownership of the IP and allocates a share to the inventor, which varies across universities. For example, Lach and Schankerman (2008) report a mean of 39% and 42% allocated to the inventor at US private and public universities, respectively. Under the PP, the university has no right to ownership in the IP. IP developed under contracts from industry, or not developed from federal funds, as mentioned, are not covered by the BDA. Further, under BDA, the inventor must "effectively assign" the IP to the university, and, if the inventor is able to avoid doing so, and under some additional legal conditions, the BDA does not apply.[2] About a decade and a half ago and following the apparent success in the US, many countries were about to adopt BDA-type IPR regime.

IP regimes and academic entrepreneurship: Theory and empirical findings

Academic entrepreneurship means university employees engaging in the commercialization of their invention.[3] Research on the role of the IP regime in affecting academic entrepreneurship is relatively small. At the same time, interest among policy makers regarding academic entrepreneurship has surged (see e.g., Government Bill 2008:50; Grimaldi et al., 2011; Kilger and Bartenbach, 2002; Mowery and Sampat, 2005; OECD, 2003; SOU, 2005).

Several approaches can be used to model the impact of IPR regimes on academic entrepreneurship. In Färnstrand-Darmsgaard and Thursby (2013), the relative advantage of each

[2] For conditions of applicability of the Act, see, e.g., Merrill and Mazza (2010) and O'Connor (2013). For example, since a contracting institution must obtain an effective assignment from the inventor in order for a patent to fall within the BDA requirements, TLOs scour universities for "invention disclosures."

[3] Under the BDA this means that the university licenses the invention to a business started by the inventor.

system depends on the level of search costs, inventor's preferences, and technology. In Lowe (2006), the relative advantage depends on inventor's opportunity cost of time, TLO skills, and the tacitness of the technology. Because inventions often require some adjustment after being licensed, inventor efforts play an important role in securing commercial success (Braunerhjelm and Svensson, 2010). Models predict that the probability of commercialization success is higher in the PP regime (Färnstrand-Darmsgaard and Thursby, 2013), as inventors effort levels are not contractible, and inventors have a lower take-home share under the BDA.

University ownership of IPR unilaterally reduces expected inventor pay-off from commercialization more than the PP (Lowe, 2006). However, as shown by Hvide and Jones (2015), the presence of general investment complementarity between commercialization efforts of the inventor and those of the university's support function may counteract this effect. In Lowe (2006) and Macho-Stadler et al. (2007), this complementarity revolves more precisely around the ability of the TLO to bid up the selling price of the IP. It is unclear whether in practice the TLOs have these business skills. In addition, splitting ownership rights introduces well-known ineffiencies through double marginalization, which reduces total welfare and may also increase transaction costs. It is plausible that university researchers under BDA may curtail their commercialization activity because they, in addition to their direct loss of revenues, find haggling with the university onerous, and it is plausible that external funders or licensors are dissuaded when multiple university-based parties become involved (Merrill and Mazza, 2010). On balance, the introduction of BDA can be expected to lead fewer inventors to commercialize their invention in the form of a spin-off.

The consequences for the realized returns to entrepreneurship are less straightforward, especially for a policy regime in which inventors are subsidized to commercialize their

inventions. First, inventors who are discouraged from engaging in firm formation because of the introduction of BDA should be those whose expected returns are at the lower tail of the distribution (cf. Lowe, 2006). Therefore, the average expected return of realized academic spin-outs should be higher under the BDA, ceteris paribus. In contrast, if the BDA incentivizes universities to provide support of academic spin-offs that increases their chances of success (Hvide and Jones, 2015), it may induce excessive entry into academic entrepreneurship, leading to lower and even, potentially, negative realized returns. This type of effect is modeled, for example, in de Meza and Southey (1996). If, however, significant market failures are associated with entry for academic entrepreneurs, and the TLO has the skills to ameliorate these frictions, then the realized rates of return will be higher under a BDA-style regime than under the PP regime, where the frictions have to be resolved mainly by the entrepreneur. Overall, introducing BDA-style regimes has various counterveiling effects on inventor pay-offs.

Conventional correlational studies provide ambiguous evidence on the effect of different IP regimes on academic entrepreneurship (e.g. Di Gregorio and Shane, 2003; Markman et al., 2009; Friedman and Silberman, 2003; Lockett and Wright, 2005; Kenney and Patton, 2011; Shane, 2004). However, studies with a clear exogenous and large downward shock to ownership and control rights find common support. After a Bayh-Dole-like system was imposed in Germany in 2002, the number of university-based inventions were estimated to decrease by 27% (19% unweighted) (Czarnitzki et al., 2015). In Finland, the reduction was at least 29% (Ejermo and Toivanen, 2018), and in Denmark the reduction was 14% relative to the benchmark Sweden (Valentin and Lund-Jensen, 2007). In the most extreme case, Norway, the rate (and quality) of new venture creation and patenting by university-based researchers plunged approximately 50% (Hvide and Jones, 2015).

Data, Measures, and Estimation Methodology

Data Generation Process and Data Definitions

For the US, we use a representative sample covering individuals with a PhD in Natural Science, Engineering, and Medicine (NSEM) fields over the period 1993–2006. We employ the restricted-use Survey of Doctorate Recipients (SDR) dataset collected by the National Science Foundation (NSF) for 1993, 1995, 1997, 1999, 2001, 2003, and 2006. Although included in the SDR, we exclude the social sciences as we want to examine PhDs where businesses based on IP are more prevalent. In Natural Science we include the natural sciences, mathematics, computer science and agricultural science. The SDR is conducted every two years (although the 2006 survey was conducted 2.5 years after the previous one, in 2003) and is a longitudinal survey that follows recipients of research doctorates from US institutions until age 76. At each observation point, new doctoral recipients are added to the survey while some previously followed individuals are dropped (because of their age or for other reasons). A significant number of individuals has been followed over the entire 14-year period (at 2–2.5-year intervals).[4] SDR surveys are integrated into the US Scientists and Engineers Statistical Data System (SESTAT), which is a database designed especially for drawing inferences about the total population of scientists and engineers, with appropriate account taken of the different population sizes across the three surveys by adding a special variable to the restricted-use data called "SESTAT integrated weights." We use the SESTAT integrated weights to allow us to recover population numbers and report them throughout.

The Swedish register of all employed individuals working in the country was matched with register data from their employers by their social security number. From this matched

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

employer-employee dataset, we extract all 39,705 individuals with a PhD in a NSEM field who at some point in 1999–2008 were employed in Sweden.

Entrepreneurship

Our identification of US academic entrepreneurship follows established practice in the literature using SESTAT data (see Braguinsky et al., 2012; Elfenbein et al., 2010) by defining entrepreneurs as individuals with a PhD in a NSEM field switched to *principal employment* in his/her own business, professional practice, or farm after previously reporting his/her principal employment at a four-year college, university, medical school, or research institute at a university. Entrepreneurs who were not employed at a university (non-university employed) are defined in the same way, though they originate with other employment types (i.e., not from a four-year college, university, medical school, or a university research institute and not from their own business, professional practice, or farm).

