Startups by Recent University Graduates versus their Faculty: Implications for University Entrepreneurship Policy

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Abstract:

Earlier research on the role of universities in fostering entrepreneurial economic development almost exclusively covers spin-offs by faculty and staff. In contrast, we provide general evidence from the U.S. showing that the gross flow of start-ups by recently graduated students with an undergraduate degree in science or engineering is at least an order of magnitude larger than the spin-offs by their faculty, that a recent graduate is twice as likely as her Professor to start a business within three years of graduation, and that the graduates' spin-offs are not of low quality. Three case studies illustrate how universities may stimulate science and engineering students and recent graduates to create new firms of high quality. We conclude that transforming university goals and practices toward increasing start-ups led by faculty might not be the most effective way for universities to stimulate entrepreneurial economic development.

Key words:
Academic entrepreneurship, University Policy, Spin-offs, Students

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1. Introduction

The last thirty years has seen an increasing rate of spin-offs from university research.[1] And an increasing fraction of academics are engaging in entrepreneurial activities (Thursby and Thursby, 2007). The dramatic increase in the rate of university spin-offs over the past decades is attributed to several reasons: the germination of biomedical research in the 1970's, the passage of the Bayh-Dole act in 1980, increased financing of research by industry, changes in university guidelines and behavior, and changes in the scientific ethos of faculty and researchers (Mowery et al., 2004).

The rapid increase in university spin-offs has stimulated policy research trying to explain differences in spin-off rates across universities. The goal of this research, sometimes implicit, has been to guide policy-makers trying to foster entrepreneurial economic development through university, state and federal policy. Most of past research and empirical work on university spin-offs thus focus on the role of university policies, government regulation (in particular the Bayh-Dole act of 1980), the organization of technology licensing and transfer activities, and researcher incentives. However, the empirical evidence on the impact of universities on new business formation typically does not cover firms started by recent university graduates because these are most often not using IP based on university research funding and so these start-ups do not get reported systematically.[2] A potentially large part of the entrepreneurial activity stemming from universities thus never gets recorded, and is hardly ever discussed. Indeed, our

[1] The Association of University Technology Managers (AUTM) which collects data on technology licensing and spin-off activities from technology licensing offices (TLOs) at U.S. universities and research institutions report 3,376 spin-offs between 1980 and 2000, and another 2,885 spin-offs between 2001 and 2007. The total number of yearly spin-offs in the U.S. has risen from approximately 59 in 1991 reported by 98 universities, to 366 spin-offs from 141 universities in 2000, and to 502 spin-offs from 155 universities by 2007.This acceleration is not confined to the U.S. There is a concomitant increase in other countries across the world. For example, in the U.K. the cumulative number of still active spin-offs based on inventions at U.K. universities was 1,307 in 2007/2008, with an addition of 219 spin-offs from 163 universities in that year (Higher Education Funding Council for England, 2009). This could be compared to an annual rate of approximate 70 spin-offs from 102 universities at U.K. universities in the years 1994-1999 (Charles and Conway, 2001). Moreover, significantly more companies are started based on research at universities than official numbers reveal since not all spin-offs are disclosed to university TLOs (Allen and Norling, 1991; Fini et al., 2009; Markman et al., 2008).

[2] University graduates may on occasion be involved in startups through past university research projects and these may thus be registered at TLOs.

review of previous literature reveals that only a few articles have covered start-ups by recent university graduates.

To rectify the paucity of information on a potentially important impact of universities, we first compare the gross magnitude of start-ups by recent graduates with an undergraduate degree in science or engineering relative to the gross magnitude of start-ups by their faculty from a representative sample of U.S. universities and colleges. We also investigate how these two categories of start-ups differ in their quality to roughly estimate their economic impact. We define start-ups by recent graduates as entrepreneurial firms started by undergraduate students in the three years immediately after graduation or while they were students.[3] To arrive at these goals we use data from the U.S. Scientists and Engineers Statistical Data System (SESTAT). We complement our general findings with three case studies to illustrate how universities with different structures and in different environments may affect start-up rates by recent graduates.

We show that start-ups by recent university graduates in general greatly outnumber that of faculty and staff. They are also about twice as likely to start new businesses as their faculty on an individual basis. In addition, start-ups by recent graduates are by no means failures and are instead of high quality. The combination of the magnitude and quality of these start-ups makes a compelling case against researchers and policy makers ignoring students as a relevant conduit for entrepreneurial economic development.

We contribute to the literature on academic entrepreneurship by highlighting a phenomenon that is largely overlooked. We also call into question the past focus on technology transfer via faculty spin-offs which may have skewed the debate and scientific inquiry towards a phenomenon that while experiencing a dramatic increase, is still relatively infrequent.

[3] This definition is chosen to match the population sample in SESTAT survey data.

Even among the 100 most active research institutions in the U.S., faculty spin-offs are not very common. For the period 1996 to 2007 the mean number of spin-offs per university was two, and the most likely outcome was zero (source: AUTM 1996 to 2007 reports). The magnitude of start-ups by recent university graduates in comparison to that of faculty may question the recent transformation of university goals and practices focusing on faculty as the most important source of firm creation.

2. University Entrepreneurship

Since the early 1980s output of university research has been increasing dramatically along many new dimensions such as patenting, licensing, and the creation of spin-off firms (Mowery et al. 2004). The process started in the U.S. and universities across the world have subsequently increased their commitments to converting scientific discoveries into commercial opportunities (Åstebro and Bazzazian, 2011; O'Shea et al., 2005; Rothaermel et al., 2007). This process has taken various forms, but it is generally assumed that technological advances are created by faculty and research staff and diffused to society through a technology transfer process, either through licensing of the technology to established firms or through the creation of new spin-off firms. Technology Licensing (or transfer) Offices (TLOs), incubators, and science parks have in turn been created to facilitate such technology transfer (Rothaermel et al., 2007). This view does not have any room for students, neither as creators nor as diffusers of new technology.

Researchers have tracked the development of universities with great interest and have been particularly keen on advising policy makers how to increase technology transfer and spin-off creation from universities. Research which focuses on spin-offs created by faculty and staff has therefore investigated the variation in the rate of spin-offs across universities as a function of; federal and industrial R&D spending, faculty quality, invention disclosures and patenting (O'Shea et al. 2005; Zucker et al., 1998); royalty, licensing, and equity investment policies, internal venture capital financing, and local economic development objectives (Di Gregorio and Shane, 2003; Friedman and Silberman, 2003; Louis et al., 1989; Markman et al. 2009); the organization and compensation structure of TLOs (Belenzon and Shankerman, 2009; O'Shea et al. 2005); environmental factors such as availability of venture capital (Di Gregorio and Shane, 2003; Powers and McDougall, 2005) and the technological density of the local region (Belenzon and Shankerman, 2009; O'Shea et al. 2005). This accumulated research, *inter alia*, shows that various faculty incentives (e.g. Belenzon and Schankerman, 2009; Di Gregorio and Shane, 2003; Friedman and Silberman, 2003; Lach and Schankerman, 2008; Lockett and wright, 2005Louis et al., 1989; Markman et al., 2009), a variety of university input metrics (e.g. O'Shea et al., 2005; Powers and McDougall, 2005; Zucker et al., 1998), the age of the TLO and TLO staff bonuses (e.g. Belenzon and Schankerman, 2009; Lockett and Wright, 2005; Markman et al., 2009), as well as university culture and norms (Bercovitz and Feldman, 2008; Louis et al., 1989; Louis et al., 2001; Stuart and Ding, 2006; Walsh et al., 2007) affect the number of university spin-offs. For more detailed reviews of this literature see Åstebro and Bazzazian (2011), Djokovic and Souitaris (2008), Rothaermel et al. (2007), and Siegel et al. (2007).

Most of past research investigating the rate of spin-offs primarily from universities uses TLO data or, more seldom, data from faculty surveys (e.g. Louis et al. 1989; Thursby and Thursby, 2007). Because graduates typically do not use intellectually property owned by universities, the TLO data excludes the formation of new firms by students and graduates. And surveys of faculty by default exclude entrepreneurship by recent graduates.

However, several recent university-specific surveys of alumni have found that university alumni create a lot of new firms (Berggren and Lindholm-Dahlstrand, 2008; Eesley et al., 2009; Eriksson, 1996; Hsu et al., 2007; Lazear, 2005; Lerner and Malmendier, 2011; Lindholm-Dahlstrand and Berggren, 2010; Roberts and Eesley, 2009). These studies provide indications of the magnitudes by which university alumni start up new businesses as a fraction of all graduating students. The percentage of university alumni which start businesses are approximately 24 percent from both MIT (Hsu et al., 2007; Roberts and Eesley, 2009), Stanford business school (Lazear, 2005) and Tsinghua University in China (Eesley et al., 2009), between 12 - 36 percent from an engineering programme at Halmstad University in Sweden (Eriksson, 1996), and 42 percent from Chalmers University's entrepreneurship school in Sweden (Lindholm-Dahlstrand and Berggren, 2010). Thirteen percent of alumni at Harvard Business School start successful businesses within one year of graduation (Lerner and Malmendier, 2011).[4] Judging by these case studies, students should not be ignored when examining the impact of universities on the creation of new firms. Note, however, that in these studies, the definition of alumni start-ups typically encompass all firms founded by university graduates irrespective of the time elapsed from their graduation (an exception is Lerner and Malmendier, 2011). As a result the causal effect of university education on the creation of new businesses is ambiguous.

