The stickiness of university spin-offs: a study of formal and informal spin-offs and their location from 124 US academic institutions

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Abstract: This paper examines the cross-university variation in spin-off activity by faculty members from 124 US academic institutions, using a unique database including data on founders of both formal and informal spin-offs. Accordingly, the rate of spawning founders is positively affected by the quality of the institution and its departments, the R&D expenditure of the institution, and the strength of the local cluster. In addition, we find that institutions with higher license revenues also have more spin-offs. In contrast to the traditional literature, we present evidence that both informal and non-local spin-offs are common and significant phenomena. Moreover, we find that the local cluster size and the university quality both increase the probability of spin-offs. However, when the relative quality of the institution is higher than the relative quality of the cluster, the probability of local academic spin-offs decreases.

Keywords: entrepreneurship; academic spawning; founders; spin-offs firms; linkedin; regional economic development.

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1 Introduction

University start-ups are important to the commercialisation of academic knowledge (Lazzeretti and Tavoletti, 2005; Lockett et al., 2005; Steffensen et al., 2000; Rothaermel et al., 2007).The literature on academic spin-off presents definitions, typologies, and stages of development of academic spin-offs (Clarysse and Moray, 2004; Druilhe and Garnsey, 2004; Nicolaou and Birley, 2003) and best practices of TTOs toward spin-offs (Rothaermel et al., 2007). The empirical work in this stream of research focuses on the propensity of academic spin-offs, their performance, and other attributes of these spin-offs. Scholars have found university and TTO structure and policy, technology orientation and quality and faculty's characteristics and networks, to affect the propensity of spin-off [for a comprehensive literature review, see Rothaermel et al. (2007)].

The start-ups of spawns that emanate from universities may be formal spin-offs created though university technology licensing agreements (Clarysse and Moray, 2004; Druilhe and Garnsey, 2004; Nicolaou and Birley, 2003). Alternatively, there is evidence that university start-ups may be informally initiated by faculty member using know-how or expertise that do not involve formal intellectual property (Markman et al. 2008; Roberts and Eesley, 2011; Egeln et al., 2004; Thursby et al., 2009; Crespi et al., 2007; Geuna and Nesta, 2006; Saragossi and de la Potterie, 2003).

Most empirical research still ignores informal academic spawning. Most of the large database studies use the Association of University Technology Managers' (AUTM) data, which captures startups based on formal knowledge of the university and reported by the technology licensing office. Other empirical work which might not ignore informal academic spawning is often based on local surveys or small databases (for example see Carayannis et al., 1998; Colombo et al., 2010; Chiesa and Piccaluga, 2000; Druilhe and Garnsey, 2004; Nicolaou and Birley, 2003; Roberts and Eesley, 2011; Shane and Stuart, 2002). The result is that both methods may result in significant bias towards local and formal spin-offs (Egeln et al., 2004) despite the reported importance of informal spawning.

This paper offers novel evidence on the full picture of academic spawns. We developed a unique database of founders with prior work experience in 124 leading US academic institutions based on data collected from *Linkedin*, the online professional social networking tool. We examine the institutional attributes associated with the founding of commercial ventures. Using other data on local economic conditions surrounding the university we examine factors that affect the location of academic spawns. We consider the academic spawning of entrepreneurs as a function of the local cluster characteristics, the ranking of the university and its departments, the size and sources of the R&D budget of the parent academic institution, and the institution's TTO policy and efficiency in licensing, after controlling for the institution type (public or private) and size. In addition, we consider the interaction between the quality of the research institution and the regional cluster strength on the propensity of spin-off creation and its location choice. Finally, we assess the probability for local academic spin-off rather than non-local spin-off.

We present evidence that the rate of spawning founders is positively affected by the institution and it departments' quality, the strength of the local entrepreneurial cluster, and its R&D expenditure. In addition, we find that the more efficient the TTO is in generating licensing revenues, the higher the rate of spawning founders from the institution. Regarding the location of the spin-off we find that the majority – 56% of spawns are not created near the parent institution. We present evidence that the propensity of a spin-off to locate in the region of the parent institution is influenced by the institution's quality, the regional cluster strength and the interaction between both of them.

2 University variation in spin-off rates

While academic spawning has become a significant phenomenon, its frequency varies significantly across different academic intuitions and different regions (Di Gregorio and Shane, 2003). Some universities, like MIT, routinely transfer their technology through the formation of new firms, while other universities, like Columbia University, rarely generate start-ups. The tendency of the institution to spawn new ventures is dependent on its research quality and orientation (Grandi and Grimaldi, 2005; O'Shea et al., 2005; Powers and McDougall, 2005). Moreover, some regions enhance and support regional academic spin-offs such as Silicon Valley, Boston, and New York City, while other regions have less developed entrepreneurial infrastructures, such as Ithaca, New York.

We distinguish between a few levels influencing the propensity of a faculty member to create a startup: individual, technological, university, regional and institutional levels. At the individual-level, research has shown that the attributes of inventors' career experience (Levin and Stephan, 1991; Shane and Khurana, 2003), inventors' psychological traits (D'Este and Perkmann, 2011; Krueger, 2005), and inventors' research skills (Friedman and Silberman, 2003; Jensen et al., 2003; O'Shea et al., 2005; Zucker et al., 1998), influence this decision. At the technological level, research has shown that the technological inventions themselves i.e. their novelty and orientation (Clarysse et al., 2011; Shane, 2001; Thursby and Kemp, 2002) influence this decision. At the university-level, research has shown that universities' research quality and orientation (Crespi et al., 2011; Di Gregorio and Shane, 2003), and the universities' IP policies (Lach and Schankerman, 2004, 2008; Goldfarb and Henrekson, 2003), influence this decision.

At the regional level, the strength of the local cluster and the availability of early stage investors influence this decision (Friedman and Silberman, 2003; Lockett and Wright, 2005; Powers and McDougall, 2005; Shane and Stuart, 2002). At the institutional level, research has shown that technology regimes (Shane, 2001), the strength of patent protection in a specific technological area (Shane, 2002), and regional innovation and entrepreneurial policies (Debackere and Veugelers, 2005; Schmiemann and Durvy, 2003) influence this decision. This paper will focus only on the effect of the university and regional level factors on the rate at which new firms are created to exploit university inventions.

Academic spin-offs are presumed to bean important mechanism for regional economic development (Astebro and Bazzazian, 2011; Bramwell and Wolfe, 2008; Breznitz et al., 2008; Breznitz and Feldman, 2012). The well-known examples of new industrial cluster growth such as Silicon Valley in California (Saxenian, 1996), Route 128 in Massachusetts (Saxenian, 1996), and the Research Triangle area in North Carolina (Link and Scott, 2003) are all closely connected to major research universities, and this fact has been marked as instrumental in positioning these regions on new technology-intensive growth trajectories (Feldman, 2003). Saxenian (1996) presented the role of Stanford spin-offs in Silicon Valley development. Dorfman (1983) and Malecki (1986) found that most of the high tech companies in the Boston area in the early 1980s were based on technologies originally developed at MIT laboratories. Lawton-Smith (2003) suggests that Oxford and its spin-offs had a significant role in Oxfordshire cluster development.

The geographic location of university spin-offs has also been of interest to researchers. Scholars have found that geographical proximity of start-ups to universities is determined by the need to transfer tacit knowledge (Vedovello, 1997). Proximity to the parent institution facilitates collaboration with the institution and might enable the use of university resources. Most studies suggest that academic spin-offs tend to locate near their parent institutions (e.g., AUTM, 2001; Mustar, 2001; Chiesa and Piccaluga, 2000; Druilhe and Garnsey, 2004). However, as Egeln et al. (2004) suggested these results are often due to bias data. Egeln et al. (2004) found that most spin-offs leave the region of the parent institution due to one of the following reasons: proximity to customers, proximity to pool of skilled labour force, proximity to supporting services providers and proximity to investors.

2.1.1 Established high tech cluster and local venture capital market

The first argument for cross-university variation in spin-off activity is the characteristics and development of the regional cluster. Certain cultures are less entrepreneurial than others. Innovative high tech firms seem to flourish especially in very particular regional clusters such as Silicon Valley and the Boston area (Saxenian, 1996). Therefore, while some regions significantly enhance academic spin-offs, other regions may depress academic spin-offs.