Like the Swedish tax authorities, we define individuals as entrepreneurs who derive the majority of their taxable income from labor in a business that they own in full or in part. Using this definition, we extract 341 individuals with a PhD in a NSEM field who left a job at a Swedish university to become an entrepreneur in 2000–2008. To augment the study with more observations, we also consider entrepreneurs individuals who left a position in academia to work full-time at a company with 10 or fewer employees founded in the year that they left academia even when we could not find a direct ownership link between them and the firm. Using this definition, we extract 165 additional entrepreneurs. Considerable regularities have been established using this augmented definition of entrepreneurship (e.g., Sorensen, 2007; Nanda and Sorensen, 2010), and we consider ourselves on safe ground using this additional sample.

Non-university-employed entrepreneurs are similarly defined as above; the 1,360 individuals with a PhD in a NSEM field who left employment at any type of organization other than a university to become entrepreneurs in 2000–2008. Parallel to the identification process described above, we also consider individuals entrepreneurs if they left a non-academic position to work full-time for a company with 10 or fewer employees founded in the year they left prior employment even when we could not find a direct ownership link to the new firm. Using this definition, we extract 586 additional entrepreneurs.

Our definition of entrepreneurship is strict. For us to classify someone as an entrepreneur, it is not enough for that person to own a business while still working for someone else. The person has to switch to *principal employment* in his/her own business. Someone who is a part-time paid consultant (or pro-bono consultant) while remaining in academia is therefore not included in our definition of entrepreneurship. This definition is consistent with Knight's (1921) view of entrepreneurs as those who proactively embrace uncertainty. According to Knight, hedging risk by working for someone else while trying out entrepreneurship at the same time would not be entrepreneurship. Nevertheless, in our robustness analysis, we include a unique analysis of the impact of the returns to entrepreneurship when measuring several part-time incomes from business ventures while employed.

Income

In line with established practice (Braguinsky et al., 2012; Elfenbein et al., 2010), US 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 of April 15 in the year that the individuals were surveyed (see http://www.nsf.gov/statistics/srvydoctoratework/#qs/). Data were also available on total

income from the survey, which would cover, among other things, bonuses, consulting, overtime, dividends, and sales of equity from a start-up, but for the year before the one in which the individuals were surveyed. This makes these data inadmissible for use in this study.

Data on Swedish annual wage income are collected from the Swedish tax register. Although it is also possible to collect data on non-wage income, such as interest and dividends earned on savings and stocks, dividends from and the sale of entrepreneurial businesses, and part-time consulting, for our main comparison with the US, we decided to exclude these data. However, we include all non-wage business income in robustness analyses on the Swedish data. Including such additional income has two effects. Such side income increases total earnings pre-entrepreneurship for academics who are engaged in such activities. It also increases earnings as a full-time entrepreneur, if any. The net effect on the returns to switching to full-time entrepreneurship from including this side income can be either positive or negative, and our analysis can indicate whether accounting for such additional income is important.

Additional Variables

We include a set of variables that are potentially related to entrepreneurial entry and to the returns to entrepreneurship. We have typical background characteristics, such as gender, marital status, and whether they were foreign born. Differences across the NSEM fields are captured by a set of dummy variables. We also include variables that capture the individual's labor market experience. For this, we measure the number of years since the person received a PhD and the number of years that person has worked at the most recent employer. We further measure whether an academic was on a tenure track or not.

Data are organized as an unbalanced panel, and entry and exit can occur any time. We exclude individual-year observations whenever an entrepreneur switches back to wage-earning

employment. Altogether we have 61,828 year-person observations for those employed at a university (including entrepreneurs at some point) in the US and 86,910 year-person observations from Sweden. The number of year-person observations for the non-university employed (including entrepreneurs at some point) is 77,539 in the US and 155,027 in Sweden.

Descriptive Statistics

Table 1 reports variables, means, and standard deviations for the US, and Table 2 reports the same for Sweden. Column 1 includes all individuals with a PhD in a NSEM field at risk of becoming entrepreneurs, and column 2 breaks down the sample by those originating in university employment or non-university employment, respectively. Column 3 includes those who left their employment and became full-time entrepreneurs some time during 1995–2006 in the US and 2000–2009 in Sweden. Column 4 reports data for those who never left their employment sector.

The data reveal that US academic entrepreneurs are very different from Swedish academic entrepreneurs, as shown in column 3 in both tables. US academic entrepreneurs are more likely than Swedish academic entrepreneurs to be in the sciences, less likely to be males, more likely to be foreign born, married, or older, and have worked longer for their current employer. All differences between the two groups are statistically significantly different at $p<0.001$, except for marital status, where the difference is significant at $p<0.01$. The magnitudes of the differences are also considerable. For example, US academic entrepreneurs are more than twice as likely to be in the sciences as Swedish academic entrepreneurs and less than half as likely to have a PhD in medicine or engineering. US academic entrepreneurs are also considerably older than their Swedish counterparts, so they have over five years more work experience. These differences are largely driven by differences in who becomes an academic in

the two countries in the first place. Direct comparisons in academic entrepreneurship across the US and Sweden are therefore inappropriate, as they reflect differences in sample characteristics.

Within-country differences also appear across academic and non-academic entrepreneurs. For example, US academic entrepreneurs are more likely than Swedish ones to be in the sciences, less likely to be foreign born, male, or married, and younger than the US non-academic entrepreneurs, as shown in column 3 of Table 1. These differences are driven largely by the gap on these variables between US academics in general and US non-academics, as indicated in column 2 of Table 1. This implies that comparing entrepreneurship rates and returns across academic and non-academic entrepreneurs without controlling for observable differences in the samples might also be inappropriate, as such a direct comparison might merely reflect differences between those who become academics and those who make a career in industry.

Insert Table 1 about here

Insert Table 2 about here

As concluded above, direct comparisons in outcomes across the US and Sweden are likely inappropriate, and even direct within-country comparisons across academics and non-academics will be muddied by differences in sample compositions. We restrict ourselves to illustrative graphs of differences in earnings within each of the two countries for entrepreneurs and non-entrepreneurs and further limited to those who originate in academia. These graphs illustrate some striking patterns. Figure 1a shows that earnings for academic entrepreneurs are typically much lower than earnings for their peers who remain in academia—the dashed-line earnings distribution shifts more to the left. This earnings difference depends on two factors illustrated in the next two figures. First, those who become entrepreneurs later earn less than their peers prior to moving, as illustrated in Figure 1b, and this lower performance in academia

tends to persist in entrepreneurship. If the prior wage is presumed to be an indication of ability (we explore this presumption in detail), then the graph indicates that academic entrepreneurs are selected from the lower portion of the ability distribution of academics. 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 also reduces income. These patterns are consistent across the US and Sweden.