As a consequence, we know very little about what role universities have for the creation of start-ups by their recent graduates. The lack of research regarding start-ups formed by university graduates might be due to several reasons. First, research on university graduates' start-ups may not have been aligned with the interest of policy makers. Instead, policy makers' focus may have been limited to the creation of intellectual property by faculty. Second, even if researchers would have liked to include students, it has not been possible to do so using traditional TLO data provided by universities. Finally, while studies using alumni surveys do provide examples of the impact of universities on start-up rates, the examples are limited to specific universities and so the general impact is unclear, and there are difficulties inferring causal effects from most of these studies.

Most research on the role of university education instead has been general in nature. From such research we know that the return to education is above the cost of capital (Becker, 1993); that the return to university education has been increasing in recent years (Ashenfelter and Krueger, 1994; Card, 2001); the return to education is higher in self employment than in wage work in the U.S. but not necessarily in

[4] They define a successful business as one that, as of October 2007, (a) went public, (b) was acquired for more than $5 million, or (c) had in October 2007 or at the time of the sale of the company at least 50 employees or $5 million in annual revenues. 13% of the post-MBA entrepreneurs were successful using these criteria.

Europe (van der Sluis et al., 2008); and that education relates positively to the economic performance of start-ups (e.g. Gimeno et al., 1997).

But universities may provide other advantages for prospective graduate entrepreneurs than simply providing an education that is useful when starting a new firm. For example, it is inferred that MBA students obtain peer advice from their fellow students which affect both the rate of start-ups after graduation as well as their quality (Lerner and Malmendier, 2011). Faculty research at universities may also provide graduates with potential business ideas which can be put into practice even long after graduation. Finally, graduates may take courses in entrepreneurship that could impact their intentions to start up a business.[5]

In sum, since the early 1980s there has been an important increase in the rate of university outputs of patents, licensing of research and spin-offs by faculty. Researchers have studied this phenomenon, primarily from the viewpoint that faculty and staff provide the majority of spin-offs. However, several alumni surveys have shown that graduates from some universities create a lot of new start-ups. But it is not clear from such studies what impact universities in general have on new firm creation. And we do not have any clear ideas about how universities may affect new firm creation by recent graduates. This leaves us with an opportunity to examine the general pattern of start-up creation by recent university graduates and to compare these rates to the start-up activities by faculty and staff.

3. Data and Methodology

We blend quantitative and qualitative sources of data to analyze the relative role of recent university graduates as creators of new businesses. To investigate general patterns of start-ups by recent graduates and university employees (hereon “faculty”) we employ the restricted-use U.S. Scientists and

[5] There is no clear evidence on what effects such courses have on future start-up rates (see e.g. Oosterbeek et al, 2008; Weber et al., 2009.)

Engineers Statistical Data System (SESTAT) for the years 1995, 1997, 1999, 2003, and 2006 (http://sestat.nsf.gov/).

The National Science Foundation administered three national surveys of individuals with (at least) a U.S. bachelor's degree in science or engineering, the National Survey of College Graduates (NSCG), the Survey of Doctorate Recipients (SDR) and the National Survey of Recent College Graduates (NSRCG).[6] These three surveys have been integrated into SESTAT, a database specially designed, in particular, 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 the special variable provided to the restricted-use data called "SESTAT integrated weights."[7] Using SESTAT integrated weights allows us to recover population numbers. Hence, despite the fact that students greatly outnumber faculty in the population, we can still meaningfully compare the numbers of start-ups created by recent graduates to those created by faculty by using those weights.

Our identification of start-ups from faculty follows established practice in the literature using SESTAT data (see Braguinsky et al., 2011; Elfenbein et al., 2010) by defining those as cases where an individual switched to principal employment in 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 also distinguished between start-ups that were previously employed as ranked faculty (full, associate and assistant professors) and all other employees (including adjunct faculty, postdocs, and administrative personnel).

We use the NSRCG surveys to identify "recent graduates" with undergraduate degrees in science and engineering. For example, the target population of the 1995 NSRCG survey is the universe of all graduates from U.S. establishments of higher education in science and engineering over the period between July 1, 1992 and June 30, 1994. This means that "recent graduates" are defined as individuals

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[6] See http://www.nsf.gov/statistics/sestat/compsrvys.cfm for the description of the target populations and other technical information about each of these three surveys.
[7] See http://www.nsf.gov/statistics/sestat/weighting.cfm for the detailed discussion of the weighting strategy.

who had graduated at least one year and at most three years prior to the year they were surveyed. Start-ups by recent graduates are identified as cases where such individuals reported their principal employment as own business, professional practice, or farm in the corresponding NSRCG survey. Integrated SESTAT data are available for seven years, 1993, 1995, 1997, 1999, 2003, and 2006 but the 1993 NSRCG survey does not contain information about the schools from which recent graduates graduated. We therefore drop the 1993 data from our analysis.

Respondents to SESTAT surveys were asked to estimate their annualized salary if salaried or otherwise to estimate their earned income excluding business expenses. To make numbers for different survey years comparable, we deflate earnings by the CPI. Respondents were also asked to report their age, sex, race, marital status, citizenship or immigration status, experience after receiving the most recent degree, detailed education field, primary activity on the job and the state in which they were employed. We use these variables as controls where relevant. We also checked whether a recent business owner (either faculty or recent graduates) still remained independent business owner or not in the surveys subsequent to the first survey which identified them as a business owner. This gives an estimate of two-year survival rates (three-year survival rate between the 2003 and 2006 data).

In subsequent analysis we also take an in-depth look at how the quality of research and education in different colleges and universities affects the number and the quality of the start-ups by former faculty and recent graduates. This is accomplished in two ways. First, we use the 1993 National Research Council (NRC) ratings of doctorate programmes to assign ratings to the universities and colleges that start-ups originated from (hereon "NRC rating").[8] In what follows we sometimes refer to "top-rated schools," defined as colleges and universities with an NRC rating of 3.25 or more. The full list is provided in the Appendix.

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[8] 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

For recent graduates we measure the impact of the quality of their education on start-up probability and quality by the relationship between the job and the most recent degree. Survey respondents were asked to report whether their job was "closely related" to the most recent degree, "somewhat related" or "not related at all." We assume that recent graduates who responded that their jobs were closely related to their most recent degree made more use of the education they received.

To further analyze the role of universities in stimulating new business creation by its students and recent graduates we set out to complement the quantitative and general SESTAT data with a few illustrative case studies. These cases were *not* selected to be representative of the underlying population of universities. Rather, the cases were selected to illustrate extreme environments (Seawright and Gerring, 2008). Such illustrations may provide a deeper understanding of the distribution of outcomes rather than studying the most likely situation (Seawright and Gerring, 2008). The three cases are MIT, Halmstad University, and Chalmers University of Technology. The latter two are located in Sweden. We make no claims to compare Sweden against the U.S. with these data.[9] The case selections were made because each university had a unique approach to stimulating entrepreneurship by their students and recent graduates.

MIT was chosen because it represents one of two universities with the largest known rate of faculty spin-offs in the U.S. (Stanford being the other.) Stanford and MIT each produced six and 24 faculty spin-offs in 2007, while the most likely number of faculty spin-offs was zero among universities reporting to AUTM in the same year (AUTM, 2008). Out of these two, the choice fell on MIT as we were able to obtain more detailed comparable data on faculty and student alumni start-ups from MIT. Another reason for selecting to present MIT is that we found the entrepreneurship rate among its alumni to be very high and we wanted to explore why. Is this for example due to a strong set of entrepreneurship courses, through the entrepreneurial orientation of its faculty (as illustrated by the high spin-off activity,) or because of something else?

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[9] For a comparison of the institutional environments in Sweden and the United States and the reasons for differences in the rates of commercialization of research from their universities, please see Goldfarb and Henrekson (2003).

The second case is Halmstad University. Halmstad University is a recently created higher education institution focused on teaching. It has an unimpressive research budget and low spin-off activity among its faculty. It has also been endowed with scant local economic conditions with little presence of local high-tech firms or venture capital. MIT with its location in Boston on the other hand has been operating with an impressive research budget, creating inspiring faculty spin-off activity and has been endowed with considerably favorable local economic conditions, some of which it generated itself (Roberts and Eesley, 2009; Saxenian, 1994). Yet these two universities both produce significant graduate start-ups in terms of fractions of graduating students. We explore how Halmstad has been able to stand up tall against MIT under these extreme conditions.

Our third case, Chalmers University of Technology, was selected because of the particular structure of its entrepreneurship programme. Chalmers has historically compared favorably to MIT on spin-off activity (Wallmark, 1997.) However, in 1997 it created an entrepreneurship school and it is this school and its unique programme design that attracted our primary attention. This programme allows the creation of a market for ideas where the commercialization of intellectual property created by Chalmers staff is carried out by students. The Chalmers case will illustrate that students/graduates can serve as effective drivers of the commercialization of university intellectual property.

We gathered case data from previous research and supplemented them with searches of web archives, university official publications, requests for administrative records, telephone calls, a large number of e-mail exchanges, and personal interviews.

4. General Patterns

4.1 Start-up numbers: SESTAT data

In this subsection we report data from the U.S. Scientists and Engineers Statistical Data System (SESTAT) on general patterns of university graduate start-ups and faculty spin-offs and provide some measures of their respective quality levels.