Location resources influence entrepreneurship and start-up development (Lechner and Dowling, 2003). Moreover, location might influence the entrepreneurial culture of the university and its faculties. Therefore, the decision to start a spin-off, certainly, depends on local conditions such as access to skilled human capital, the availability of local networks that mobilise the resources essential to founding a new firm (Sorenson, 2003; Stuart and Sorenson, 2003a, 2003b), the strength of the entrepreneurial infrastructure and the level of local R&D activity (Degroof and Roberts, 2004; Thornton, 1999), entrepreneurial culture and tolerance for risk and entrepreneurial activity (Audretsch and Keilbach, 2004; Davidsson and Wiklund, 1997; Mueller and Thomas, 2001; Thornton, 1999), and local availability of risk capital and other supportive services (Florida and Kenney, 1988; Saxenian, 1996).

Fini et al. (2011) documented that universities can benefit from the commercialisation of advanced knowledge only when the local context in which they are settled has sufficient absorptive capacity (Cohen and Levinthal, 1990) to leverage on academic resources. Friedman and Silberman (2003) found that universities located in regions with a high concentration of high tech firms will generate more license income. The empirical literature suggests that in contrast to the rate of academic spin-offs in established high tech clusters, academic spin-offs in regions outside such clusters are rare (Degroof and Roberts, 2004). In general

H1a The more entrepreneurial and developed the cluster surrounding the university, the greater the rate of the university spawning.

One characteristic of the local cluster - availability of venture capital in the area - has a significant impact on cross-university variation in spin-off activity (Carayannis et al., 1998; Di Gregorio and Shane, 2003). Insufficient finance is regularly cited by nascent-entrepreneurs as a major barrier to starting a business (Da Rin el al., 2006; Kouriloff, 2000). The entrepreneurial finance literature has recognised venture capital as the main source of finance to entrepreneurship (Gompers and Lerner, 2004; Zook, 2004, 2008).

Universities located in geographic areas rich in venture capital are more likely to generate spin-offs due to several reasons. First, access to financial resources has a significant influence on the propensity of people to become entrepreneurs. Chen et al. (2010) suggest that the importance of overcoming financing constraints may be even more important for academic spin-offs, because the ideas upon which these startups are based are characterised by an even greater degree of uncertainty, asymmetries and transaction costs. Second, in addition to providing capital, venture capitalists play an important role in the innovation process by providing valuable operating and strategic assistance to innovative startups (Gompers and Lerner, 2004; Zook, 2004). Third, venture capitalists serve as ‘market makers’ for business development resources by connecting new technology companies with potential suppliers, customers, lawyers, manufacturers, and employees (Florida and Kenney, 1988; Zook, 2008). While such value added and networking assistance is crucial to most startups, they are even more important to academic spin-offs as they often lack managerial skills and business networks. Finally, venture capital opportunity scouting and investments tend to be local (Chen et al., 2010; Sorenson and Stuart, 2001; Zook, 2002). Therefore, the local existence of VC partners in the region of the academic institution is crucial for spin-off creation.

Wright et al. (2006) found evidence that involvement of venture capitalists in university spin-offs facilitates their creation. Zhang (2009) found that the total venture capital investment within 50 miles of the university campus is significantly and positively correlated with a university’s number of academic entrepreneurs. Therefore we argue that:

H1b The greater the availability of venture capital in the area, the greater the rate of the university spawning.

2.1.2 The scope and orientation of the research

The second argument for cross-university variation in spin-off activity is the scope and the commercial orientation of university research. There is often tension in the universities' mission between basic research and the search for ideas with potential commercial application (Ambos et al., 2008; Breznitz, 2011; Debackere and Veugelers, 2005). In some institutions, basic research is considered as a legitimate function, while commercial activity is regarded as inappropriate. This situation is reflected in the academic reward systems, in the proportion of industry sponsored research, and in the institutional policy toward technology transfer (Feldman, 2003). D'Este and Perkmann (2011) found that encouragement of researchers toward commercial research by their institutions has a positive and significant impact on both invention disclosure and university spin-off rate.

Universities also differ on the degree to which their researchers focus on industrial problems. Commercially-oriented universities receive more of their research budget from industry (Rosenberg and Nelson, 1994) and are more likely to make commercially-oriented discoveries and to generate spin-offs (Powers and McDougall, 2005; Zucker et al., 1998).

O'Shea et al.(2005) found that industry-funded faculty members are more commercially productive than those who are not industry-funded. Di Gregorio and Shane (2003) found only limited support for the effect of the commercial orientation of a university on its spin-off rates. Powers and McDougall (2005) found a positive and significant relationship between annual university commercially oriented R&D expenditure and spin-off activity.

To sum up, O'Shea et al. (2005) found that both the total R&D budget of the academic institution and the portion of funding that comes from the industry have a positive and statistically significant impact on the level of spin-offs. Therefore, we suggest that:

H2a The greater the amount of R&D activity at the university, the greater the rate of spin-off activity.

H2b The greater the share of research activity financed by the industry at the university, the greater the rate of spin-off activity.

In addition, Thursby and Kemp (2002) and Thursby et al. (2009) found that private (versus public) universities tend to be more commercially oriented, more efficient in licensing, and have higher levels of patenting by faculty. On the other hand, Friedman and Silberman (2003) did not find significant differences in the level of licensing between different types of institutions. Therefore, we suggest that:

H2c Private (compared to public) universities will have a higher rate of spin-off activity.

2.1.3 University research quality and reputation

The third argument for cross-university variation in spawning activity is university research quality. Highly rated universities are more likely to generate spin-offs for two main reasons. First, high ranked schools are more likely to employ star scientists and high quality researchers and such researchers are more likely to start firms to exploit their inventions (Darby et al., 1999; Lowe and Gonzalez-Brambila, 2007; Perkmann et al., 2011; Zucker and Darby, 1996, 2001, 2007). Both university-level and individual-level analyses show a positive relationship between faculty quality and involvement in patenting (Carayol, 2007; Crespi et al., 2011; Rogers et al., 2001; Siegel et al., 2007; Stephan et al., 2007; Van Looy et al., 2006). Therefore, spin-offs will be more common at highly ranked schools (Di Gregorio and Shane, 2003; Fuller and Rothaermel, 2012; O'Shea et al., 2005; Powers and McDougall, 2005; Zucker et al., 1998; Zucker and Darby, 2001). Second, the reputation of the university and its faculty makes it easier for researchers to raise capital for their new venture (Baum et al., 2000; Di Gregorio and Shane, 2003). In addition, to the technological departments intellectual ranking the specific ranking of business schools can influence the level of the academic spin-off activity (O'Shea et al., 2005). The ranking of the business school might be a proxy for the institution's commercial orientation. Moreover, leading business schools are often involved in the TLO activity or in other forms of entrepreneurial development (e.g., business plan competitions and entrepreneurship courses).

Di Gregorio and Shane (2003) found that spin-off companies from top universities were more likely to attract venture capital than those from less prestigious institutions. They also found that the university's ranking positively influences academic spin-off rates and that it is easier for academics from top tier universities to assemble resources to create start-ups due to their increased credibility. O'Shea et al., (2005) found that faculty quality has a positive and statistically significant impact on the level of university spin-off, while the numbers of faculty and research students are not significant. This indicates that it is quality rather than quantity of human capital resources that matters in determining university spin-off activity. Zhang (2009) found that university's research quality is the most significant variable in explaining the number of academic entrepreneurs from a university. Therefore, we suggest that:

H3a The higher the ranking of the university, the higher the rate of spin-off activity.

H3b The higher the ranking of the technological departments of the university, the higher the rate of spin-off activity.

H3c The higher the ranking of the business school, the higher the rate of spin-off activity.

2.1.4 University TTO capacity and policies

The fourth argument for cross-university variation in spin-off activity is that universities differ in their policies toward technology transfer and that those policies influence the level of spin-off activity.