Insert Figure 1 about here

Estimation methodology

Using the full sample of academics and non-academics to do analysis independently for the US and Sweden, we first estimate individuals' propensity to leave employment for entrepreneurship using a panel-data linear probability random-effects generalized least squares estimator.

$$P(E_{it}) = \alpha + \beta U_i + \delta X_i + \varepsilon_{it} \quad (1)$$

where E_{it} is employment status at time *t* for individual *i* (= 1 if entrepreneur, = 0 if working for someone else), U_i is a person-fixed employment-origin effect (= 1 if originating in university employment, = 0 if originating in non-university employment), X_{it} is a vector of (potentially time-varying) covariates that may in addition determine entrepreneurship, and ε_{it} is an i.i.d. error term. Errors are clustered on the individual. Our primary interest is the size of the coefficient β that will indicate the difference in the rate of entrepreneurship between those originating in university and non-university employment.

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

$$y_{it} = \alpha + E_{it}(\gamma + \beta U_i + \delta X_{it}) + \theta_i + \varepsilon_{it} \quad (2)$$

where y_{it} is the natural logarithm of earnings,[5] θ_i are individual-fixed effects that do not vary over time, and the remaining notation is as before. The size of the coefficient γ will indicate the return to entrepreneurship. Parameter β in equation 2 indicates whether the returns to entrepreneurship differ between those originating in university employment and those originating in non-university employment. Similarly, the terms δ indicates whether any of the covariates describing individuals are associated with differences in the returns to entrepreneurship. The difference in earnings between those who are university employed and those who are non-university employed is absorbed by θ_i.

The choice of entrepreneurship might be a function of unobserved (for the econometrician) characteristics, such as a permanent disposition and inclination toward entrepreneurial activity. To address this problem, the fixed-effects model analyze only the difference in earnings for those who become entrepreneurs, whose disposition toward entrepreneurship and other unobservable individual-specific characteristics are absorbed by θ_i. We thus estimate the difference in income between entrepreneurship and employment for a given individual who change employment status only once.

Results

Who becomes an entrepreneur in the US?

A key question is: Among the US PhD's, who becomes an entrepreneur? Results are presented in Tables 4 and 5.[6] In Table 3, we observe that the probability of becoming an

[5] For those who have 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 recoded as zero in the logarithmic measure of earnings. Earnings are index adjusted with the consumer price index.
[6] The US data have missing survey item reponses on variables such as tenure-track status and years of work with the last employer. We conducted robustness analyses including and excluding variables that suffer from having the most missing data and found that results were not sensitive to such missing data. These results are available from the corresponding author on request.

entrepreneur increases with the number of years after the PhD but decreases in terms of the number of years at the last employer. Both results represent typical life-cycle patterns observed in many other studies of entrepreneurship. Entrepreneurship is more prevalent among those with a PhD in medicine or engineering than among those with a PhD in the sciences. Surprisingly, in this sample, males are less likely than females to become entrepreneurs, with a difference in probability of about 0.9 percentage points, which represents approximately a 20 percent difference in the mean probability of becoming an entrepreneur (which is 4.5 percent in the full sample, per Table 1). Notably, in the US, the probability of becoming an entrepreneur is significantly lower among academics than among those who originate in the non-university sector. Further, those with a lower (real lagged) salary are more likely to become entrepreneurs, suggesting selection from the lower end of the wage distribution into entrepreneurship. We explore this result in more detail.

Insert Table 3 about here

The returns to becoming an entrepreneur in the US

The difference (in logs) between earnings from entrepreneurship and wage earnings shows that becoming an entrepreneur in the US reduces earnings by 14.8% [exp(-0.160)-1] for PhDs in a NSEM field (Table 4, column 1). Those who originate in academia do not suffer more, nor are they better rewarded, than those who originate in non-university-sector employment when they become entrepreneurs. After we interact several background characteristics to capture differences in the rewards from becoming an entrepreneur, we note that the mean entrepreneurial earnings rewards is negative 24% [exp(-0.273)-1] for the omitted group, which represents unmarried domestically born females with no labor market experience and a PhD in the sciences, and still find no difference between those who originate in academia and those from the non-university sector (Table 4, column 2). Those in the omitted group who are foreign born receive 16% [exp(-

0.149)-1] higher compensation, and those in the omitted group who are married receive 11% [exp(0.105)-1] higher compensation—which together almost (but not quite) nullifies the penalty from becoming an entrepreneur. Moreover, for each year of additional work at the last employer, relative earnings from becoming an entrepreneur increase by 1.6%, such that had those in the omitted group stayed at one employer for 20 years (and remained unmarried) and then become entrepreneurs, the earnings premium from becoming an entrepreneur would be 8.1%.

Insert Table 4 about here

Who becomes an entrepreneur in Sweden?

Table 5 shows that the probability of becoming an entrepreneur in Sweden increases in the years after the PhD is obtained but decreases in terms of the number of years at the last employer. Both results represent typical life-cycle patterns observed in many other studies of entrepreneurship. In contrast to the US, entrepreneurship in Sweden is less prevalent among those with a degree in medicine, but, as in the US, those with PhDs in engineering are more prevalent as entrepreneurs than those with a PhD in the sciences. As in the US, men with PhDs are less likely than women to become entrepreneurs.

Notably, in Sweden, as in the US, the probability of becoming an entrepreneur is significantly lower among academics than among those originating in non-university-sector employment. Further, those with lower (real lagged) salaries are more likely to become entrepreneurs, suggesting selection from the lower end of the earnings distribution into entrepreneurship, as in the US. Overall, the coefficients in both countries are remarkably similar.

In the Online Appendix[7], we interact the dummy for originating in university employment with the covariates to further explore the differences between academics and non-university sector

[7] Available at http://dx.doi.org/10.2139/ssrn.2677283

employees who become entrepreneurs in both the US and Sweden. In the US, the coefficient on originating in university employment loses its statistical significance but has a higher absolute value. In Sweden, the corresponding coefficient remains statistically significant, and its absolute value is also is higher. Interestingly, while some covariates strongly predict the probability that those who originate in the non-university sector of will become entrepreneurs, their effects on the probability that academics will become entrepreneurs are much more muted. Thus, having a PhD in engineering (and also in medicine in the US) is a good predictor of the probability that non-university employees will become entrepreneurs, but for those in academia, the effect is not different from zero (compared to a degree in the sciences). Also, two-thirds of the positive impact of the number of years after a PhD is received in the US and 20-25% of this impact in Sweden, as well as 60% of the negative impact of the salary in the previous period among non-university-sector employees in US and over 90% in Sweden is offset by the interaction term, such that entrepreneurs who previously held university jobs tend to be younger and better paid in their previous jobs than their counterparts who originate in the non-university sector. The effect of being foreign born, however, differs from between the US and Sweden. In the US, the foreign born are more likely to become entrepreneurs in the nonacademic sample, but the effect of this covariate among academic entrepreneurs is reversed while in Sweden, foreign-born PhDs in Sweden do not deviate from domestic PhDs as a group to a statistically significant degree.