Table 1 about here

Table 1 presents basic summary statistics on the number of start-ups in the U.S. For completeness, we present both the number of observations in the actual sample and the estimated population numbers using SESTAT integrated weights as described in the previous section. The fraction of start-up owners among recent graduates is 6.4% for all universities and colleges and 5.2% for top-rated schools. These fractions are several times higher than the fraction of start-up owners among faculty, which is 1.3% for all schools and 1.6% for top-rated schools. Indeed, start-ups by recent graduates outnumber start-ups by faculty by a factor of 24.3 among all colleges and universities and by a factor of 11.7 when looking only at "top-rated schools".

A few words of caution are in order here. First, our count of start-ups by faculty may not be complete if some of them keep their jobs in academia while also running the start-up and continue to report the university as their principal employer. Second, the population of faculty is less than 20 percent of the population of recent graduates in any given year. If both categories were equally likely to start an independent business, we would expect start-ups by recent graduates to outnumber the start-ups by faculty by 5-6 times just by virtue of this sheer difference in numbers. Note, however, that start-ups by recent graduates outnumber start-ups by faculty by a much larger factor than that in Table 1.

To make the notion of the relative probability of the start-up by faculty and recent graduates more precise, we conduct regression analysis. Specifically, we estimate the following probit regression:

$$\Pr\left(st\right) = \Phi\left(\alpha + \beta_1 emp + \beta_2 prof + \beta_3 assocprof + \beta_4 asstprof + \gamma_1 score + \gamma_2 empscore + \delta X\right), \quad (1)$$

where Pr(*st*) is the probability of forming a start-up, *emp* is equal to 1 if the start-up was formed by faculty, zero if by a recent graduate; *prof* is equal to 1 if the start-up was formed by a former full professor, zero otherwise; *assocprof* is equal to 1 if the start-up was formed by a former associate professor, zero otherwise; *asstprofessor* is equal to 1 if the start-up was formed by a former assistant professor, zero otherwise; *score* is the NRC rating of the university/college for the period preceding the start-up (if any); *empscore* is an interaction term between *score* and the dummy representing faculty, and *X* is a vector of controls.

The dependent variable takes the value 1 *if* the individual was a recent graduate *and* reported his or her primary job as an independent business owner in the first NSRCG survey that he/she participated in, else it takes the value 0 for all other recent graduates. It is also equal to 1 *if* the individual was employed by a college/university in one survey (for example 1995) *and* reported his/her primary job to be an independent business owner in the next survey (for example 1997). It is equal to 0 for all other individuals employed by a college/university in a given survey. Observations are weighted using SESTAT integrated weights, so the estimation results reflect true population numbers.

Table 2 about here

Table 2 presents results. In column (1) only age, gender, ethnicity and citizenship status (naturally born citizen, naturalized citizen, green card holder or temporary resident) are controlled for. In column (2) we also add 48 dummies for different education classes (mechanical engineering, electrical engineering, psychology, economics, etc.) and 57 dummies for the location. Finally, in column (3) we add year dummies.

The omitted category in all three specifications is recent graduates, so all coefficients on full professor, associate professor and assistant professor should be interpreted relative to this category. We report marginal effects at sample means rather than coefficients.

The probability of launching a start-up is between 2.5 and 3.6 percentage points lower for faculty than for recent graduates. The corresponding coefficient is highly statistically significant. Since the expected probability of a start-up in the population of recent graduates is about 6.4 percent, we conclude that the conditional probability of launching a start-up is about twice as large for recent graduates as compared to faculty when controlling for demographics, education fields, year and location.

The difference is even larger when comparing to tenured faculty. Table 2 shows that being a full professor represents an additional 3.6 to 4.4 percentage point decline in the probability of launching a start-up as compared to recent graduates. The difference in magnitudes is similar for associate professors. The data thus reveals that faculty are much less likely than recent graduates to create start-ups; that non-tenure track university employees (such as postdocs, lecturers, adjunct instructors and staff) are more likely than tenure-track faculty to create start-ups, whilst among the latter, non-tenured assistant professors are more likely to launch start-ups than their tenured colleagues.

Demographic and other controls, with the exception of year dummies, were mostly small and not statistically significant and are therefore not reported. As for year effects, the probability of forming a start-up appears to be declining in the 1990s and then sharply increase during 2003-2006 (the omitted year is 1995, so all coefficients should be interpreted relative to that year). This is perhaps not surprising as start-ups tend to decrease during economic booms when employment opportunities are more plenty, and increase when the economy is less buoyant. It also appears that recent graduate start-ups are more affected by year effects (economic conditions) as is manifested in the decline in the magnitudes of all coefficients on faculty dummies in column (3). The difference between the rate of start-up formation by recent graduates and faculty remains strong and statistically highly significant, however, even when year dummies are added to the regression.

It is also interesting to note that neither the coefficient on the NRC rating of the school nor the coefficient on its interaction term with faculty is significant. Thus, the relative probability of launching a start-up does not depend on school quality. In other words, it appears that entrepreneurship is a widespread phenomenon, not limited to a particular category of schools.

4.2 Start-up quality: SESTAT data

One possible caveat about comparing numbers of start-ups of recent graduates to faculty is that these two types of start-ups may differ sharply in terms of quality and economic impact. Indeed, from a policy perspective we are mostly interested in the economic impact of entrepreneurship. If the majority of start-ups by recent graduates are of extremely low quality (or even represent some kind of a disguised unemployment), their policy significance will be rather limited even if their numbers are large.

In this section we look into this issue by comparing earnings and survival rates. Of course, it makes little sense to simply compare the earnings of start-ups by recent graduates, most of whom are young individuals starting their labor market participation, with those of start-ups by faculty, who on average have had much longer labor market experience and are often more educated (have a Ph.D. degree). The comparisons we make below, however, is not about absolute levels of such earnings (although we do show those as well) but about comparing earnings of start-up owners with their peers. If it turns out that faculty who launch their own start-ups do much better compared to their peers who do not launch start-ups, while the same is not true of recent graduates, then the quality concerns would be well-founded. However, as we show, not only is the above statement not true, but, if anything, start-ups by recent graduates outperform start-ups by former university employees relative to their corresponding peers by a rather significant margin, especially if start-ups by recent graduates make use of education they received in school.

It is well known that many individuals, maybe especially at an older age, start businesses to pursue a specific life-style (see e.g. Hamilton, 2000). In fact, for over 40 percent of start-ups by faculty in the SESTAT data (almost 44 percent for tenure-track and tenured faculty), employment in the start-up is reported as part-time even though the start-up is also reported as the main employment. There are a variety of reported reasons for part-time efforts, including, but not limited to, family planning and reaching retirement. Among start-ups by recent graduates, slightly over 20 percent of those also report that their jobs in their own business were part time. It thus appears that recent graduates are much more likely to start their firms working full-time than do faculty, especially when compared to tenure-track and tenured faculty.[10] Preliminary examination of the evidence further reveals that "part-time" start-ups by recent graduates and faculty alike also tend to have very low earnings. Thus, including part-timers among all start-ups pushes their average earnings well below the earnings of their peers who do not launch independent businesses, and especially so for start-ups by faculty. We have therefore limited the comparisons of earnings and other quality measures between start-ups and their peers to those individuals employed full-time in their business, those not previously retired and excluded those reporting zero annualized salaries from their business. Employing these restrictions raises the relative quality of start-ups by faculty more than it raises the relative quality of start-ups by recent graduates.

Table 3 about here

Table 3 presents summary statistics. Average annualized earnings of new business owners who are recent college graduates are about 1/2 of the average annualized earnings of new business owners who previously were faculty. This is of course what should be expected given the difference in age, educational attainment and labor market experience. Note, however, that the gap in earnings narrows

[10] We thank an anonymous referee for bringing this issue to our attention.

substantially as we narrow the sample to those whose businesses are closely related to the degree they received in college. Education can thus be seen to play an even more important role in generating higher returns for entrepreneurs if they rely more heavily on what they learned at university.

Turning now to the comparisons between start-up owners and employed, we can first see that among all recent graduates, entrepreneurs earn 12 percent more than their peers employed full-time elsewhere in the economy (the difference is statistically significant at the 1 percent level and the same is true of all other differences discussed below unless explicitly stated otherwise). Thus, entrepreneurship immediately pays off for the average university graduate; it is by no means "failures" that we are observing. The gap in initial earnings increases to 23 percent when we limit the sample to those whose jobs are closely related to their degrees and to a whopping 31 percent when looking only at education-related entrepreneurs that come from top-rated schools. This strongly indicates that exploiting ideas received during college and especially ideas of high quality (in high-rated research environment) improves economic outcomes for start-ups more than it improves labor market outcomes overall (for more on this issue see Braguinsky et al., 2011).

Faculty who become entrepreneurs receive sharply higher compensation than their peers (most of which stay in academia, although some move to industry or government employment). This is not particularly surprising as previous studies have revealed the presence of compensating differentials in academia (e.g., Stern 2004). It is interesting, however, that the earnings differential between entrepreneurs and their peers in academia is higher in the whole sample than in the subsample of top-rated schools. This may indicate either that spinoffs from top-rated schools may take longer to generate economic impact (Mansfield, 1991; 1998), or that top-rated schools pay their faculty relatively more. Also, the pre-move earnings of faculty who launch their own businesses are much lower than earnings of those who stay in academia (or move to other non-start-up employment). This may indicate that university spin-offs may actually be driven by less productive scientists, at least less productive as members of the academic community. Of course, other factors, such as age differential also play a role, so to examine these patterns more formally we now turn to regression analysis.