The traditional literature on technology transfer from academia focused on the TTO Policy and characteristics (e.g., Bercovitz et al., 2001; Belenzon and Schankerman, 2009; Markman et al., 2004). This literature suggests two main arguments. First, universities that adopt certain policies and incentive structures could generate more spin-offs when these policies provide greater motivation for entrepreneurial activity by faculty members (Breznitz et al., 2008; Friedman and Silberman, 2003; Powers and McDougall, 2005; Siegel et al., 2007). In particular, the distribution of royalties between inventors and the institutions was found to influence the propensity of entrepreneurs to found firms to exploit university inventions (Baldini, 2010; Friedman and Silberman, 2003; Lach and Schankerman, 2004, 2008; Shane, 2004). Thus, we suggest that:

H4a The higher the share of royalties received by the investor, the higher the rate of spin-off activity.

Second, TTO's skills and strategies can play an important role in either encouraging or impeding entrepreneurial activity among faculty members (Roberts and Malonet, 1996; Chapple et al., 2005).While, the quality of the TTO is associated with higher level financial rewards from technology transfer activities in general, it is not clear that it has the same effect on different technology transfer instruments (i.e., patent licensing, spin-off creation, consulting services, and joint research agreements with the industry).

Most research in the field is under an implicit assumption that success in one type of technology transfer by a given TTO is a proxy to its professionalisation. Thus, we might expect a strong correlation between the TTOs success in patent licensing and its success in spin-off creation. Moreover, often only inventions with a potential for significant revenues can be a potential for a new venture. We suggest that a stronger correlation should exist between the TTOs success in generating high licensing revenuers and its success in spin-off creation. However, this assumption should be tested.

H4b The more efficient the TTO in terms of licensing revenues the higher the rate of spin-offs.

2.1.5 The location of academic spin-offs

Formal academic spin-offs appear to be mostly local. According to AUTM (2001, 2013), in 2000 and in 2012, 80% of firms formed from university licenses operated in the state where the university was located. Zhang (2009) found that 78% of university spin-offs, which raised VC finance between 1991 and 2001, were located in the same state as their parent academic institution. Investigation of 72 spin-offs from MIT between 1980 and 1996 (Shane, 2004) revealed that 50% are located within 20 kilometres of MIT and nearly 70% are located less than 50 kilometres from MIT. Egeln et al. (2004) find that 66% of academic spin-offs in Germany locate within 50 kilometres of their university. Astebro and Bazzazian (2011) and Åstebro et al. (2012) argue that a dominant fraction of spin-offs are located extremely close to their parent, within 50 kilometres.

The literature presents several reasons why most academic spin-offs are local. Often, an academic inventor will retain employment with the academic institution (Zucker et al., 1998). Moreover, even when the founder leaves the university to form the spin-off, he/she may want to use the students and university labs to engage in additional research to support the spin-off (Hsu and Bernstein, 1997). Further, the inventor may want to exploit his/her local networks to support the spin-off (Heblich and Slavtchev, 2013). Finally, the inventor may prefer not to move a household as it is costly both socially and economically (Dahl and Sorenson, 2012).

However, setting the spin-off outside the region of the parent organisation may be useful if local conditions are not ideal for the startup (Egeln et al., 2004). For high potential spin-offs the opportunity costs of staying in a less-developed cluster are higher than those of changing ones location. Moreover, studies found that star scientists and high quality startups find it easier (compared to lower quality founders) to build new networks and raise capital out of their parent institution region (Lockett et al., 2005;

Zucker et al., 1998).Star scientists are often located at leading institutions within high ranked departments. Therefore, we suggest that:

H5 The greater the gap between the university quality and the local entrepreneurial cluster strength, the lower the probability a local spin-off (compared to non-local spin-off) will occur.

3 Data and methodology

In order to estimate the number of founders of spin-offs from a given academic institution, we created a unique dataset, based on an online professional network of trusted business contacts called *Linkedin*. This online professional networking resource is targeted to executives of various organisations in more than 200 countries and territories. *Linkedin* contains profiles of over 238 (215) million members as of September 2013 (March 2013). This professional network is biased toward high-level managerial and entrepreneurial positions[1].

Linkedin members are asked to indicate the title and description of their current and past work position. One of the available work position titles is 'founder' (or 'co-founder'). According to *Linkedin* on30 September 2013 (31 March 2013), there were 1,309,178 members that are titled as current or past founders (1,133,034 founders) and 936,603 members that are titled as current founders worldwide; there are 451,257 current and past founders in manufacturing industries and 302,441 current founders in manufacturing industries.

Our sampling frame includes 124 academic institutions (83 public and 41 private), which reported all the relevant information to AUTM and that are ranked in the US News rank of best national universities. We collected data on past or current faculty members of each of the 124 academic institutions in our sample who founded startup companies.

We relied on the following data collection procedure (see also Avnimelech and Feldman, 2010; Zelekha et al., 2014). We used Linkedin advanced search functions. In the position title line, we wrote 'founder' with the timing of 'current or past' (for a robustness test we also used only 'current' founders). In the company line, we chose the name of a given academic institution with the timing of 'current or past'. In the location line, for local spin-offs we choose a radius of 35 miles[2] from the zip code of the university and for global spin-offs we choose 'anywhere'. In the industry field, we marked all manufacturing industries. We conducted this procedure in September 2013 (as a robustness test we also used the gap between the number of founders we found in this search and the number of founders we found in a search we conducted in March 2013).

While AUTM's data presents only formal spin-offs (i.e., spin-offs based on formal knowledge of the university and reported by the TTO), our data also includes informal spin-offs (i.e., any startups created by current or previous employees of academic institutions that are not reported by the TTOs). Our working definition of a spin-off is any new venture created by a faculty member of the relevant research institution (we do not include ventures of professional services and consulting)[3]. In our sample of 124 leading US universities[4] we have 18,172 faculty founders of spin-offs.

Data for independent variables was obtained from a variety of sources, including ATUM annual surveys, the Integrated Postsecondary Education Data System (IPEDS) database, WebCaspar site and Lach and Schankerman (2004)[5]. Box 1 provides a summary of each variable and its source.

3.1 Dependent variable

The dependent variable is a count of present and past faculty members from a given university that founded a new start-up company. This data was collected from *Linkedin*. It is divided into founders of local spin-offs, defined as those within a 35-mile radius from the zip code of the university, and founders of non-local spin-offs. We were not able to obtain details on the number of spin-offs created but only on the number of founders. However, there is no reason to think that the average number of founders per firm (often between 2 and 3 – see Mellewigt and Späth 2002; Porter et al., 2005; Weterings and Koster, 2007) should be systematically biased between different institutions.

3.2 Independent variables

- *The size of the entrepreneurial cluster:* as an index of the size of the local entrepreneurial cluster, we used the number of entrepreneurs in the 35 miles radius from the zip code of the university in question. This information was gathered from *Linkedin* data. In order to prevent causality problems we excluded the number of the institution's local spin-offs in this index.
- *Venture capital availability:* as an index of the venture capital availability in different locations, we counted the number of venture capital partners in the 35 mile radius from the zip code of the university in question. This information was also gathered from *Linkedin* data. The variable is highly correlated to the entrepreneurial cluster size variable. Therefore, we used only one of them in a specific regression.
- *University Ranking:* As an index of university reputation we used the academic rating score of US News ranking of colleges and universities for the year 2009 (US News & World Report, 2009). There is a strong correlation between the ranks of the different scientific departments; therefore, we used only the score for the entire university and the score of a few representative departments (engineering, the life science departments and the business school).
- *R&D expenditure:* R&D expenditure data was collected from the AUTM database for each institution. As a proxy to the commercial orientation of university research, we used the sources of R&D financing following Di Gregorio and Shane (2003). This data was gathered from the WebCaspar site.
- *TTO outputs:* we collected data on each institution's TTO output (number of disclosures, patents, licenses, and total revenues). There is a high correlation between the different TTO output variables. Therefore, in the regression we used only the figure of licensing revenues per R&D expenditure.
- *Investors' royalties share:* we used the data on royalty-sharing arrangements (cash flow rights) from Lach and Schankerman (2004). This information was downloaded from the websites of individual TTOs in 2001. TTOs often give different royalties and different incomes (as the income increases the share of the inventor decreases). We used the average share.

- *Institution size:* the number of faculty members might impact the spin-off rate. This information was gathered from the National Center for Education Statistics (The IPEDS). We use this variable only as a control variable as O'Shea et al. (2005) and Zhang (2009) suggest that it has no significant impact on the number of spin-offs from a given institution.