To summarize the regressions on the probability of entering entrepreneurship, it appears that, in both the US and Sweden, academic entrepreneurs tend to be younger and better paid in their previous job than non-academic entrepreneurs. The two countries differ in the relative role of the effect of gender and being foreign born across academic and non-academic entrepreneurs.

Insert Table 5 about here

The returns to becoming an entrepreneur in Sweden

Becoming an entrepreneur in Sweden reduces earnings by 10.1% [exp(-0.107)-1] for PhDs in a NSEM field originating in non-university-sector employment (Table 6, column 1). Those who originate in academia have less negative returns (-6.8%), but the difference is not statistically significant compared to those who originate in non-university-sector employment when becoming entrepreneurs. After we interact several background characteristics to capture differences in the rewards to becoming an entrepreneur across different groups, we still see no difference between those who originate in academia and those who do not (Table 6, column 2). The mean entrepreneurial earnings reward in the omitted category is zero, for unmarried females with a PhD in the sciences, with zero years of work experience. The mean earnings penalty to entrepreneurship noted in the prior regression is driven primarily by two large groups: males and those who are foreign born. Males have an 8.7% [exp(-0.083)-1] penalty for becoming an entrepreneur, and the foreign born have a rate of return of -11% [exp(-0.113)-1], although the latter effect is not significant at conventional levels. For each year of additional work since obtaining a PhD, relative earnings from becoming an entrepreneur decreases by 0.8% per year, while remaining at the same employer for another year increases earnings from entrepreneurship by 0.9% per year. As in the US, in Sweden being married leads to a positive earnings difference, possibly indicating either greater financial capital or social capital or both, which might be associated with the relaxation in credit constraints from becoming an entrepreneur.

To summarize the earnings regressions, US and Swedish individuals appear to suffer an earnings penalty from becoming entrepreneurs, irrespective of whether they originate in university or non-university employment.

Insert Table 6 about here

Tenure-track effects

We could not study the effect of having a tenure-track position when those in the sample originating in the non-university sector were included. Nevertheless, tenure-track considerations might feature prominently in the decision to become an entrepreneur and the earnings impact of this choice. In the Online Appendix, we examine the returns to entrepreneurship for US academics who are laid off, and those who move to entrepreneurship because it presents better prospects of financial reward. We also examine selection effects based on whether someone is on tenure track for US academics.

We show that 66 percent of the individuals who leave academia for entrepreneurship do not have a tenure-track position. In comparison, among those who stay in academia, 64 percent have a tenure-track position suggesting that there might be differences in outcomes based on tenure-track status. Indeed, those who are not on a tenure track (research assistants, post-docs, and the like) are two percentage points more likely to become entrepreneurs than tenure-track professors. When the tenure-track dummy is included, the coefficient on the previous wage is estimated to be -0.004, but when it is removed (as in Table 3), the same coefficient is estimated to be -0.008. In both cases, the previous wage is shown to have a statistically significant negative impact on the probability of becoming an entrepreneur, but the magnitude is reduced in half when the tenure-track dummy is included. This indicates that not being on a tenure track is positively correlated with lower wages, and both lower wages and not being on a tenure track are correlated with selecting into entrepreneurship. In both regressions, we control for labor market experience and years of service at the latest employer, which are both strong predictors of wages. After these controls, what remains as wage determinants is typically associated with individual ability.

In a random-effects estimation of log earnings, we find that those on a tenure track on average earn 28% [exp(0.249)-1] more than those who are not on a tenure track. In a fixed-effects regression, we find instead a small negative effect from being on a tenure track, which, moreover, is statistically not significant at conventional levels. The large difference in the coefficient for having a tenure track position between the random- and fixed-effects regressions indicates selection from the bottom of the ability distribution into academic entrepreneurship. That is, those in non-tenure-track positions are more likely to have low pre-entry earnings, more likely to enter entrepreneurship, and earn significantly less in entrepreneurship than those with a prior tenure track position. While these results are not altogether conclusive in and of themselves, the general inference is that academic success is positively correlated with entrepreneurial success (e.g. Azoulay et al., 2009; Buenstorf, 2009; Lowe and Gonzales-Brambila, 2007).

We further analyze the relationship between tenure-track status, being laid off versus leaving for better opportunity, and earnings as an entrepreneur. For academics who are laid off, 22.9% are on a tenure track, while among those who leave voluntarily for better opportunity a much larger proportion, 42.5%, have a tenure-track position. Differences in tenure-track status are not statistically significantly different at conventional levels among those who are laid off, those who leave for better opportunity, and those who leave for other reasons, respectively. Nevertheless, because choosing to leave for better opportunity is the only one of the categories that shows significant positive returns to entrepreneurship in earnings, it appears that promoting entrepreneurship specifically among tenure-track professors might be more advantageous than promoting it among all academics, should its promotion seem necessary.

An additional noteworthy result in the US data is that older academics, as measured by years since obtaining a PhD, have the worst-performing entrepreneurial ventures in relation to their

prior earnings, while younger academics on average generate higher earnings when they become entrepreneurs compared to their prior earnings in academia. The coefficient for work experience (years since receiving a PhD) is about -4% per year of work experience at entry. To further illustrate the negative correlation between work experience and entrepreneurial earnings, in our auxiliary analysis, we split the US academic subsample by age above and below 40 years old.

The results from this auxiliary regression (also reported in the Online Appendix) show that switching to entrepreneurship below the age of 40 involves an earnings increase of 34% [exp(0.290)-1], while for those over age 40 the average earnings penalty is -31% [exp(-0.366)-1]. We might interpret this result by saying that, in the US, the opportunity cost from leaving academia to become an entrepreneur increases greatly with academic experience. An alternative interpretation is that older academics have worse entrepreneurial ideas than younger academics. In summary, it appears that a minority of academic entrepreneurs are successful, and they more often come from among young tenure-track professors who leave because they are chasing an opportunity, not because they do not get tenure.

Dividends, business sales, consulting, and other part-time entrepreneurial income

Although we cannot compare non-wage income in the US and Sweden, we can examine three non-wage incomes exclusively in Sweden because of data uniquely collected there. The Online Appendix reports descriptive data on dividends and income from the sale of firm equity in which the individual is one of at most 4 owners who jointly hold at least 50% ownership in a private, closely held firm. Most of the non-wage income comes from annual dividends, and very little from the occasional sale of firm equity. Academics earn a pittance in dividends and equity sales, less than $1,000 in dividends and approximatively $100 in equity sales on an annual basis. When they are full-time entrepreneurs, their annual dividends increase to approximately $8,300,

and income from equity sales increases to approximately $800, annualized. However, individuals who originate in the non-university sector more often earn higher dividends/equity as well as more in non-wage income, both as employees and as entrepreneurs. For example, as employees their annual dividends are on average approximately $4,000, and when they become entrepreneurs, their annual dividends increase to approximately $11,000.