We separately estimate a Mincer-type earnings model for recent graduates and faculty:

$$ln\, y_{it} = \alpha + \beta D_{it} + \gamma X_{it} + \varepsilon_{it}, \qquad (2)$$

where y_{it} is the annualized earnings of individual *i* at date *t*, D_{it} equal 1 if the individual *i* was primarily employed in his/her own independent business at date *t*, zero otherwise, *X* is a vector of controls and ε_{it} is the error term. The universes consist of all individuals who were employed by academic institutions in the previous surveys and of all recent graduates. Estimation is conducted with pooled OLS with robust standard errors clustered at the individual level. All observations are also weighted by SESTAT integrated weights.

In the first specification of faculty earnings in Table 4 we include as controls age (and its square term), years of experience after the most recent degree (and its square term), gender, ethnicity, marital and citizenship status as well as year dummies. In the second specification we also include university NRC rating prior to launching a start-up and its square term, a dummy equal to 1 if the individual was tenured or tenure track faculty in period *t*-1, 0 otherwise, and also interaction terms between launching a start-up and the NRC rating and its square term. We also add a full set of controls for job types, education and location: 63 dummies for occupational class, 48 educational class dummies, 14 primary work activity dummies and 57 employment state dummies.

Table 4 about here

In the first column, the economic rewards to launching a start-up for former faculty as compared to their peers are estimated as negative 12 percent, although the coefficient is not statistically significant at conventional levels. All other coefficients come out as would be expected, in particular, both age and experience are positively associated with earnings and their effects are concave. Being married, white and male also positively affect earnings as does being a naturalized citizen, while being a temporary resident has a pronounced negative effect on earnings (the omitted category are naturally born citizens). Estimation results in the second column are more illuminating. The effect of becoming an entrepreneur is now insignificant both economically as well as statistically. The NRC rating of the institution has a positive effect on earnings, which, moreover, is convex, so that earnings increase more than proportionate to the quality of the institution. Relative earnings are also much higher for tenured and tenure track faculty than for other former university employees. What is interesting is the sign and magnitude of the interaction terms of the NRC rating and its square term with entrepreneurship. The coefficient on the linear term is negative, while the coefficient on the quadratic term is positive and also quite large. The magnitudes of these coefficients indicate that school quality starts having a positive impact on entrepreneurial earnings (as compared to peers) from NRC rating 4.0 and up, which corresponds to the top 10 research universities in the U.S. (see Appendix). The coefficient on the interaction term between entrepreneurship and tenured or tenure track faculty is negative (although statistically not significant), indicating that there is no advantage to such faculty becoming entrepreneurs as compared to other university employees. In the third column we estimate earnings growth and include pre-move salary. The overall results are very similar to those in column 2 which looked at first-year earnings. There is no significant effect on earnings growth for faculty who become entrepreneurs. However, growth in earnings for entrepreneurs is a positive function of the quality of the school, but only for the top 10 research universities in the U.S.

The lack of relationship between entrepreneurship and earnings growth which comes out of the regression analysis is in rather sharp contrast to the results from the raw data presented in Table 3, which, to recap, show a large increase in earnings for former faculty who launch startups compared to university faculty who do not. We investigated this apparent puzzle and determined that it is driven by just a few outliers among continuing university employees, some of whom report increases in salaries of 10 times and more between two observation points. This may be due either to coding errors or to large temporary incomes from licensing and/or consulting (respondents are supposed to report only their basic salaries, excluding other income, but some may not pay attention to this caveat). To test for this effect more formally, we estimated the same regressions as reported in Table 4, but excluding a combined 1 percent of observations with the highest and lowest reported rates of changes in earnings between two adjacent surveys.[11] Excluding these outliers results in the coefficient for choosing entrepreneurship to equal 0.285, statistically significant at 1 percent level. We also estimated a median regression, which examines the effect of explanatory variables not on average earnings but on earnings at the median, and the coefficient for entrepreneurship was very similar to the OLS regression without outliers (0.241, statistically significant at 1 percent level). Excluding outliers the regression results are thus in line with the summary statistics. Of course, outliers are in the data “for a reason” (if they do not represent coding errors). We leave investigating these outliers for future research.

Table 5 presents results using the sample of recent graduates. In the first column we include demographics and year dummies. In the second column we add the full set of controls for job types, education and location. We also add a dummy equal to one if the individual’s job was closely related to his or her degree and zero otherwise, and its interaction with choosing entrepreneurship. Finally, in the third column we add the NRC rating and three more interaction terms between this rating and (a) choosing entrepreneurship, (b) if the job is closely related to the degree, and (c) the interaction between choosing entrepreneurship and whether the job is closely related to the degree.

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[11] This resulted in dropping 411 observations out of 45,681 in column 3, Table 4.

Table 5 about here

The estimated coefficient for entrepreneurship in column 1 is negative 0.074, statistically highly significant. Thus, recent graduates choosing entrepreneurship earn on average about 7.2 percent (exp(-0.074)-1) *less* than recent graduates employed elsewhere in the economy when controlling for age, demographics and year effects. This estimated negative return to entrepreneurship increases to negative 8.7 percent (exp(-0.091)-1) when all other controls are added. However, this negative return to entrepreneurship is almost fully offset by 8.1 percent (exp(0.078)-1) earned by entrepreneurs whose businesses are closely related to their degrees.[12] Thus, recent graduates who make use of their degrees as entrepreneurs earn on average about the same as their employed peers.

The advantage that the quality of education gives to entrepreneurs comes through even more strongly in the last specification in Table 5. In particular, recent graduates who choose entrepreneurship do not have higher earnings than their peers if they graduated from higher-ranking schools. Neither do the entrepreneurs have higher earnings if they just start a business that is related to their degree. But, entrepreneurs earn 10.6 percent (exp(0.101)-1) extra when compared to their peers for each extra point in the NRC rating, if they start their businesses in degree-related areas. This implies that individuals from the top 10 schools (NRC rating 4 and above) who start education-related businesses can expect to earn on average 40 percent more than their peers graduating from the same schools, who also take jobs related to their degrees. Thus, recent graduates from top programmes who get ideas for new businesses which are related to their degrees reap immediate and very large benefits from entrepreneurship.

Finally, we examine survival rates and the growth of earnings of surviving start-ups. We identify a business as continuing if the individual who was identified as entrepreneur in the previous survey is still

[12] We also estimated regression (2) only on those whose jobs were closely related to their degrees. The coefficient for choosing entrepreneurship is then small and statistically insignificant, in line with the results presented in the second column of Table 5.

an entrepreneur at the time of the next survey. (Of course, there is a chance that it may not be the same business, but we ignore that possibility here.) If, on the other hand, the individual reports they are employed in the next survey we consider his/her previous business to have exited. Since the number of observations for this analysis is fairly limited, we do not attempt regression analysis but present simply summary statistics in Table 6.

Table 6 about here

Table 6 shows that overall survival rates are higher for start-ups founded by faculty than for start-ups founded by university graduates. About 57 percent of new businesses launched by former faculty survive, while among start-ups generated by recent graduates the survival rate is approximately 36 percent. The differences remain approximately the same when looking at entrepreneurs from top-rated schools, tenured faculty, or graduates with businesses close to their degrees. Earnings growth, on average, is also higher for faculty (13.3%) than for recent graduates (6.9%). The growth in earnings, however, is markedly lower for the surviving start-ups founded by faculty from top-rated schools, which is partly a reflection of the much higher earnings they post in the first survey after launching a start-up. Thus, it seems that higher-quality research transplanted into a business idea pays dividends more quickly than lower-quality research, but the businesses founded by faculty from less prominent institutions still tend to catch up over time.[13]

The most striking aspect of the findings presented in Table 6 is a very large increase in earnings for graduates from top schools which choose entrepreneurship, and especially those graduates who start a business closely related to their degrees. This reinforces the conclusions drawn from Table 5. Start-ups by

[13] We thank an anonymous referee for the suggestion to look into these patterns. Of course, the above-mentioned findings need to be interpreted with caution as the longitudinal aspect of our data is rather limited.

recent graduates from top-rated schools who use their education in their businesses not only command a one-time premium of 40 percent in earnings as compared to their peers but also exhibit an astounding almost 40 percent growth rate in earnings over the subsequent 2-3 years. Thus the role of top-level education in the success of entrepreneurial ventures by recent graduates appears to be of first-order importance.

In sum, the results of our analysis of general patterns confirm that start-ups by recent graduates outnumber start-ups by faculty and staff by a wide margin; a factor of 24.3 to one. At the individual level they are twice as likely as faculty to start a business in the three years after graduation. They are also of comparable quality to their peers. They earn more, on average, than their peers in paid employment. Controlling for a number of variables, recent graduates whose start-ups make use of their degrees earn on average about the same as their employed peers, while recent graduates that do not use their degrees in their start-up, however, earn less than their employed peers.

5. Three Cases

In the previous section we showed that the majority of start-ups emanating from universities are created by recent graduates and that start-ups by faculty only constitute a minority. In this section we provide three illustrations of how universities in various ways may affect recent graduates to start new businesses.