Box 1 Description of the variables used in the regressions

Variable name	*Variable description*	*Source*
Total C_P Faculty Founders	Number of founders spawned from a specific academic institution by past or present faculty members (active and inactive)	*Linkedin*
Local Faculty C_P Founders (35Miles)	Number of founders spawned locally (35 mile radius) from a specific academic institution by past or present faculty members	*Linkedin*
Non_Local C_P Faculty Founders	Number of non-local founders spawned from a specific academic institution by past or present faculty members	*Linkedin*
FT_eq	Count of full time equivalent faculty for 2008	IPEDS
Univ_score	The score of the entire institution (and of each department including engineering, computer science, medical and biotech)	US News Report National Universities Rankings (2009)
MBA_score	The score of the business school	
Tech_score	The average score of the engineering, medical, computer science, and biotechnology departments	
ICT_score	The average score of the engineering departments	
LS_score	The average score of the life science departments (excluding medical schools)	
VC_Partners	Number of local VC partners located at the radius of 35 mile from the zip code of the university for 2013.	*Linkedin*
Cluster_35M	The count of entrepreneurs in the region (35 miles) of the institution (excluding spin-offs from the institution) for 2013.	*Linkedin*
Licenses_per	Total revenues granted from license (average 2003–2007) per 1M$ R&D expenditure	AUTM
Royalities_S	The share the researcher receives from the license income.	Lach and Schankerman (2004)
R&D Exp	R&D expenditure in US dollars (average 2003–2007)	AUTM
%Federal	The share of the R&D expenditure in the institution financed by the federal government (2008)	WebCaspar
%Industry	The share of the R&D expenditure in the institution financed by the industry(2008)	WebCaspar
%Local_Gov	The share of the R&D expenditure in the institution financed by the local government (2008)	WebCaspar
%Other	The share of the R&D expenditure in the institution financed by other sources (mostly non-for profit organisations) (2008)	WebCaspar

Box 1 Description of the variables used in the regressions (continued)

Variable name	*Variable description*	*Source*
%Institution (omitted)	The share of the R&D expenditure in the institution financed by the institution itself (2008)	WebCaspar
Rank_Dist	The gap between the university and the cluster (opposite rank) - if the university rank is higher it will be positive.	Calculated
Public_Univ	1 when the university is a public university (0 for private)	AUTM

3.3 Methodology

Our dependent variables are count variables of occasional events (spin-offs), banded by zero. When we examined the distribution of the dependent variable as a Poisson, the goodness-fit test rejected the Poisson distribution assumption because of over-dispersion, suggesting that the negative binomial model is more appropriate than the Poisson model to analyse the data (Hilbe, 2007). When we examined the distribution of the dependent variable as a negative binomial, the likelihood ration test supported the model.

Linkedin's advance search tool provides data on individuals that are currently or were previously employed at a given parent institution and subsequently founded a start-up company. However, we lack data on the years these new ventures were created, prohibiting time series modelling or the specification of a causal model. The data only allow a test of the association between characteristics of the academic institution and the rate of local and non-local spin-off founders. However, we used, in a robustness test, the data on spin-off created in the last six months (March–September 2013)[6] to insure that our results are not systematically biased due to the fact that we do not have data on the founding year of the spin-off.

In order to examine the location choice of spin-offs we used a Probit model in which the dependent variable is a binomial variable (18,172 observations) indicating whether the spin-off is local (1 for local spin-offs and 0 for non-local spin-offs).

4 Empirical results

Table 1 and Table 2 present the descriptive statistics and correlation matrix of the variables used in the regressions. We can see that as opposed to the common argument (e.g., AUTM, 1996–2013) there are more non-local academic spin-offs than local ones. In our sample, 44% of the academic spin-offs are located in the region of the parent academic institution. As expected, there is a strong correlation between the number of entrepreneurs and the number of VC partners in a cluster. There is also a strong correlation between the 'University score' and different department scores; therefore, we do not use them together in a regression. In the other variables used in the regressions there is no evidence of strong multicolinearity.

Tables 3a and 3b present the empirical results of the Negative Binomial regressions, considering total faculty spin-offs. Model 1 considers the impact of the university rank on the number of founders of spin-offs, controlling for university size. The results indicate that the university quality has a positive and statistically significant effect on spawning founders. These results suggest that higher ranked universities spawn more founders (supporting H3a). These results are similar to the findings of Di Gregorio and Shane (2003).

Model 2 considers the impact of the technology departments' average rankings and the rank of the business school on the number of founders of spin-offs. The results suggest that the rank of the technology departments has a significant and positive impact on spawning founders(supporting H3b) and that the rank of the business school has a positive and statistically significant impact on spawning founders (supporting H3c), controlling for technology department average rank. The results indicate that universities with high quality technical programs and highly ranked business schools spawn more founders.

Model 3 and Model 4 consider the impact of the local cluster (e.g., the number of local VC partners and number of entrepreneurs active in the region of the parent institution omitting the local founders spawned from the local university) on spawning founders. The results suggest that both variables have positive and statistically significant impacts on spawning founders (supporting H1a and H1b).

Model 5 considers the impact of the effectiveness of the TTO measured by the license revenues per R&D expenditure. The results suggest that the more effective the TTO is in licensing patents, the higher the rate of spawning founders of the institution. These results are statistically significant (supporting H4b).

Table 1 Descriptive statistics for the independent variables

Variable	*Obs.*	*Mean*	*Std. dev.*	*Min*	*Max*
Total C_P faculty founders	*124*	*146.54 (100%)*	*239.96*	*0*	*1,571*
Local C_P faculty founders	*124*	*64.98 (44%)*	*125.61*	*0*	*952*
Non_local C_P faculty founders	*124*	*81.56 (56%)*	*127.95*	*0*	*929*
FT_eq	124	6792	4527	104	23,796
Univ_score	124	42.23	29.24	0	100
MBA_score	124	27.52	34.80	0	100
ICT_score	124	28.19	28.58	0	100
LS_score	124	50.32	30.87	0	100
Cluster_35M	124	1629	2887	3	17,648
VC_partners	124	164.25	350.26	0	1,725
Lic_Rev_Per_RD	124	0.042	0.148	0	1.478
Royalities_Share	124	0.43	0.13	0.20	0.97
RD_exp	124	62,403	257,686	1,074	2.9M
%Federal	124	59.656	14.766	29	90.9
%Local	124	7.738	7.999	0	43.8
%Industry	124	6.264	6.359	0.3	48.5
%Other	124	5.668	3.849	0	18.2
%Institution (Omitted)	124	21.037	12.437	0	56.8
Public_Univ	124	0.669	0.472	0	1
Rank_Dist	124	0	38.80	–93	90

Table 2 Correlation matrix

	Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*
1	FT_eq	1.00															
2	U_score	0.25	1.00														
3	ICT_score	0.26	*0.63*	1.00													
4	LS_score	0.39	*0.68*	0.53	1.00												
5	MBA_score	0.37	*0.69*	0.52	0.54	1.00											
6	Cluster_35M	0.02	0.36	0.25	0.17	0.25	1.00										
7	Local_VCs	–0.01	0.32	0.18	0.14	0.21	*0.97*	1.00									
8	Lic_Re_P_RD	0.17	0.20	–0.07	0.13	0.26	0.31	0.34	1.00								
9	R_share	–0.02	–0.05	–0.03	–0.06	–0.08	–0.17	–0.19	–0.09	1.00							
10	RD_exp	0.45	*0.60*	*0.66*	*0.60*	*0.50*	0.20	0.15	0.06	–0.02	1.00						
11	S_federal	–0.08	0.29	0.12	0.15	0.23	0.31	0.27	0.09	0.10	0.20	1.00					
12	S_local	0.09	–0.34	–0.10	–0.13	–0.28	–0.28	–0.25	–0.09	–0.11	–0.20	*–0.60*	1.00				
13	S_industry	0.01	0.01	0.03	–0.12	0.07	–0.03	–0.05	–0.05	0.10	–0.02	–0.13	–0.6	1.00			
14	S_other	0.24	0.42	0.13	0.34	0.36	0.30	0.31	0.29	–0.13	0.26	0.15	–0.31	–0.17	1.00		
15	Public_Univ	0.05	–0.58	–0.20	–0.24	–0.33	–0.36	–0.34	–0.23	0.01	–0.13	0.17	0.30	–0.06	–0.21	1.00	
16	Rank_Dist	0.20	0.51	0.33	0.41	0.43	–0.33	–0.31	0.01	0.06	0.32	–0.18	0.08	0.01	0.13	–0.12	1.00