In the Online Appendix we also report other non-wage income not classified as dividends or equity sales or as other capital income. (We can only report these for full-time academics who operate a sole proprietorship under which these part-time earnings are recorded. However, this may be the most common legal form for academics with side business income.) This type of income is often dominated by part-time consulting. Indeed, some consulting income is recorded, but very little. On average, approximately 7 percent of employees make some side income from consulting, regardless of whether they are in academia. Those outside academia earn approximately SEK 10,000 (around $1,300) per year from consulting while academics earn approximately SEK 6,000 (less than $1,000) per year in consulting income.

To summarize, these earnings are part of the unmeasured "hybrid" entrepreneurship that we pick up this way. As in prior studies (Folta et al., 2010; Louis et al., 1989), these sources of income are not substantial, and few academics earn much consulting income. In terms of documented side income, we find that earning such income is much more common among non-academics than academics, a fact not previously documented.

Finally, the Online Appendix contains a table with the exact same earnings regressions as in Table 6, while including dividends, equity realizations, and part-time consulting income. The direction of the results is consistent with that of results reported in Table 6. If anything, they point to an even more severe earnings penalty from becoming an academic entrepreneur.

Discussion

Table 7 summarizes our results. We find a lower rate of entrepreneurship by university employees than by non-university-sector employees in both countries, with the US having only a slightly lower rate of academic entrepreneurship than Sweden. This difference supports the view that the PP is associated with a higher willingness by academics to leave their university to start a new business than when universities assert control and property rights over university inventions.

We further observe that losses from becoming an entrepreneur are statistically similar across the four groups, but appear to be smaller for Swedish academic entrepreneurs, consistent with the fact that they have larger cash-flow rights and control rights than US academic entrepreneurs.

The differences between the US and Sweden are primarily due to sample composition differences across the two countries, not only in who becomes an entrepreneur but also who becomes an academic in the first place. However, after we condition on observables, the rate of academic entrepreneurship and the rate of return to academic entrepreneurship, as well as most other coefficient estimates are strikingly similar in the US and Sweden.

Insert Table 7 about here

Our policy conclusions must be guarded. Our systematic large-scale comparative study of academic entrepreneurship across two different IP regimes represents a first assessment. With novelty comes some limitations, associated primarily with the type of data we could observe but also with having two cases that vary across a number of dimensions. To facilitate cross-case comparison, we use a difference-in-difference approach in which the effect of the IP rights regime in academia in a country is compared to the effect of the IP rights regime in non-academia in the same country, while controlling for observable covariates. This approach allows a substantial

reduction of country-level sample differences and thereby facilitates an exploratory investigation of how academic entrepreneurship plays out in an environment with a mature Bayh-Dole IP rights regime, compared to an environment with mature PP legislation, respectively.

A comparison of our two case studies suggests that if an increase in academic entrepreneurship in the US is desired, a greater share of ownership of the IP should be given to its creators in academia. However, a wholesale changeover from Bayh-Dole regulation to the PP in the US would increase academic entrepreneurship only by 4.5%, if our estimates are accepted. Such a small increase hardly seems worth the effort.

We further conclude that in both countries too many academics enter into entrepreneurship considering that these efforts do not pay off financially for the individuals, on average. The risk-adjusted returns to academic entrepreneurs would look even worse than the non-risk-adjusted returns computed in this article.

In both the US and Sweden, several general policy instruments have been adopted to encourage university employees to become entrepreneurs. We presume that these policies are based on the idea that these projects will generate large social rates of return even if they are personally unprofitable, on average. Other studies indicate this is a plausible but unverified assumption (e.g. Mansfield, 1991). If the projects indeed have large social surpluses, then there is an argument in favor of compensating academics for the income losses they are apparently making when trying to commercialize their IP.

However, our results suggest that too much emphasis has been placed on the general stimulus of academics, because of the selection from the bottom of the ability distribution in both countries. Furthermore, even if the idea to financially compensate academics for making personally unprofitable efforts is appealing at first blush, it should also be recognized that such

incentives encourage excessive investment in marginal projects. Our earnings data are consistent with the existence of excess entry into entrepreneurship. In addition, the regressions are consistent with negative selection. We find that non-tenure-track employees and those with lower wages pre-entry as well as those who are laid off are more likely to become entrepreneurs but earn less as entrepreneurs than tenure-track professors who become entrepreneurs. At the same time, younger academics find greater success than older academics as entrepreneurs.

Although these results must be regarded as preliminary, they indicate some directions for more effective policy. While simply encouraging more academics to become full-time entrepreneurs may not be the right recipe, more targeted policies aimed at supporting entrepreneurial decisions by a more narrowly defined group of prospective entrepreneurs, consisting primarily of younger, tenure-track academics, may produce more effective results for society. To reduce marginal entrepreneurship, it may be better to counsel someone considering a business opportunity against entrepreneurship, especially if such advice is coupled with an independent critical evaluation of whether that opportunity has "legs," as offered, for example, by the Canadian Innovation Centre or through advice from jurors in business plan competitions (see, e.g., Åstebro and Elhedhli, 2006; Howell, 2018). A system that allows easier return to academia in case entrepreneurial projects do not pan out may also be good policy.

Most of our analysis concerns individuals who become full-time entrepreneurs, taking significant income risk. Others studies have argued that university employees may serve new ventures better if they are more loosely affiliated with them as part-time owners, consultants, or advisors, rather than engaged full time as owner-entrepreneurs (Braunerhjelm and Svensson, 2010; Nicolaou and Birley, 2003). Our Swedish data that include dividends and equity income from both part-time (hybrid) and full-time participation as well as part-time consulting income suggest that

such additional part-time income tilts the scale even further away from full-time entrepreneurial efforts. This study therefore encourages policy makers, deans, and other university decision makers to permit academics more flexibility in accepting external projects while still holding university employment.

Finally, changing the allocation of ownership and control rights for individual faculty must be considered from a wider perspective, because such changes may also affect the incentives at universities for transferring technology to established firms. In the US, universities have established a system of invention commercialization that favors technology transfer, rather than academic entrepreneurship. We do not measure the effects on technology transfer here, and the US system may well excel on this account. What we can say regarding overall social welfare is therefore limited and rests on theory, rather than empirical analysis. In Sweden and other countries that operate with a Professor's Privilege, the decision about which route of commercialization to take is up to a single individual, rather than multiple parties with conflicting objectives. Contracting theory suggests that such a system is more efficient.