5.1 Massachusetts Institute of Technology

Massachusetts Institute of Technology (MIT), founded in 1861 in Cambridge, Massachusetts, is one of the most prestigious universities in the world. MIT is at the forefront of cutting edge research and its current research and development expenditures surpass one billion dollars. MIT is also exceptionally well endowed with favorable local conditions to foster spin-offs (Saxenian, 1994). There has been a large amount of applied engineering research done at MIT, an early development of the venture capital industry in Boston, and a large supply of potential co-founders and employees (BankBoston, 1997; Roberts and Eesley, 2009). MIT also has a unique entrepreneurial culture with its very first start-ups by its alumni dating back to the early 20th century. For example, Aurian Chase, MIT class of 1900, founded Chase Motor Truck Company in 1906 and supplied vehicles to the U.S. Army during World War I. MIT also had close ties with industry from its early years. Notable examples of such ties are with Thomas Edison, and Alexander Graham Bell (Roberts and Eesley, 2009). All of the above conditions make MIT an entrepreneurial hotbed.

In Roberts and Eesley's (2009) report, 23.5 percent of alumni indicated that they had founded at least one company in their life time.[14] A special extract of these data made by Charles Eesley revealed 388 firms started by university alumni in 1980 growing to 710 in 1995 and to 1,089 started in 2000, subsequently to decline to 313 started in 2003.[15] These numbers indicate an enormous response to the dot-com boom, both up and down (see Figure 1.) In comparison, the number of TLO-registered spin-offs by MIT faculty and staff were 2 in 1980, growing to 14 in 1995 and 23 in 2006. Note that the number of registered spin-offs from MIT is leading among all U.S. universities.

The data in Figure 1 indicate that the cumulative number of alumni start-ups outnumber cumulative faculty spin-offs by a ratio of 22:1 between 1980 and 2003 (computation method in notes to Figure 1). However, in calculating this ratio the time elapsed since graduation for alumni has not been considered. The extract that we obtained from Charles Eesley shows that MIT alumni consistently start businesses in each year since graduation and that this trend continues to more than 20 years after graduation. This makes the causal effect of MIT on business formation by its alumni less obvious and possibly less comparable to our previous analysis using SESTAT data.

14 There were two different alumni surveys. The figure is computed based on the first survey where there, however, is no data on the time of founding. New firms are those that employed 10 or more individuals. A second figure of 18 percent reported by Hsu et al., (2007) is based on a follow-up survey reporting businesses started with known founding dates. As well, duplicates started by several university graduates are removed from this number.

15 With students in leading positions. We thank Charles Eesley for generously providing the data and his time. These data exclude all MIT faculty spin-offs. Eesley further removed duplicates in cases a company was founded by more than one alumni and we count all firms founded. The raw response numbers were scaled up by a factor of 9.5 to account for survey non-responses as in Roberts and Eesley (2009).

Insert figure 1 here

To obtain a comparable ratio to the SESTAT extract, we first compute the number of start-ups by MIT alumni who started their business while they were students or within 2 years of graduation. The ratio of the number of start-ups by recent MIT graduates to start-ups by MIT faculty is then 1.5 (97/66), which is a much smaller number than the ratio obtained by SESTAT data. Since MIT is the leading producer of faculty start-ups among American universities, obtaining this smaller ratio is not that surprising. MIT's faculty engage in technology based start-ups more than any other institution in the U.S.

A critical influence on these alumni start-ups is the effect of "positive feedback" arising from early role models and successes. In particular, Roberts and Eesley (2009) show that in the 1950s, 17 percent of alumni who eventually formed companies chose to study at MIT for its entrepreneurial environment. By the 1990s, as much as 42 percent of graduates who formed companies claim they went to MIT because of its entrepreneurial environment, suggesting that MITs entrepreneurial reputation created an important student selection effect. Further, university student-run activities (mostly many different clubs) are pointed to as the major reason for the vast number of student start-ups. Importantly, student-run activities initiated already in the 1950s and have grown organically and slowly. Faculty are assessed to be more important in terms of stimulating graduates' start-ups through their research and openness to entrepreneurship rather than through starting new businesses on their own (Roberts and Eesley, 2009). Furthermore, the MIT TLO office took a very non-interventionist role (see e.g. Nelsen, 2007; Pfeiffer, 1997) and MIT did not provide any great deal of courses on entrepreneurship (Pfeiffer , 1997). In fact, begun in 1961, only one course in entrepreneurship was being taught at MIT until 1990. Thus, while there has been a late growth in a variety of support activities and entrepreneurship courses at

MIT since the mid 1990's, these cannot be said to have had any impact on the trend that got started already in the 1950s.

5.2 Halmstad University

MIT is a special case that might be hard to replicate by other well-intending universities that want to stimulate local economic development. For example, MIT graduates may have been exceptionally well endowed with local supporting resources that are often thought of as complementary to a vibrant spin-off activity: top-notch research faculty; local venture capital; large amounts of industry funding of engineering and science research; and an entrepreneurship centre. An antithesis to MIT is Halmstad University in Sweden which appears to generate a large fraction of entrepreneurs from some of its programmes without being well endowed with any of the local supporting resources listed above.

Halmstad is a relatively recently created teaching institution that neither focuses on research, nor on commercialization of its research.[16] One of the first new undergraduate programmes created in 1979 was Innovation Engineering (IE). It quickly received the nickname the "Inventor programme" and attracted students from across the country, many with prior work experience. The programme aimed at combining broad engineering knowledge with business skills. A Mechatronics programme was started next, followed by Computer Engineering. The percentage of alumni starting new businesses from the IE programme was estimated through a survey in 1992 of the cohorts 1979 through 1991 to be 36 percent (Eriksson, 1996). Since some start-ups were team-based the fraction of unique start-ups was somewhat

[16] Halmstad has close to 90,000 inhabitants. The local economy is a mixture of different small-scale operations with no venture capital, research labs, or research-driven businesses. Instead, trade and services are important due to seasonal tourism. The largest private company employs 600, while 75 percent of inhabitants are employed in companies with 10 or less employees. A small teachers' college was created in Halmstad in 1973 from which a university was formed in 1983 during a general Swedish university system reform; it is thus one of the youngest universities in Sweden. In the mid 1980s it was focussed on teacher's education and shorter degree programmes. Not until 1997 was the university granted the rights to employ Full Professors, prior to that teaching staff had lower status positions. The first Ph.D. was not conferred until 1999. Nevertheless, by 2008 Halmstad University had some 50 degree programmemes, 5,000 full-time (11,500 total) university students, approximately 40 professors and a research budget of 88 MSEK (13 mill USD). Thus, it currently graduates students in numbers 55 percent of Chalmers University of Technology in Göteborg, although it has an R&D budget only 6 percent to that of Chalmers (see next section for more information about Chalmers.)

lower, 28 percent. To explain the high rate of start-ups from the IE programme, Eriksson (1996) points out that in that programme, students' thesis projects are geared to develop a technical idea into a product, predominantly in co-operation with an established local company.[17] Further, Eriksson argues that Halmstad University experienced large institutional changes which ended up creating a supportive environment for entrepreneurship. The programme's closeness to industry and the students' independence and greater maturity are further explanations put forth by Eriksson (1996).

The design of the IE programme is relevant as its success meant that some of its features were copied by other Swedish institutions. The first two years of coursework includes math, engineering, and business courses. In the third year the students work exclusively on their thesis project, the most important stimulus for further entrepreneurial actions. However, neither is there any courses offered in "entrepreneurship", nor is the word used in marketing the programme. The focus is on innovation and product development. The aim of the thesis project is for the students to apply coursework knowledge in a real product development project to deliver a prototype, and to document their work in a thesis. Students are, however, encouraged to specify a business idea and think about how to build a business. Much of this appears through discussions between the students themselves. Halmstad University supplies base funding for direct development costs, and for some costs associated with starting a small business. Students are advised by a patent agent on the specifics of how to write a patent application. The school further provides lab space, equipment and some expendable material as needed. Participating firms also provide lab space and material on a project-by-project basis.

Notwithstanding the particular design of the IE programme, even the research laboratories at Halmstad University produce considerably more graduate start-ups than faculty spin-offs. In a study of 15

[17] During one year in the late 1990's, among the 20-30 projects conducted by approximately 50 to 60 students, projects ideas at that time came from: small local businesses; Swedish large multinationals not locally situated; former students, a business commercialization office at the school ("Småföretagarcentrum"), programme administrators, the students themselves and finally other faculty at Halmstad. Examples of projects generated from small local businesses were control programmes for printers, remote controlling of devices, a poker web site, games for virtual worlds, traditional mechanical devices, and prototype development for other businesses. An example of a project from a Swedish large multinational was a new car seat design.

spin-offs from the Center for Research on Embedded Systems, Berggren and Lindholm-Dahlstrand (2008) found that twelve (80 percent) were formed by graduates and only three by faculty. The first wave of graduate-entrepreneurs from this center (1988-1996) “were inspired by the unique IE programme and the spirit of new settlement that surrounded the university at the time” (ibid, p. 50). A second generation of entrepreneurs started after 2000 as more resources were given to the university’s incubator and venture capital became available from Halmstad University. Some of the first generation graduate entrepreneurs returned to the university, became advisors, and in some cases provided financing for ventures in the second wave (ibid, p. 50-51).