Table 3 NBREG estimation of faculty spawning

	Model 1		Model 2		Model 3		Model 4	
	Coef.	*Std.*	*Coef.*	*Std.*	*Coef.*	*Std.*	*Coef.*	*Std.*
FT_eq	5.9e-5*	2.2e-5	3.7e-5‡	2.0e-5	3.6e-5†	1.8e-5	3.6e-5†	1.8e-5
Univ_Score	0.0284*	0.0027						
ICT_Score			0.0162*	0.0028	0.0163*	0.0027	0.0158*	0.0027
LS_Score			0.0097*	0.0029	0.0092*	0.0027	0.0091*	0.0027
MBA_score			0.0109*	0.0023	0.0084*	0.0023	0.0084*	0.0023
VC_Partners					0.0008*	0.0002		
Cluster_35M							0.0001*	2.7e-5
Constant	2.9283*	0.1704	2.9377*	0.1558	2.8763*	0.1478	2.8567*	0.1481
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.0701		0.0951		0.1047		0.1053	

Notes: All manufacturing industries
*Significant under 0.01; †significant under 0.05; ‡significant under 0.1.

Table 3 NBREG estimation of faculty spawning (continued)

	Model 5		*Model 6*		*Model 7*		*Model 8*	
	Coef.	*Std.*	*Coef.*	*Std.*	*Coef.*	*Std.*	*Coef.*	*Std.*
FT_eq	2.9e-5	1.8e-5	3.0e-5*	1.8e-6	1.0e-5	1.9e-5	2.1e-5	2.0e-5
ICT_Score	0.0177*	0.0028	0.0177*	0.0028	0.0137*	0.0031	0.0153*	0.0032
LS_Score	0.0091*	0.0027	0.095*	0.0027	0.0077*	0.0027	0.0062†	0.0028
MBA_score	0.0074*	0.0023	0.0069*	0.0024	0.0066*	0.0023	0.0042‡	0.0025
Cluster_35M	7.2e-5*	2.9e-5	7.7e-5*	3.0e-6	4.9e-5*	2.9e-5	4.9e-5‡	2.9e-6
Licenses_per	0.8602‡	0.4800	0.8719‡	0.4802	0.9204†	0.4650	0.9205†	0.4629
Royalities_S	-	-	0.4139	0.5046	0.3860	0.4966	0.2775	0.4838
R&D_Exp_per	-	-	-	-	1.1e-9*	4.2e-10	1.0e-9†	4.5e-10
%Federal	-	-	-	-	-	-	0.0009	0.0063
%Local_Gov	-	-	-	-	-	-	*-0.0153*	0.0114
%Industry	-	-	-	-	-	-	0.0069	0.0118
%Other	-	-	-	-	-	-	0.0155	0.0198
Public_Univ	-	-	-	-	-	-	-0.1729	0.1833
Constant	3.1619*	0.0218	2.6744*	0.2828	2.7558*	0.2795	2.9139*	0.6031
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.1079		0.1083		0.1131		0.1177	

Notes: All manufacturing industries
*Significant under 0.01; †significant under 0.05; ‡significant under 0.1.

Table 4 Estimation of local vs. non-local faculty spawning

	Normalised local		*Normalised non-local*		*Probit (local)*		*Probit (local)*	
	Coef.	*Std.*	*Coef.*	*Std.*	*Coef.*	*Std.*	*Dy/dx*	*Std.*
FT_eq	0.0026	0.0021	0.0007	0.0018	*1.0e-5**	*2.5e-6*	*4.1e-6**	*7.0e-7*
ICT_score	1.0070†	0.5197	1.5704*	0.4561	*–0.0042**	*0.0006*	*–0.0016**	*0.0002*
LS_score	0.5734	0.5655	0.6005	0.5137	*0.0002*	*0.0006*	*0.0001*	*0.0003*
MBA_score	1.0005*	0.0024	0.5720‡	0.3338	*0.0034**	*0.0004*	*0.0013**	*0.0002*
Cluster_35M	0.0032	0.0024	–0.0019	0.0027	*4.5e-5**	*3.4e-6*	*1.8e-5**	*1.0e-6*
Licenses_per	52.869	34.627	88.276*	33.389	*–0.3373**	*0.0474*	*–0.1330**	*0.0187*
Royalities_S	*–4.6500*	24.821	–6.3216	21.523	*0.1385‡*	*0.0782*	*0.0546‡*	*0.0308*
R&D_Exp	6.1e-8	4.3e-8	4.6e-8	3.5e-8	*1.1e-10†*	*5.0e-11*	*4.4e-11†*	*8.0e-12*
%Federal	1.5645	1.1703	0.4096	0.9694	*0.0045**	*0.0013*	*0.0018**	*0.0005*
%Local_Gov	0.0540	2.5420	*–0.8529*	1.9477	*0.0059†*	*0.0027*	*0.0023†*	*0.0011*
%Industry	1.3024	3.7e-7	0.5022	1.6025	*0.0031*	*0.0022*	*0.0012*	*0.0009*
%Other	1.7428	6.1e-7	2.1067	2.4342	*–0.0038*	*0.0032*	*–0.0015*	*–0.0013*
Public	0.1210	0.0332	–0.1025	0.2791	*0.1333**	*0.0324*	*0.0526*	*0.0128*
Rank_Dist	*–0.9410**	0.3877	–0.0535	0.3270	*–0.0075**	*0.0005*	*–0.0029**	*0.0002*
Constant	–3.9221*	1.3106	–2.2070†	1.0804	*–0.8138**	*0.1202*	-	-
Observation	124		124		*18,172*		*18,172*	
Prob > chi2	0.0000		0.0000		*0.0000*		*Predict – 0.4394 (99%)*	
Pseudo R2	0.4080		0.3626		*0.0536*		*Actual – 0.4434*	

Notes: *Significant under 0.01; †significant under 0.05; ‡significant under 0.1.

Model 6 considers the impact of the royalty share policy of the institution. This impact is not significant (rejecting H4a). This might be due to a few reasons. First, our royalty share data is quite dated – it is possible that there were changes in these shares in the last couple of years. Second, we used only the average royalties share while in spin-off creation the minimum share (in cases of high revenues) might be more relevant. Moreover, Markman et al. (2004) saw similar results.

Models 7 and 8 consider the impact of the scope and the orientation of the R&D expenditure (e.g., total size of R&D expenditure and the sources of their finance) on spawning founders. We control for the type of the university (private or public). The results suggest that the size of the R&D budget has a positive and statistically significant impact on spawning founders (supporting H2a). However, the impact of the different sources are not significant (rejecting H2b). We suggest that this result might be driven by the contradicting forces industry funding has on academic spawning. On one hand, as O'Shea et al. (2005) found, industry-funded faculty members are more commercially productive than those who are not industry-funded. On the other hand, in universities with a large amount of research funded by industry there might be contractual agreements that impede the researchers to commercialise it in the form of spin-offs. The impact of the private institution is also insignificant (rejecting H2c).

Table 4 presents a comparison between the Negative Binomial regressions for local spin-offs and for non-local spin-offs and adds a Probit regression to determine, which variables increase the probability of a local spin-off. According to Negative Binomial regressions, while both ICT related department scores and MBA scores impact both local and non-local spin-offs, the relative strength of the MBA score is much more significant in the local context. In addition, the gap between the institution quality rank and the cluster size rank (i.e., Rank_Dist) is negative and significant only for local spin-offs. Moreover, the TTO patent licensing capacity has a positive and significant impact only on non-local spin-offs.