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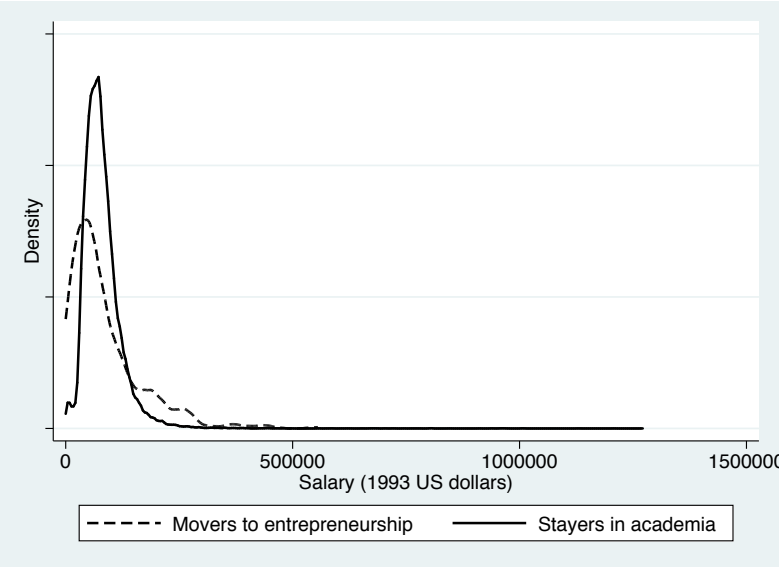
Figure 1.

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



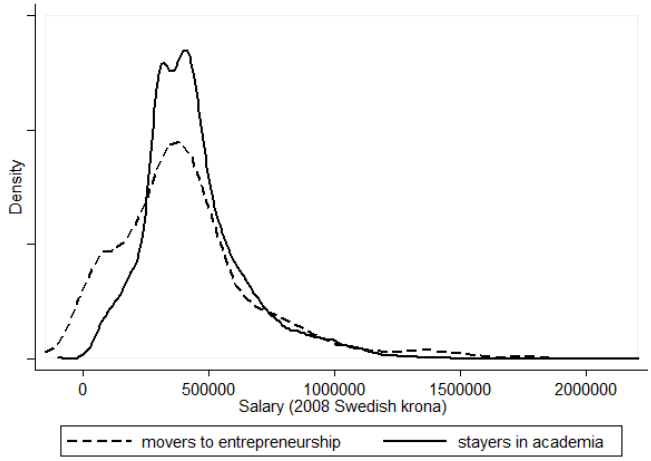
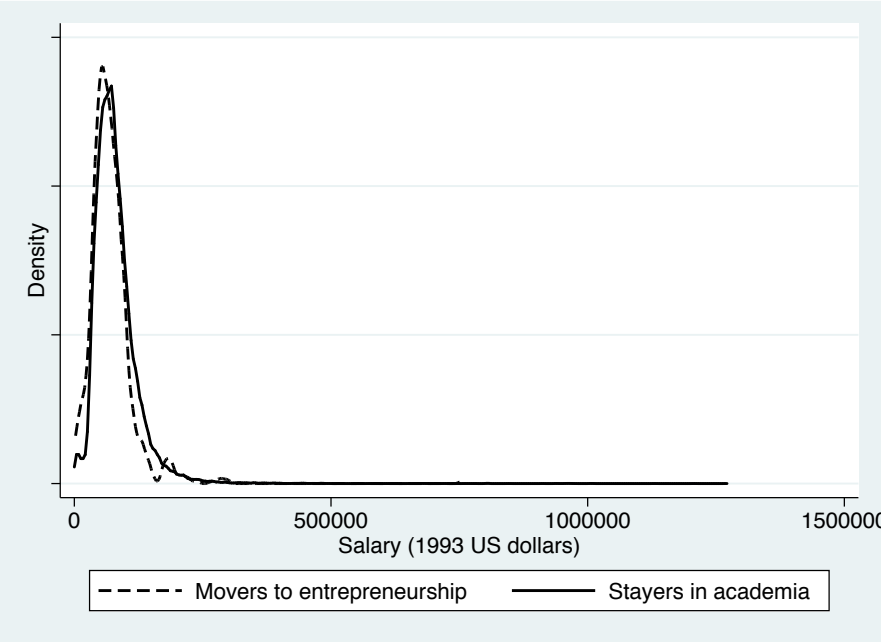


Figure 1b. Probability density functions of wages prior to moving for those moving to entrepreneurship from academia (dashed line) and wages for those staying in academia (solid line) (1993 US dollars and 2008 Swedish krona).



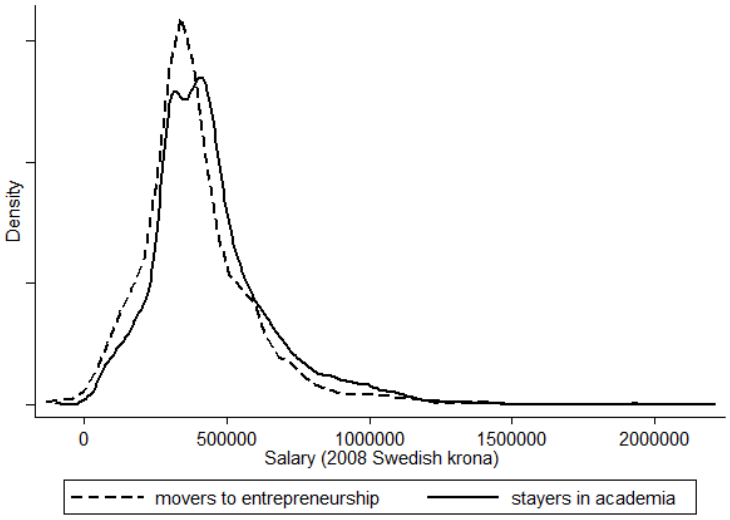
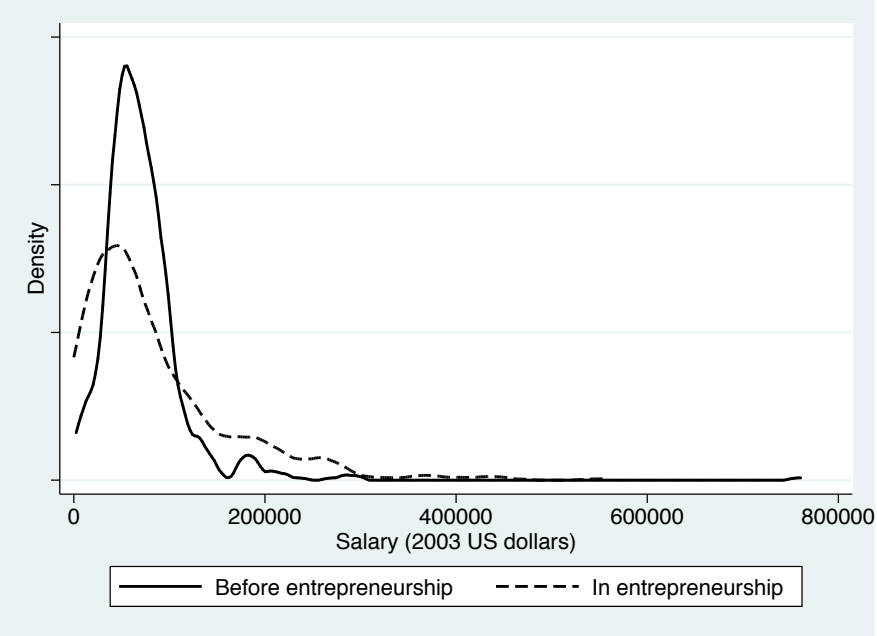


Figure 1c. Probability density functions of wages prior to moving (solid line) and earnings after moving (dashed line) for those moving to entrepreneurship from academia (1993 US dollars and 2008 Swedish krona).