Some might argue that Halmstad University is an aberration which simply produces a long list of low-quality start-ups. The argument would further be that university graduates may not be the source of great business ideas while their faculty produce great ideas. However, it is not clear that the quality of the start-ups by Halmstad University graduates is low. Indeed, Eriksson (1996) report that approximately 52 percent of the 1979-1991 graduates’ firms were still active as of 1992. Furthermore, our general data previously reported refutes the argument that recent graduates produce low-quality start-ups.

In our final case the educational institution has arranged a systematic process whereby the academic inventor is “replaced” by university graduates to lead the venture. University graduates may be more flexible in adopting business attire than the university inventor, certainly have lower opportunity costs in doing so, and are in reasonably good supply so that a talent market from where to pick the best is possible to develop. The potential drawbacks of using university graduates as entrepreneurs are that they may not have the technical expertise and may still be too “green” to be able to carry a business forward effectively. Such drawbacks may be solved if an effective talent market is developed and the inventor remains with the business to complement graduates’ lack of technical expertise.

5.3 Chalmers University of Technology

Chalmers University of Technology (hereon Chalmers), located in Gothenburg, Sweden, was founded in 1829.[18] Chalmers went through radical changes in its innovation ecosystem during 1994-2007, precipitated by several events. In 1994 Chalmers became private, only the second Swedish university to do so.[19] Chalmers also appointed a new chair in Innovation in 1993. The Chair's first task was to create seed financing for its spin-offs.[20] And a new building for the incubator was opened in 1999. However, the most radical impact on spin-offs from Chalmers was the Entrepreneurship School (E-school) founded in 1997, the first of its kind in Sweden.

The idea of the E-school was to pair high-quality Chalmers undergraduate students with inventions from Chalmers' laboratories to create spin-offs. The E-school was designed to combine formal coursework with giving students the task of creating real companies in a one-year programme; since 2007 it was converted into a two-year International Master programme. The E-school, when started, was similar in design to the third year in Halmstad's IE programme, although it differed in that incoming students to E-school already had undergraduate degrees. The first intake in 1998 comprised 12 students and in steady state E-school admits 20 students each year from approximately 100 applicants. Applicants are screened for being open to new ideas, having self-efficacy, stamina and creativity. In the early years a dominating fraction of applicants had an undergraduate degree from Chalmers. The uptake has broadened somewhat over time; for the three intakes 2009-2012, 37 percent of admitted do not come from Chalmers.

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[18] It has always had close interaction with local industry. Large local employers located in Göteborg such as Volvo, SKF, and Ericsson typically hire considerable number of engineers from Chalmers every year. The region has almost twice as many university spin-offs among high-tech firms as the country as a whole and experiences a disproportionate impact of Chalmers compared to other regions with universities (Lindholm-Dahlstrand, 1999). Chalmers has had a steady stream of spin-offs with the first recorded in 1946, 13 ventures recorded in 1980, growing to 22 in 1985 and declining to 10 in 1994 (Wallmark, 1997).

[19] Chalmers received a loan from the Swedish government of approximately U.S. $166 million to jump-start structural changes. This loan turned out to be instrumental for funding various spin-off activities. The change in legal status allowed Chalmers to accumulate capital from its entrepreneurial activities, which became an important incentive (Jacob et al., 2003). Privatizing also allowed Chalmers, among other things, to set market wages, although that opportunity has been less often used, and to locally determine programme offers, which has been a big boon.

[20] A modest seed financing fund was first created by appropriating 20 million SEK (approx. 2.6 mill. USD) from the 1994 government privatization loan. Two additional early-stage venture capital funds were subsequently created, reaching 300 million SEK and 115 million SEK, respectively, before closing. These were the first venture capital pools with university investment in Sweden.

A key feature of the programme is that students do *not* bring or develop their own venture ideas. Instead, the projects are promising inventions developed by faculty and staff at Chalmers, and initially to a small but lately increasing degree by inventors from outside Chalmers. The source of projects together with the assignment of students to projects is the major difference to the IE programme at Halmstad. At Chalmers students select projects and inventors select students. A double-sided competitive selection process clears the market. A contract is signed where the inventor is left with a third ownership rights, students obtain a third conditional on continuing the project after graduation, and Chalmers obtains the remaining third. Each project is funded with up to SEK 100,000 in cash (for patenting, legal and other costs) which is raised by Chalmers from local public seed funds. Many external services are provided at reduced fees or in kind. The inventor agrees in writing to provide reasonable efforts (typically two days a month). After finishing E-School approximately half of the graduates continue in the newly incorporated businesses in a leading position, and many take the next step to the incubator. Approximately 80 percent of the businesses remain in the region. The graduates often return to Chalmers as guest speakers, providing contract research, and their start-ups provide many opportunities for undergraduate theses work. The E-school produced two start-ups in its first year of operations, increasing to six in 2007. Between 1998 and 2000, 45 students had graduated, creating 12 new businesses. These companies together had raised more than US$ 10 million, and created 136 new jobs (Jacobs et al., 2003). The 2007 annual report from the E-school claimed an accumulation of 32 started firms with 26 still operating and employing 220 (Chalmers School of Entrepreneurship, 2007)[21]. This final case illustrates that students that self-select into an entrepreneurship programme where they are paired with high-quality inventions may produce very high quality businesses in large numbers directly upon graduation.

6. Case Discussion

[21] Other businesses started by students after graduation are not counted.

The three cases highlight that universities can affect entrepreneurship by university graduates in several ways. At MIT, a critical influence on alumni start-ups appears primarily to be students themselves, and secondarily the entrepreneurial orientation of its faculty. Halmstad University, on the other hand, provides great hope for universities which lack the ecosystem that MIT has developed for itself over many decades. The case shows that even in situations with great local resource constraints there appears to be actions that a university can take to create local economic development, primarily through programme design. Most important at Halmstad, and similar to MIT, was the IE programmes' industry orientation and spirit of entrepreneurship. All three cases highlight the importance of peers (entrepreneurs returning to the university) influencing subsequent students' decisions to start up businesses.

The case of Chalmers also indicates the importance of programme design, as well the impact of using high-quality inventions, access to researchers, and an extensive entrepreneurial ecosystem built around the programme. To further understand the difference between the IE programme and the E-school Lindholm-Dahlstrand and Berggren (2010) survey alumni from both programmes. They discover that while 12% of recent IE alumni were entrepreneurs, 43% of E-school alumni were entrepreneurs.[22] Furthermore, the 70 respondents from E-school had created 105 businesses (1.5 per alumni), while the 183 respondents from the IE programme had created 34 businesses (0.19 per alumni).

The entrepreneurship rate from the E-school to our knowledge thus tops all other known programmes. The high fraction from the E-school may not be that surprising given that students self-select into it with the expressed intent of becoming entrepreneurs. However, one should still consider that it is very difficult to commercialize inventions and that the high rate of entrepreneurship from the E-

[22] The rate of entrepreneurship from the IE programme in Halmstad has declined significantly since the pre-2001 period measured by Eriksson (1996). There can be several reasons. One likely reason is the increased competition from recently created entrepreneurship programmes in Sweden. The IE programme enjoyed almost monopoly status for the first ten years of operations and selected high-quality students from all over Sweden. Lately, it may have obtained applications from individuals that are more focussed on product development per se and found individuals interested in entrepreneurship selecting other programmes. As an indication, Lindholm-Dahlstrand and Berggren (2010) find that recent IE programme graduates have a significantly lower expressed interest in starting a business and report significantly less opportunity seeking activities than E-school graduates.

school in large part must be due to the quality of the inventions provided by the inventors. There must also be credit given to the design of the programme. Alumni from the E-school score significantly higher than IE graduates on nine out of ten benefits obtained from the study programme (Lindholm-Dahlstrand and Berggren, 2010). Worth mentioning is the high importance attributed to relationships created with collaborators, financiers, and university researchers. Only with respect to obtaining access to customers did alumni from the IE programme compare evenly with those from E-school. It thus seems that the E-school is submerged in an ecosystem that can well promote business development beyond graduation.

From these three cases the university administrator / policy maker may want to draw the conclusion that it is important to teach entrepreneurship. However, our case studies cannot be used to make statements about the role of teaching entrepreneurship to a broader audience. It might be useful to point out that the evidence is not clear that general entrepreneurship courses do anything to change graduates' start-up rates. The only thing we know for sure about such courses is that they affect students' intentions to start businesses after graduation (Oosterbeek et al, 2008; Peterman and Kennedy, 2003; Souitaris et al., 2007).[23] Sometimes such courses on average increase students intentions to start businesses (Peterman and Kennedy, 2003; Souitaris et al., 2007) and sometimes they on average reduce university students' intentions to start businesses (Oosterbeek et al, 2008; Weber et al., 2009.) The latter results may indicate that in some courses some university students get better calibrated on the vagaries of starting up businesses leading them to be less interested in starting a business. Furthermore, it stands to reason that in the case of MIT, teaching entrepreneurship was not the reason for its large rate of student alumni start-ups. And the Halmstad and Chalmers cases illustrate the use of a particularly costly programme design. This type of programme is difficult to scale up and may not work well beyond a small classroom.

[23] In the best studies, such as that by Oosterbeek et al., (2008) the researcher controls for prior held beliefs, and of sorting into the programme. There are many other studies which purport to study the effects of entrepreneurship education that we do not mention here as they do no such thing.