The Probit model estimates the likelihood of a new spin-off to locate in the region of the parent institution. The main finding is that, as predicted, the gap between the university quality ranking and the entrepreneurial cluster ranking decreases the likelihood of a local spin-off (supporting H5). In other words, spin-off founders from highly ranked institutions that are located in less-developed clusters will tend to establish the spin-off outside the regional cluster. Moreover, the model also indicates that while high score ICT related departments decrease the likelihood of a local spin-off, high score business schools actually increase the likelihood of a local spin-off. In addition, the strength of the local entrepreneurial cluster increases the likelihood of a local spin-off. Other variables that have a positive and significant impact on local spin-offs are the size of the institution, its R&D expenditure and its share from local and federal government, and public universities. The effectiveness of the TTO actually decreases the likelihood of a local spin-off.

4.1 Robustness tests

In Table 5 we present three robustness tests with similar predictor variables. The first model in Table 5 is the original Model 8 from Table 3. In the second model, we changed the dependent variable to only active founders (as of September 2013). In the third model, we changed the dependent variable to founders of spin-offs created between March and September 2013. There are a few significant changes between the results.

Licensing per R&D expenditure became insignificant in the model of only currently active founders. This might suggest that while professional TTOs increase the rate of spin-off creation they might not change the rate of successful spin-offs. MBA scores and cluster size became insignificant in the model that uses only spin-offs created in the last six months. However, we need to remember that this includes a small group of spin-offs which were created within six months (March to September 2013).

Table 5 Robustness tests

	Original M8		*Active spawns*		*Last six month*	
	Coef.	*Std.*	*Coef.*	*Std.*	*Coef.*	*Std.*
FT_eq	2.1e-5	2.0e-5	2.6e-5‡	1.4e-5	3.1e-5	2.2e-5
ICT_Score	0.0153*	0.0032	0.0132*	0.0024	0.0170*	0.0037
LS_Score	0.0062†	0.0028	0.0072*	0.0021	0.0057‡	0.0034
MBA_Score	0.0042‡	0.0025	0.0042†	0.0019	0.0023	0.0028
Cluster_35M	4.9e-5‡	2.9e-6	5.4e-5*	2.0e-5	3.3e-5	3.5e-5
Licenses_per	0.9205†	0.4629	0.4737	0.3503	1.8092*	0.5035
Royalities_S	0.2775	0.4838	0.2775	0.4838	0.6370	0.5765
R&D_Exp	1.0e-9†	4.5e-10	8.1e-10*	3.1e-10	1.1e-9†	4.9e-10
%Federal	0.0009	0.0063	0.0053	0.0047	0.0011	0.0075
%Local_Gov	*–0.0153*	0.0114	*–0.0123*	0.0086	*–0.0192*	0.0133
%Industry	0.0069	0.0118	0.0079	0.0088	0.0073	0.0142
%Other	0.0155	0.0198	0.0263‡	0.0148	0.0221	0.0238
Public_Univ	*–0.1729*	0.1833	0.0436	0.1300	*–0.3115*	0.2265
Constant	2.9139*	0.6031	1.7730*	0.4421	0.9272	0.7237
Observations	124		124		124	
Prob > chi2	0.0000		0.0000		0.0000	
Pseudo R2	0.1177		0.1657		0.1524	

Notes: *Significant under 0.01; †significant under 0.05; ‡significant under 0.1.

5 Conclusion and discussion

In this study, we analysed the influence of several institutional and regional characteristics on cross-institutional variation in spin-off rate. We find that spawning founders is a function of the university R&D expenditures and of the ranking of the university, its technology departments, and it business school. In addition, we find that institutions which have more efficient licensing activity will also have a higher spin-off rate. Concerning the regional characteristics, we find that institutions located in more advanced clusters will spawn more founders.

We believe that one of the major strengths of this study is that we used a unique and comprehensive data source on founders of academic spin-offs based on the professional social networking site *Linkedin*.

The most commonly used data source on academic spin-offs is AUTM data. AUTM annually surveys university TTOs to obtain information related to disclosures, patenting, licensing, and start-up firm activity. AUTM has collected data regarding university spin-off activity since 1994. According to AUTM, the total number of spin-offs created by approximately 300 leading US academic institutions between 1980 and 2012 is 9,992 companies (AUTM, 1996–2013).

One of the major limitations of AUTM data is that it contains only data on formal spin-offs (Miner et al., 2012). While one might think that the majority of the academic spin-offs are formal spin-offs, there is increasing evidence that this is not the case. Link et al. (2007) reported that many faculty members are not disclosing their inventions to their university. Furthermore, they also found that even when an invention is publicly disclosed, some firms will contact scientists directly and arrange to work with them through informal technology transfer. Markman et al. (2008) suggest that many technologies developed in research institutions are 'going out the back door' rather than through the TTOs. Clarysse et al. (2011) argue that in the 1980s most of the spin-offs from MIT were not based on formal technology licenses. Markman et al. (2008) suggest that the real number of academic spin-offs is actually twice as many as reported to AUTM. Moreover, Roberts and Eesley's (2011) comprehensive report on MIT spin-offs presented a clear picture that the number of spin-offs reported by AUTM is a significant underestimation of faculty spin-offs. Thursby et al. (2009) examine a sample of 5,811 US patents on which at least one of the inventors was a faculty member. He found that 26% of faculty patents are assigned solely to firms (i.e., informal spin-off). Aldridge and Audretsch (2010, 2011) and Bagchi-Sen and Smith (2012) point out that AUTM data on academic spin-offs does not include many of the spin-offs. Taken together, these findings suggest that informal channels of technology transfer are common at universities. Our database includes founders of both formal and informal spin-offs. *Linkedin* includes profiles of more than 72,000 (44,000) founders of (currently active) US academic spin-offs. Given that each spin-off often has 2-3 founders, this number represents 24,000–32,000 spin-offs. Accordingly, AUTM data (formal spin-offs) represents only 30–40% of the real number of academic spin-offs. We argue that in order to better understand the academic spin-off phenomena one must also consider informal spin-offs. Moreover, we believe that informal spin-offs might have different motivation, characteristics, and patterns. For example, Markman et al. (2008) suggest that informal spin-offs tend to be based on more valuable discoveries.

Another important strength of our research is providing new information on spin-off locations. While the common notion is that university spin-offs are often a local phenomenon and therefore possibly important to regional economic development (AUTM, 1996–2013; Shane, 2004; Slavtchev, 2013; Tornatzky, 2001), our findings suggest that this is not always the case. We find that more than half of the spin-offs are not local and the share of non-local spin-offs is much higher in underdeveloped clusters. This is also supported by other works. Audretsch and Stephan (1996) show that the majority of links between university scientists and US biotechnology firms and 40% of the biotechnology spin-offs are non-local. Similar results have been obtained for Germany (Beise and Stahl, 1999; Grotz and Braun, 1997). Moreover, Degroof and Roberts (2004) suggest that academic spin-offs in regions outside established high tech clusters are rare. This finding might have significant impact on regional development policy.

Regional entrepreneurial development policies have become widely used by policy makers. One common government initiative in the early stages of such cluster development process is strengthening the local academic institutions and their technology transfer activities (and particularly their spin-off activities). As our Probit model indicated, strengthening the local academic institutions without strengthening the local cluster absorptive capacity can actually reduce the positive impact of the academic institutions on the local cluster (i.e., reduce the likelihood of local spin-offs).

Therefore, the broader policy implication of this study suggests that simply strengthening the academic institutions in the region would not be efficient for regional development policy; rather a dual focus strategy should be used – both strengthening the local academic institutions and increasing the entrepreneurial absorptive capacity of the region.

The key is that clusters surrounding research institutions must have the competencies to absorb and exploit the knowledge that such institutions generate (Fini et al., 2011). Thus, strong local research institutions are a necessary but not sufficient condition for regional economic development. Only regions that can absorb and apply scientific knowledge and turn them into economic wealth will enjoy the fruits of high quality local research institution (Fini et al., 2011).