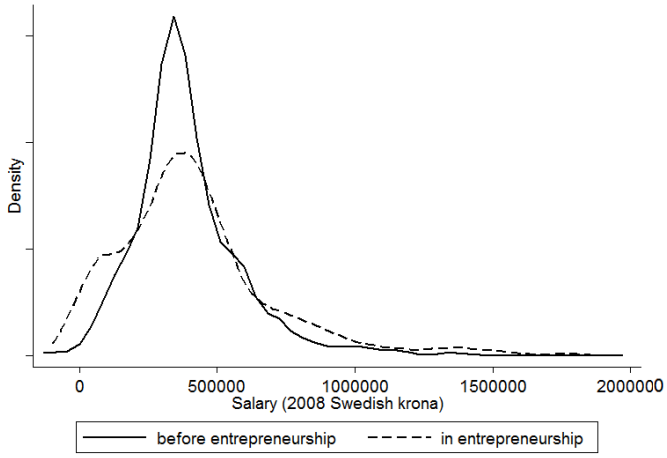


Table 1. Variables, means, and standard deviations for the US.

	Column 1	Column 2		Column 3		Column 4	
	Sample averages	Sample split by origin		Ever-entrepreneur=1		Ever-entrepreneur=0	
		University-employed	Not university employed	University-employed	Not university employed	University-employed	Not university employed
Dependent variables							
Probability of entrepreneurship	0.026 (0.159)	0.009 (0.093)	0.040 (0.195)	0.493 (0.500)	0.421 (0.494)	0	0
Log(real wage income)	11.34 (0.692)	11.18 (0.623)	11.47 (0.716)	10.93 (1.034)	11.47 (0.901)	11.19 (0.613)	11.47 (0.694)
Independent variables							
Natural Sciences=1	0.711 (0.453)	0.771 (0.420)	0.665 (0.472)	0.743 (0.437)	0.652 (0.476)	0.771 (0.420)	0.666 (0.472)
Medicine=1	0.050 (0.218)	0.067 (0.251)	0.037 (0.188)	0.101 (0.301)	0.038 (0.191)	0.067 (0.250)	0.036 (0.187)
Engineering=1	0.239 (0.426)	0.162 (0.368)	0.299 (0.458)	0.156 (0.363)	0.310 (0.463)	0.162 (0.368)	0.297 (0.457)
Foreign born=1	0.275 (0.447)	0.240 (0.427)	0.302 (0.459)	0.215 (0.411)	0.287 (0.452)	0.241 (0.428)	0.304 (0.460)
Male=1	0.799 (0.401)	0.758 (0.428)	0.831 (0.375)	0.675 (0.468)	0.847 (0.360)	0.760 (0.427)	0.829 (0.376)
Married/cohab=1	0.808 (0.393)	0.794 (0.404)	0.819 (0.385)	0.745 (0.436)	0.827 (0.378)	0.795 (0.404)	0.819 (0.385)
Years since obtaining PhD	13.72 (8.99)	13.56 (9.22)	13.85 (8.80)	13.41 (8.33)	15.79 (8.50)	13.56 (9.24)	13.65 (8.80)
Years at last employer	7.95 (7.81)	9.27 (8.50)	6.93 (7.06)	5.61 (6.32)	6.07 (6.31)	9.39 (8.52)	7.02 (7.13)
Tenure track=1		0.713 (0.453)		0.439 (0.496)		0.644 (0.479)	
Reason leaving for pay/promotion				0.250 (0.433)	0.157 (0.364)		
Reason for leaving is being laid off				0.117 (0.321)	0.164 (0.370)		
Job was strongly related to the PhD degree	0.651 (0.477)	0.818 (0.386)	0.521 (0.500)	0.563 (0.455)	0.455 (0.498)	0.822 (0.382)	0.527 (0.499)
Number of observations	136,250	61,828	74,422	1,045	6,415	60,783	68,007

Source: Authors' estimates using NSF data. **Notes**: Column 1 includes all individuals with a PhD in NSEM fields in 1993–2006 at risk of becoming entrepreneurs. In Column 2 these data are split by originating in university employment and non- university employment. Column 3 includes those who left their employment and became full-

time entrepreneurs some time in 1995–2006, split by university employment and non- university employment. Column 4 reports data for those who never leave their sector of employment, split by university employment and non- university employment. SESTAT-provided weights are used.

Table 2. Variables, means and standard deviations for Sweden.

	Column 1	Column 2		Column 3		Column 4	
	Sample averages	Sample split by origin		Ever-entrepreneur=1		Ever-entrepreneur=0	
Originating sector		University-employed	Not university-employed	University-employed	Not university-employed	University-employed	Not university-employed
Dependent variables							
Probability of entrepreneurship	0.028 (0.166)	0.013 (0.113)	0.037 (0.189)	0.415 (0.493)	0.444 (0.497)	0	0
Log(real wage income)	13.05 (0.579)	12.87 (0.545)	13.15 (0.574)	12.68 (0.824)	13.06 (0.767)	12.88 (0.531)	13.15 (0.553)
Independent variables							
Natural Sciences=1	0.311 (0.463)	0.402 (0.490)	0.259 (0.438)	0.362 (0.480)	0.272 (0.445)	0.403 (0.491)	0.258 (0.437)
Medicine=1	0.370 (0.483)	0.269 (0.443)	0.427 (0.495)	0.223 (0.417)	0.355 (0.479)	0.270 (0.444)	0.434 (0.496)
Engineering=1	0.306 (0.461)	0.313 (0.464)	0.303 (0.459)	0.408 (0.491)	0.364 (0.481)	0.310 (0.462)	0.297 (0.457)
Foreign born=1	0.174 (0.379)	0.196 (0.397)	0.160 (0.367)	0.141 (0.348)	0.127 (0.333)	0.198 (0.398)	0.163 (0.370)
Male=1	0.706 (0.456)	0.697 (0.460)	0.711 (0.453)	0.755 (0.430)	0.815 (0.389)	0.695 (0.460)	0.702 (0.458)
Married/cohab=1	0.726 (0.446)	0.690 (0.462)	0.746 (0.435)	0.698 (0.459)	0.756 (0.430)	0.690 (0.463)	0.745 (0.434)
Years since obtaining PhD	9.76 (7.90)	9.67 (8.47)	9.81 (7.55)	8.24 (6.91)	10.92 (7.37)	9.72 (8.51)	9.71 (7.56)
Years at last employer	7.00 (6.74)	9.11 (7.32)	5.80 (6.06)	4.72 (5.71)	3.48 (4.62)	9.25 (7.32)	6.00 (6.13)
Number of observations	238,512	86,910	151,602	2,721	12,599	84,189	139,003

Source: Authors' estimates using Statistics Sweden data. **Notes:** Column 1 includes all individuals with a PhD in NSEM fields in 1993–2006 at risk of becoming entrepreneurs. In Column 2 these data are split by originating in university employment and non- university employment. Column 3 includes those who left their employment and became full-time entrepreneurs some time in 1995–2006, split by university employment and non- university employment. Column 4 reports data for those who never leave their sector of employment, split by university employment and non- university employment.