7. Conclusions

There has been a dramatic increase in the number of spin-offs generated by universities over the last 40 years. This has been driven by, or associated with, an increase in university research activities, an increase in privately protected ownership of research at universities, and an increase in research-for-profit activities, to name a few.

Policy makers have watched the Stanford and MIT “miracles” and become much enthralled with the possibility of encouraging economic development through directing university research policy. For example, the United States created the Bayh-Dole to transfer ownership of intellectual property from the research sponsor to the university. In Europe, several countries have recently created laws or regulations transferring ownership of intellectual property from professors/employees to universities, created financial stimulus for university scientists to start their own businesses, and supported the creation of university TLOs (for a review of these developments see Åstebro and Bazzazian, 2011.)

However, in this article we make a counterpoint: start-ups by recent university graduates in general outnumber faculty spin-offs by at least an order of magnitude. This is not just a volume effect driven by the larger number of students graduated, although graduation volumes certainly matters. Recent graduates are twice as likely as their faculty to create a start-up within three years of graduation. We also found that entrepreneurship among graduating students is a widespread phenomenon, not limited to a particular category of schools. At the same time, outcomes are not of lower quality than what would have been expected if recent graduates instead took employment. The importance of universities for creating start-ups may therefore be considerably underestimated by looking exclusively at faculty spin-offs where absolute numbers are small. National and regional policy makers as well university administrators therefore may need to reconsider the most effective ways to stimulate entrepreneurial economic development when designing university policy. For example, it is unlikely that much entrepreneurial economic development will be accomplished by tweaking TLO staff conditions or invention disclosure rules when the modal number of spin-offs from the top-100 U.S. research universities is zero. Instead, what faculty does in the classroom and the design of educational programmes may matter much more.

While creating start-ups is partly driven by simply graduating more engineering and science students, we would also like to insure that recent university graduates create start-ups of high quality. To address this, our representative data show that those who start businesses where they use their education have greater relative earnings and better survival prospects. There is also an important interaction (but no main effect) with the quality of the educational institution. Individuals from the top 10 schools who start businesses where they use their education can expect to earn on average 40 percent more than their peers graduating from the same schools, who also take jobs related to their degrees. Thus, recent graduates of top programmes who get ideas for new businesses related to their degrees reap immediate and very large benefits from entrepreneurship.

To dig deeper into how universities may affect start-up rates and start-up quality by recent graduates we performed three case studies. We highlighted two cases (MIT and Halmstad) where much is due to university student-run activities and the development of positive local norms among university students and faculty. At Halmstad, and similar to MIT, it was the engineering programme's industry orientation and spirit of entrepreneurship as well the quality of the students which caused a lot of the start-up activity. Notably, the Halmstad case shows that even in situations with great local resource constraints and little university-R&D and faculty spin-off activity, a university can stimulate entrepreneurial development through clever programme design.

We also described a case (Chalmers) which illustrates that a reasonable alternative to incentivize the university inventor to create a spin-off may be to create a two-sided market for entrepreneurial talent and inventions and let students and university inventors match up to commercialize university inventions. The Chalmers case, while innovative and apparently effective, however, may be difficult to implement in a legal environment where universities take *de jure* ownership of intellectual property. The administration must then (reluctantly?) agree that the inventor freely decides whom to give away IP to. In a jurisdiction with the *Professor's Privilege*, such as in Sweden, the Chalmers arrangement poses no administrative difficulties.

The SESTAT data, which consists of scientists and engineers, reveals that graduate student entrepreneurship in general is widespread even without any special "entrepreneurial education" (there are no MBAs in the SESTAT target population). Our three cases also focused on engineering programmes/schools as sources of business ideas. However, it should be noted that graduates from the management school at MIT are about as likely to create businesses as graduates from its engineering programmes (Hsu et al., 2007, Figure 8.) And it appears that the business schools at Stanford and Harvard are also very productive in terms of producing entrepreneurs. It remains to be analyzed whether there are qualitative differences between businesses created by MBAs versus engineers.

In conclusion; research on the role of recent university graduates in creating entrepreneurial activity is lacking although it appears to be a very important phenomena. We would like to know a lot more about what drives university graduates to create start-ups. This article hopes to stimulate research on this topic.

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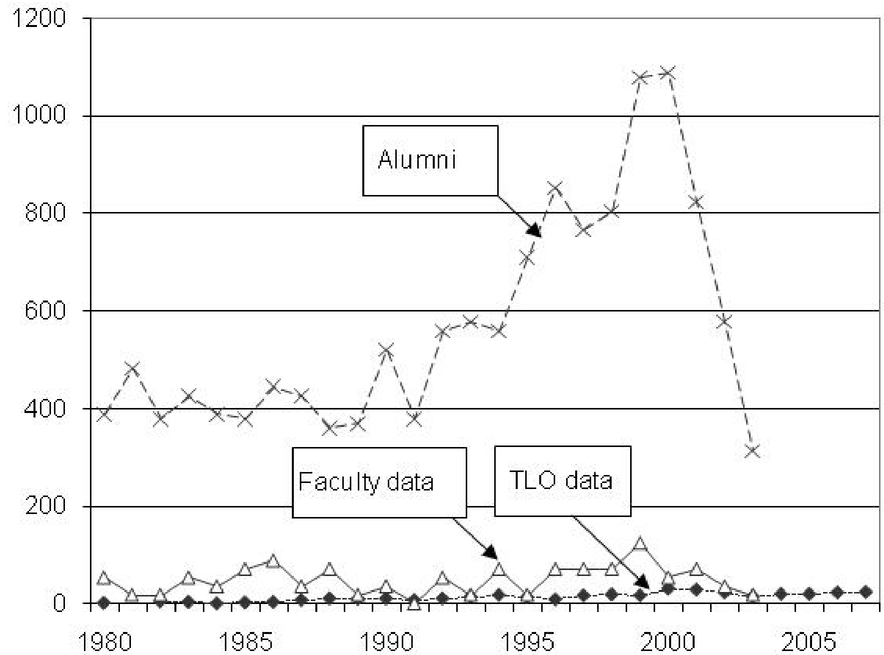
Figure 1

Number of Faculty Spin-offs and Alumni Start-ups from MIT between 1980 and 2007.



Sources: AUTM, Roberts and Eesley (2009).

Notes: TLO data (black diamonds) as reported by the MIT TLO to AUTM and as reported by Shane (2001). University alumni and faculty data are from Eesley and Roberts (2009). Faculty data are computed as follows: The number of current MIT faculty responding to Eesley and Roberts (2009) survey who are MIT alumni reported starting 66 companies during 1980-2003. Each start-up is multiplied by the product of the inverses of the two survey non-response rates = 2.425*3.906. To approximate the number of spin-offs by *all* MIT faculty (and not just MIT alumni employed at MIT as faculty) we compute the fraction of MIT faculty in the mechanical and electrical engineering departments in 2000 who were MIT alumni (53 percent). This gives an additional scale-up factor of (1+0.47/0.53).

Table 1

Number of start-ups by recent graduates and former university employees ("faculty")

	All colleges and universities		Colleges and universities with NRC score 3.25 and above	
	Sample	Population	Sample	Population
Number of start-ups by				
Recent graduates	2,789	312,430	393	36,264
Faculty	622	12,855	153	3,107
Of which: ranked faculty	321	8,828	56	2,087
Percent start-ups among				
Recent graduates	4.97%	6.41%	4.07%	5.21%
Faculty	1.25%	1.34%	1.47%	1.58%
Ratios: startups by recent graduates to startups by				
Faculty		24.30		11.67
Of which: by ranked faculty		35.39		17.37

Note: Authors' calculations based on restricted-use SESTAT data. 1995, 1997, 1999, 2003, and 2006 SESTAT data pooled together. Population numbers use SESTAT integrated weights developed by the NSF. NRC programme scores from Golderberger et al. (1995); see also http://www.stat.tamu.edu/~jnewton/nrc_rankings/nrc1.html

Table 2

Number of start-ups by recent graduates and faculty: probit estimation results

	Column 1	Column 2	Column 3
Faculty	-0.036***(0.004)	-0.031***(0.004)	-0.025***(0.003)
Full professor	-0.044***(0.002)	-0.042***(0.002)	-0.036***(0.001)
Assoc. professor	-0.042***(0.002)	-0.040***(0.002)	-0.034***(0.001)
Asst. professor	-0.033***(0.002)	-0.031***(0.002)	-0.028***(0.002)
NRC rating	0.000 (0.001)	0.000(0.001)	0.000 (0.001)
NRC rating X faculty	-0.001(0.001)	-0.002 (0.001)	-0.001 (0.001)
Control variables			
Age,gender,ethnicity, citizenship status	Yes	Yes	Yes
48 education class and 57 employment state dummies	No	Yes	Yes
Year 1997			-0.008**(0.003)
Year 1999			-0.014***(0.003)
Year 2003			0.063***(0.006)
Year 2006			0.060***(0.004)
Number of observations	105,816	105,495	105,495
Log likelihood	-22026.107	-21470.419	-20483.792

Note: Authors' estimations based on restricted-use SESTAT data. 1995, 1997, 1999, 2003, and 2006 SESTAT data pooled together. Probit regression with the dependent variable the probability of forming a start-up, reporting marginal effects at sample means. Observations are weighted by integrated SESTAT weights. The omitted category is recent graduate. The omitted year is 1995. *** indicates that the coefficient is significant at 1 percent level, ** at 5 percent level.