5.1 Limitations of the research and future research

Using *Linkedin* data has several limitations. First, *Linkedin* is a voluntary online professional social networking tool that clearly does not include all founders of academic spin-offs. *Linkedin* includes only 138 million members worldwide, which is a minority of the world population. However, due to the fact that professional networking is a significant task in startup creation, we believe that entrepreneurs are highly represented at *Linkedin*. Moreover, we do not think that this creates a systematic bias in the data on academic spin-offs. Second, *Linkedin* data is provided by the members themselves and there is always a chance that individuals will present incorrect information. However, there is an incentive to report correctly because each member's profile is available to be verified by other *Linkedin* members. Individuals who presenting accurate information can damage their own reputation and can be expelled from membership. Thus, we believe this transparency is expected to yield reliable data, which is much more accurate than survey data. Third, currently our database includes only limited data on each founder (for example, we do not have data on the year of establishment of the spin-offs or the department to which the founder belongs). We suggest that future research should seek to cooperate with *Linkedin* and thus not to be subject to limited details on each profile (or biased to profiles in one's own network).

Moreover, this study started as a feasibility test of research based on *Linkedin*. Therefore, the scope of the data gathered was quite limited – only 124 academic institutions. Further research based on *Linkedin* should target many more institutions without a bias toward leading institutions and should collect more and update explanatory variables.

This paper is about the propensity of academic staff to create a spin-off and not about their ability to do so or the spin-off's actual success. If many spin-offs are created that fail very quickly, there is no positive impact on regional economic development at all. Therefore further research should also examine academic spin-off performance rather than only spin-off creation. This is also related to the Roberts and Malonet (1996) model of spawning policies. Roberts and Malonet (1996) developed a typology of two entrepreneurial dimensions to analyse spin-off policies (i.e., support and selectivity).

They suggested that only two strategies make sense: low support-low selectivity policy and high support-high selectivity policy. The low support-low selectivity policy consists of spinning off many ventures, but with little support by the TTO. The high support-high selectivity policy consists of spinning off a few well-supported ventures. Based on this typology and on further research (Clarysse et al., 2005; Degroof and Roberts, 2004; Powers and McDougall, 2005), Breznitz et al. (2008) suggested that low support-low selectivity policies are more fitted to developed entrepreneurial clusters, whereas high support-high selectivity policies are more efficient in underdeveloped entrepreneurial clusters. Following these studies, we believe that future research should focus more on cross-institutional variation in spin-off success and in its contribution to regional development, in the context of different spin-off policies.

References

Aldridge, T.T. and Audretsch, D.B. (2010) 'Does policy influence the commercialization route? Evidence from National Institutes of Health funded scientists', *Research Policy*, Vol. 39, No. 5, pp.583–588.

Aldridge, T.T. and Audretsch, D.B. (2011) 'The Bayh-Dole act and scientist entrepreneurship', *Research Policy*, Vol. 40, No. 8, pp.1058–1067.

Ambos, T.C., Mäkelä, K., Birkinshaw, J. and D'Este, P. (2008) 'When does university research get commercialized? Creating ambidexterity in research institutions', *Journal of Management Studies*, Vol. 45, No. 8, pp.1424–1447.

Association of University Technology Managers (1996–2013) *AUTM Licensing Survey*, Association of University Technology Managers, Norwalk, CT.

Astebro, T. and Bazzazian, N. (2011) 'Universities, entrepreneurship and local economic development', *Handbook of Research on Entrepreneurship and Regional Development*, pp.252–333, Edward Elgar, Cheltenham.

Åstebro, T., Bazzazian, N. and Braguinsky, S. (2012) 'Startups by recent university graduates and their faculty: Implications for university entrepreneurship policy', *Research Policy*, Vol. 41, No. 4, pp.663–677.

Audretsch, D.B. and Keilbach, M. (2004) 'Does entrepreneurship capital matter?', *Entrepreneurship Theory and Practice*, Vol. 28, No. 5, pp.419–429.

Audretsch, D.B. and Stephan, P.E. (1996) 'Company-scientist locational links: the case of biotechnology', *The American Economic Review*, Vol. 86, No. 3, pp.641–652.

Avnimelech, G. and Feldman, M. (2010) 'Regional corporate spawning and the role of homegrown companies', *Review of Policy Research*, Vol. 27, No. 4, pp.475–489.

Bagchi-Sen, S. and Smith, H.L. (2012) 'The role of the university as an agent of regional economic development', *Geography Compass*, Vol. 6, No. 7, pp.439–453.

Baldini, N. (2010) 'Do royalties really foster university patenting activity? An answer from Italy', *Technovation*, Vol. 30, No. 2, pp.109–116.

Baum, J.A., Calabrese, T. and Silverman, B.S. (2000) 'Don't go it alone: alliance network composition and startups' performance in Canadian biotechnology', *Strategic Management Journal*, Vol. 21, No. 3, pp.267–294.

Beise, M. and Stahl, H. (1999) 'Public research and industrial innovations in Germany', *Research Policy*, Vol. 28, No. 4, pp.397–422.

Belenzon, S. and Schankerman, M. (2009) 'University knowledge transfer: private ownership, incentives, and local development objectives', *Journal of Law and Economics*, Vol. 52, No. 1, pp.111–144.

Bercovitz, J., Feldman, M., Feller, I. and Burton, R. (2001) 'Organizational structure as a determinant of academic patent and licensing behavior: an exploratory study of Duke, Johns Hopkins, and Pennsylvania State Universities', *The Journal of Technology Transfer*, Vol. 26, Nos. 1–2, pp.21–35.

Bramwell, A. and Wolfe, D.A. (2008) 'Universities and regional economic development: the entrepreneurial University of Waterloo', *Research Policy*, Vol. 37, No. 8, pp.1175–1187.

Breznitz, S.M. (2011) 'Improving or impairing? Following technology transfer changes at the University of Cambridge', *Regional Studies*, Vol. 45, No. 4, pp.463–478.

Breznitz, S.M. and Feldman, M.P. (2012) 'The engaged university', *The Journal of Technology Transfer*, Vol. 37, No. 2, pp.139–157.

Breznitz, S.M., O'Shea, R.P. and Allen, T.J. (2008) 'University commercialization strategies in the development of regional bioclusters', *Journal of Product Innovation Management*, Vol. 25, No. 2, pp.129–142.

Carayannis, E.G., Rogers, E.M., Kurihara, K. and Allbritton, M.M. (1998) 'High-technology spin-offs from government R&D laboratories and research universities', *Technovation*, Vol. 18, No. 1, pp.1–11.

Carayol, N. (2007) 'Academic incentives, research organization and patenting at a large French university', *Economics of Innovation and New Technology*, Vol. 16, No. 2, pp.119–138.

Chapple, W., Lockett, A., Siegel, D. and Wright, M. (2005) 'Assessing the relative performance of UK university technology transfer offices: parametric and non-parametric evidence', *Research Policy*, Vol. 34, No. 3, pp.369–384.

Chen, H., Gompers, P., Kovner, A. and Lerner, J. (2010) 'Buy local? The geography of venture capital', *Journal of Urban Economics*, Vol. 67, No. 1, pp.90–102.

Chiesa, V. and Piccaluga, A. (2000) 'Exploitation and diffusion of public research: the case of academic spin-off companies in Italy', *R&D Management*, Vol. 30, No. 4, pp.329–340.

Clarysse, B. and Moray, N. (2004) 'A process study of entrepreneurial team formation: the case of a research-based spin-off', *Journal of Business Venturing*, Vol. 19, No. 1, pp.55–79.

Clarysse, B., Wright, M. and Van de Velde, E. (2011) 'Entrepreneurial origin, technological knowledge, and the growth of spin-off companies', *Journal of Management Studies*, Vol. 48, No. 6, pp.1420–1442.

Clarysse, B., Wright, M., Lockett, A., Van de Velde, E. and Vohora, A. (2005) 'Spinning out new ventures: a typology of incubation strategies from European research institutions', *Journal of Business Venturing*, Vol. 20, No. 2, pp.183–216.

Cohen, W.M. and Levinthal, D.A. (1990) 'Absorptive capacity: a new perspective on learning and innovation', *Administrative Science Quarterly*, Vol. 35, No. 1, pp.128–152.

Colombo, M.G., D'Adda, D. and Piva, E. (2010) 'The contribution of university research to the growthof academic start-ups: an empirical analysis', *Journal of Technology Transfer*, Vol. 35, No. 1, pp.113–140.

Crespi, G., D'Este, P., Fontana, R. and Geuna, A. (2011) 'The impact of academic patenting on university research and its transfer', *Research Policy*, Vol. 40, No. 1, pp.55–68.