Table 3. Probability of entrepreneurship among US PhDs in NSEM fields.

	Dependent variable =1 if an entrepreneur, zero otherwise	
Originating from academia	Coefficient	-0.038***
	Std.Err.	0.002
Medicine	Coefficient	0.023***
	Std.Err.	0.004
Engineering	Coefficient	0.010***
	Std.Err.	0.002
Foreign born	Coefficient	0.002
	Std.Err.	0.002
Male	Coefficient	-0.009***
	Std.Err.	0.002
Married	Coefficient	0.000
	Std.Err.	0.002
Years since PhD	Coefficient	0.004***
	Std.Err.	0.000
Years at last employer	Coefficient	-0.002***
	Std.Err.	0.000
Log prev. year real wage	Coefficient	-0.008***
	Std.Err.	0.002
Constant	Coefficient	0.010***
	Std.Err.	0.002
Individual-fixed effects		Not included
# of observations		93,053
# of individuals		31,696

Source: Authors' estimates using NSF data. **Notes**: *** $p<0.001$. The first row represents a dummy variable that takes a value of one for those originating in university employment. The probability is estimated using a random-effects Generalized Least Squares (GLS) linear probability model with standard errors clustered on the individual.

Table 4. Earnings effects of becoming an entrepreneur among US PhDs in NSEM fields, comparing those originating in university employment to those originating in non-university employment employment.

	Dependent variable: Log real salary		
Entrepreneur	Coefficient	-0.160***	-0.273***
	Std.Err.	0.027	0.081
Entrepreneur * Originating in academia	Coefficient	0.009	0.047
	Std.Err.	0.081	0.094
Entrepreneur * Medicine	Coefficient		0.157
	Std.Err.		0.119
Entrepreneur * Engineering	Coefficient		-0.013
	Std.Err.		0.063
Entrepreneur * Foreign born	Coefficient		0.149*
	Std.Err.		0.062
Entrepreneur * Male	Coefficient		0.019
	Std.Err.		0.064
Entrepreneur * Married	Coefficient		0.105
	Std.Err.		0.063
Entrepreneur * Years since PhD	Coefficient		-0.002
	Std.Err.		0.006
Entrepreneur * Years at last employer	Coefficient		0.016***
	Std.Err.		0.003
Constant	Coefficient	11.443***	11.341***
	Std.Err.	0.010	0.073
Individual-fixed effects		Included	Included
# of observations		7,345	6,314
# of individuals		1,957	1,951

Source: Authors' estimates using NSF data. **Notes**: *** $p<0.001$, * $p<0.05$. The first row represents a dummy variable that takes a value of one in the year and every year after becoming an entrepreneur. The second row represents a dummy variable taking a value of one for those originating in university employment and for the year and every year after becoming an entrepreneur. Individual-fixed-effects regression, standard errors clustered on the individual, with and without covariates.

Table 5. Probability of entrepreneurship among Swedish PhDs in NSEM fields.

	Dependent variable =1 if an entrepreneur, zero otherwise	
Originating in academia	Coefficient	-0.031***
	Std.Err.	0.001
Medicine	Coefficient	-0.001
	Std.Err.	0.001
Engineering	Coefficient	0.006***
	Std.Err.	0.001
Foreign born	Coefficient	-0.001
	Std.Err.	0.001
Male	Coefficient	-0.003*
	Std.Err.	0.001
Married	Coefficient	0.001
	Std.Err.	0.001
Years since PhD	Coefficient	0.003***
	Std.Err.	0.000
Years at last employer	Coefficient	-0.004***
	Std.Err.	0.000
Log prev. year real wage	Coefficient	-0.009***
	Std.Err.	0.001
Constant	Coefficient	0.144***
	Std.Err.	0.015
Individual-fixed effects		Not included
# of observations		195,689
# of individuals		34,547

Source: Authors' estimates using Statistics Sweden data. **Notes**: *** $p<0.001$, * $p<0.01$. The first row represents a dummy variable that takes a value of one for those originating in university employment. The probability is estimated using a random-effects GLS linear probability model with standard errors clustered on the individual.

Table 6. Earnings effects of becoming entrepreneur among Swedish PhDs in NSEM fields, comparing those originating in university employment to those originating in private sector employment.

	Dependent variable: Log real salary		
Entrepreneur	Coefficient	-0.107***	-0.016
	Std.Err.	0.018	0.057
Entrepreneur * Originating in academia	Coefficient	0.037	0.038
	Std.Err.	0.046	0.048
Entrepreneur * Medicine	Coefficient		0.069
	Std.Err.		0.041
Entrepreneur * Engineering	Coefficient		-0.017
	Std.Err.		0.039
Entrepreneur * Foreign born	Coefficient		-0.113
	Std.Err.		0.062
Entrepreneur * Male	Coefficient		-0.083*
	Std.Err.		0.041
Entrepreneur * Married	Coefficient		0.068*
	Std.Err.		0.034
Entrepreneur * Years since PhD	Coefficient		-0.008***
	Std.Err.		0.002
Entrepreneur * Years at last employer	Coefficient		0.009***
	Std.Err.		0.002
Constant	Coefficient	13.039***	13.040***
	Std.Err.	0.007	0.007
Individual-fixed effects		Included	Included
# of observations		15,320	15,320
# of individuals		2,452	2,452

Source: Authors' estimates using Statistics Sweden data. **Notes**: *** p<0.001, * p<0.05. The first row represents a dummy variable that takes a value of one in the year and every year after becoming an entrepreneur. The second row represents a dummy variable taking a value of one for those originating in university employment and for the year and every year after becoming an entrepreneur. Individual fixed-effects regression, standard errors clustered on the individual, with and without covariates.

Table 7. Summary of main findings.

		Relative entrepreneurship rate academics compared to non-academics	Annual loss to earnings from switching to entrepreneurship
U.S.	Originating in non-academia		-14.8%
	Originating in academia	-3.8%	-14.0%
Sweden	Originating in non-academia		-10.1%
	Originating in academia	-3.1%	-6.8%

Source: Authors' estimates using NSF data and Statistics Sweden data. **Notes**: A summary of comparison of the differences in the relative rates of entrepreneurship and earnings improvements for prior academics and non-academics with a PhD in NSEM fields who become entrepreneurs in the US (1993–2006) and Sweden (1999–2008). The entrepreneurship rate is estimated relative to that of PhDs originating in non-university employment using a regression. The earnings differences are estimated through regressions with log of wages or earnings as the dependent variable, an entrepreneurship indicator, and an indicator for originating from university employment on the right-hand side interacted with the entrepreneurship indicator. Results are drawn from separate regressions across countries and outcome variables.

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