Table 3

Comparing the quality of start-ups: earnings in 1993 US dollars.

	Entrepreneurs		Employed		Ratio: entrepreneurs to employees
	Mean	St.Deviation	Mean	St.Deviation	
Recent graduates					
All	35,047	28,778	31,192	15,480	1.12
Whose job is closely related to degree	40,797	34,062	33,131	15,898	1.23
Recent graduates from top NRC-rated schools					
All	37,664	35,715	33,724	16,555	1.12
Whose job is closely related to degree	45,685	53,621	34,816	16,993	1.31
Faculty					
Contemporaneous Earnings	70,183	68,379	58,924	31,078	1.19
Two-year lagged earnings*	42,747	22,446	55,238	28,577	0.77
Growth rates	0.642		0.067		
Faculty from top NRC-rated schools					
Contemporaneous Earnings	73,642	83,503	66,405	35,247	1.11
Two-year lagged earnings*	42,310	24,606	61,065	34,256	0.69
Growth rates	0.741		0.087		

Note: Authors' calculations based on restricted-use SESTAT data. 1995, 1997, 1999, 2003, and 2006 SESTAT data pooled together. Annualized reported earnings in US dollars, deflated by the Consumer Price Index for corresponding years, with 1993 as the baseline year. "Start-ups" refers to new independent business owners, either recent graduates or faculty in the previous survey. "Employed" refers to recent graduates who were not independent business owners and full time employed at the time they were first surveyed and to faculty at the time of the survey. *Three years for 2006.

Table 4

Earnings regressions for faculty

	Log earnings at *t*		Log earnings at *t* - Log earnings at *t*-1
	Column 1	Column 2	Column 3
Entrepreneur	-0.120 (0.082)	0.021(0.138)	0.044 (0.150)
Age	0.029*** (0.005)	0.024*** (0.004)	0.014*** (0.004)
Age squared	-0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Experience	0.029*** (0.002)	0.022*** (0.002)	0.015*** (0.002)
Experience squared	-0.000*** (0.000)	0.000*** (0.000)	0.000** (0.000)
Male	0.080*** (0.008)	0.072*** (0.008)	0.048*** (0.006)
White	0.037*** (0.011)	0.033*** (0.010)	0.027*** (0.008)
Married	0.057*** (0.009)	0.031*** (0.008)	0.024*** (0.006)
Naturalized citizen	0.068*** (0.013)	0.012 (0.011)	0.010 (0.010)
Green card	0.010 (0.015)	-0.037*** (0.014)	-0.022* (0.012)
Temporary resident	-0.111*** (0.034)	-0.101*** (0.032)	-0.082*** (0.030)
NRC rating		0.016** (0.007)	0.011* (0.030)
NRC rating squared		0.009*** (0.002)	0.007*** (0.002)
NRC rating X entrepreneur		-0.296* (0.174)	-0.321* (0.191)
NRC rating squared X entrepreneur		0.074* (0.045)	0.083* (0.051)
Tenured/tenure track faculty		0.254*** (0.010)	0.142*** (0.010)
Tenured/tenure track faculty X entrepreneur		-0.081(0.161)	-0.039 (0.174)
Log earnings at t-1			-0.689*** (0.018)
Constant	9.723*** (0.101)	10.225*** (0.178)	6.203*** (0.347)
Year dummies	Yes	Yes	Yes
Other controls	No	Yes	Yes
Number of observations	46,006	46,006	45,681
Adjusted R-squared	0.13	0.25	0.27

Note: Authors' estimations based on restricted-use SESTAT data. 1995, 1997, 1999, 2003, and 2006 SESTAT data pooled together. Pooled OLS with robust clustered standard errors. Observations are weighted by integrated SESTAT weights. The omitted year is 1995. *** indicates that the coefficient is significant at 1 percent level, ** at 5 percent level, *at 10 percent level. Other controls include 63 occupational dummies, 14 primary work activity dummies, 48 education class dummies, and 57 employment state dummies.

Table 5

Earnings regressions for recent graduates

	Log earnings at *t*		
	Column 1	Column 2	Column 3
Entrepreneur	-0.074*** (0.027)	-0.091*** (0.035)	-0.021 (0.037)
Age	0.015*** (0.001)	0.012*** (0.001)	0.013*** (0.001)
Male	0.192*** (0.007)	0.060*** (0.007)	0.059*** (0.007)
White	-0.009 (0.008)	0.002 (0.007)	0.003 (0.007)
Married	0.130*** (0.008)	0.094*** (0.007)	0.098*** (0.006)
Naturalized citizen	0.115*** (0.019)	-0.008 (0.016)	-0.011 (0.016)
Green card	0.100*** (0.020)	-0.030* (0.017)	-0.024 (0.015)
Temporary resident	0.215*** (0.016)	-0.004 (0.013)	-0.005 (0.013)
Year 1997	0.064*** (0.008)	0.067*** (0.007)	0.068*** (0.007)
Year 1999	0.146*** (0.008)	0.139*** (0.007)	0.141*** (0.007)
Year 2003	0.197*** (0.011)	0.150*** (0.009)	0.151*** (0.009)
Year 2006	0.174*** (0.009)	0.115 (0.008)	0.118*** (0.008)
Job closely related to degree		0.080*** (0.007)	0.106*** (0.009)
Job closely related to degree X entrepreneur		0.078* (0.045)	-0.069 (0.053)
NRC rating			0.028*** (0.003)
NRC rating X entrepreneur			-0.049* (0.025)
NRC rating X Job closely related to degree			-0.017*** (0.004)
NRC rating X Job closely related to degree X entrepreneur			0.101*** (0.031)
Constant	9.493*** (0.019)	10.617*** (0.091)	10.657*** (0.104)
Other controls	No	Yes	Yes
Number of observations	47,945	47,705	47,622
Adjusted R-squared	0.126	0.383	0.387

Note: Authors' estimations based on restricted-use SESTAT data. 1995, 1997, 1999, 2003, and 2006 SESTAT data pooled together. Pooled OLS with robust clustered standard errors. Observations are weighted by integrated SESTAT weights. The omitted year is 1995. *** indicates that the coefficient is significant at 1 percent level, ** at 5 percent level, *at 10 percent level. Other controls include 63 occupational dummies, 14 primary work activity dummies, 48 education class dummies, and 57 employment state dummies.

Table 6

Comparing the quality of start-ups: survival rates and survivors' earnings.

	All Start-ups	Survivors only		
	Percentage surviving	Mean earnings at the first survey	Mean earnings at the next survey	Growth rates of mean earnings*
All colleges & universities				
Start-ups by recent graduates				
All	35.7	37,244	39,816	0.069
Job closely related to degree	33.9	47,055	43,324	-0.079
Faculty				
All	57.0	63,797	72,303	0.133
Tenured and tenure track	60.3	64,329	78,661	0.223
All colleges & universities with NRC rating 3.25 and above				
Start-ups by recent graduates				
All	32.2	29,389	37,658	0.281
Job closely related to degree	34.2	33,064	45,656	0.381
Faculty				
All	51.4	79,082	83,094	0.051
Tenured and tenure track	65.1	89,713	95,402	0.063

Note: Authors' calculations based on restricted-use SESTAT data. 1995, 1997, 1999, 2003, and 2006 SESTAT data pooled together. Annualized reported earnings in US dollars, deflated by the Consumer Price Index for corresponding years, with 1993 as the baseline year. Mean earnings for all start-ups are measured at the survey preceding exit (if any). * Two-year growth rates between 1995 and 1997 and between 1997 and 1999. Three-year growth rates between 2003 and 2006, four-year growth rates between 1999 and 2003 (for former employee start-ups only).

Appendix 1

Table A.1
Universities and colleges with the average 1993 NRC score of rated doctorate programmes 3.25 and above in the SESTAT data.

School name	NRC average score of rated doctorate programmes
Massachusetts Institute of Technology	4.62
University of California (Berkeley)	4.54
Harvard University	4.51
Stanford University	4.36
California Institute of Technology	4.29
Princeton University	4.29
University of Chicago	4.27
Yale University	4.13
The Rockefeller University	4.10
University of California (San Diego)	4.08
Cornell University	3.98
University of Michigan	3.96
University of California (Medical Center-San Francisco)	3.94
University of Wisconsin	3.93
University of California (Los Angeles)	3.92
Baylor College	3.87
Columbia University	3.85
University of Washington	3.81
University of Pennsylvania	3.79
University of Illinois (Urbana-Champaign)	3.75
University of Texas (Austin)	3.72
Carnegie Mellon University	3.70
Albert Einstein College of Medicine (Yeshiva University)	3.69
Northwestern University	3.69
University of Minnesota	3.65
University of Texas (Southwestern Medical Center)	3.64
John Hopkins University	3.58
University of North Carolina	3.53
Duke University	3.47
New York University	3.45
University of Texas (Health Science Center-Houston)	3.43
Brown University	3.37
Purdue University	3.34
Rutgers University	3.31
Pennsylvania State University	3.31
University of Massachusetts (Worcester-Medical Center)	3.31

Washington University (St. Louis)	3.29
University of Arizona	3.28
University of Virginia	3.27
Rice University	3.26
University of California (Irvine)	3.25