Crespi, G.A., Geuna, A. and Nesta, L. (2007) 'The mobility of university inventors in Europe', *The Journal of Technology Transfer*, Vol. 32, No. 3, pp.195–215.

D'Este, P. and Perkmann, M. (2011) 'Why do academics engage with industry? The entrepreneurial university and individual motivations', *The Journal of Technology Transfer*, Vol. 36, No. 3, pp.316–339.

Da Rin, M., Nicodano, G. and Sembenelli, A. (2006) 'Public policy and the creation of active venture capital markets', *Journal of Public Economics*, Vol. 90, No. 8, pp.1699–1723.

Dahl, M.S. and Sorenson, O. (2012) 'Home sweet home: entrepreneurs' location choices and the performance of their ventures', *Management Science*, Vol. 58, No. 6, pp.1059–1071.

Darby, M.R., Liu, Q. and Zucker, L.G. (1999) *Stakes and Stars: The Effect of Intellectual Human Capital on the Level and Variability of High-Tech Firms' Market Values (No. W7201)*, National Bureau of Economic Research, Cambridge, MA.

Davidsson, P. and Wiklund, J. (1997) 'Values, beliefs and regional variations in new firm formation rates', *Journal of Economic Psychology*, Vol. 18, No. 2, pp.179–199.

Debackere, K. and Veugelers, R. (2005) 'The role of academic technology transfer organizations in improving industry science links', *Research Policy*, Vol. 34, No. 3, pp.321–342.

Degroof, J.J. and Roberts, E.B. (2004) 'Overcoming weak entrepreneurial infrastructures for academic spin-off ventures', *The Journal of Technology Transfer*, Vol. 29, Nos. 3–4, pp.327–352.

Di Gregorio, D. and Shane, S. (2003) 'Why do some universities generate more start-ups than others?', *Research Policy*, Vol. 32, No. 2, pp.209–227.

Dorfman, N.S. (1983) 'Route 128: the development of a regional high technology economy', *Research Policy*, Vol. 12, No. 6, pp.299–316.

Druilhe, C. and Garnsey, E. (2004) 'Do academic spin-outs differ and does it matter?', *The Journal of Technology Transfer*, Vol. 29, Nos. 3–4, pp.269–285.

Egeln, J., Gottschalk, S. and Rammer, C. (2004) 'Location decisions of spin-offs from public research institutions', *Industry and Innovation*, Vol. 11, No. 3, pp.207–223.

Feldman, M.P. (2003) 'Entrepreneurship and American research universities: evolution in technology transfer', in Hart, D. (Ed.): *The Emergence of Entrepreneurship Policy: Governance, Start-Ups, and Growth in the U.S. Knowledge Economy*, pp.92–112, Cambridge University Press, Cambridge.

Fini, R., Grimaldi, R., Santoni, S. and Sobrero, M. (2011) 'Complements or substitutes? The role of universities and local context in supporting the creation of academic spin-offs', *Research Policy*, Vol. 40, No. 8, pp.1113–1127.

Florida, R.L. and Kenney, M. (1988) 'Venture capital-financed innovation and technological change in the USA', *Research Policy*, Vol. 17, No. 3, pp.119–137.

Friedman, J. and Silberman, J. (2003) 'University technology transfer: do incentives, management, and location matter?', *The Journal of Technology Transfer*, Vol. 28, No. 1, pp.17–30.

Fuller, A.W. and Rothaermel, F.T. (2012) 'When stars shine: the effects of faculty founders on new technology ventures', *Strategic Entrepreneurship Journal*, Vol. 6, No. 3, pp.220–235.

Geuna, A. and Nesta, L.J. (2006) 'University patenting and its effects on academic research: the emerging European evidence', *Research Policy*, Vol. 35, No. 6, pp.790–807.

Goldfarb, B. and Henrekson, M. (2003) 'Bottom-up versus top-down policies towards the commercialization of university intellectual property', *Research Policy*, Vol. 32, No. 4, pp.639–658.

Gompers, P.P.A. and Lerner, J. (2004) *The Venture Capital Cycle*, MIT press, Cambridge, MA.

Grandi, A. and Grimaldi, R. (2005) 'Academics' organizational characteristics and the generation of successful business ideas', *Journal of Business Venturing*, Vol. 20, No. 6, pp.821–845.

Grotz, R. and Braun, B. (1997) 'Territorial or trans-territorial networking: spatial aspects of technology-oriented cooperation within the German mechanical engineering industry', *Regional Studies*, Vol. 31, No. 6, pp.545–557.

Harrison, R.T. and Mason, C.M. (2000) 'Venture capital market complementarities: the links between business angels and venture capital funds in the United Kingdom', *Venture Capital: An international Journal of Entrepreneurial Finance*, Vol. 2, No. 3, pp.223–242.

Heblich, S. and Slavtchev, V. (2013) 'Parent universities and the location of academic startups', *Small Business Economics*, Vol. 42, No. 1, pp.1–15.

Hilbe, J.M. (2007) *Negative Binomial Regression*, Cambridge University Press, Cambridge, UK.

Hsu, D.H. and Bernstein, T. (1997) 'Managing the university technology licensing process: findings from case studies', *Journal of the Association of University Technology Managers*, Vol. 9, No. 9, pp.1–33.

Jensen, R.A., Thursby, J.G. and Thursby, M.C. (2003) 'Disclosure and licensing of University inventions: 'The best we can do with the s** t we get to work with'', *International Journal of Industrial Organization*, Vol. 21, No. 9, pp.1271–1300.

Kouriloff, M. (2000) 'Exploring perceptions of a apriori barriers to entrepreneurship: a multidisciplinary approach', *Entrepreneurship Theory and Practice*, Vol. 25, No. 2, pp.59–80.

Krueger Jr., N.F. (2005) 'The cognitive psychology of entrepreneurship', *Handbook of Entrepreneurship Research*, pp.105–140, Springer US.

Lach, S. and Schankerman, M. (2004) 'Royalty sharing and technology licensing in universities', *Journal of the European Economic Association*, Vol. 2, Nos. 2–3, pp.252–264.

Lach, S. and Schankerman, M. (2008) 'Incentives and invention in universities', *The RAND Journal of Economics*, Vol. 39, No. 2, pp.403–433.

Lawton-Smith, H. (2003) 'Knowledge organizations and local economic development: the cases of Oxford and Grenoble', *Regional Studies*, Vol. 37, No. 9, pp.899–909.

Lazzeretti, L. and Tavoletti, E. (2005) 'Higher education excellence and local economic development: the case of the entrepreneurial university of Twente', *European Planning Studies*, Vol. 13, No. 3, pp.475–493.

Lechner, C. and Dowling, M. (2003) 'Firm networks: external relationships as sources for the growth and competitiveness of entrepreneurial firms', *Entrepreneurship & Regional Development*, Vol. 15, No. 1, pp.1–26.

Levin, S.G. and Stephan, P.E. (1991) 'Research productivity over the life cycle: evidence for academic scientists', *The American Economic Review*, Vol. 81, No. 1, pp.114–132.

Link, A.N. and Scott, J.T. (2003) 'The growth of research triangle park', *Small Business Economics*, Vol. 20, No. 2, pp.167–175.

Link, A.N., Siegel, D.S. and Bozeman, B. (2007) 'An empirical analysis of the propensity of academics to engage in informal university technology transfer', *Industrial and Corporate Change*, Vol. 16, No. 4, pp.641–655.

Lockett, A. and Wright, M. (2005) 'Resources, capabilities, risk capital and the creation of university spin-out companies', *Research Policy*, Vol. 34, No. 7, pp.1043–1057.

Lockett, A., Siegel, D., Wright, M. and Ensley, M.D. (2005) 'The creation of spin-off firms at public research institutions: managerial and policy implications', *Research Policy*, Vol. 34, No. 7, pp.981–993.

Lowe, R.A. and Gonzalez-Brambila, C. (2007) 'Faculty entrepreneurs and research productivity', *The Journal of Technology Transfer*, Vol. 32, No. 3, pp.173–194.

Malecki, E.J. (1986) 'Research and development and the geography of high-technology complexes', in Rees, J. (Ed.): *Technology, Regions, and Policy*, pp.51–74, Rowman & Littlefield, Boston.

Markman, G.D., Gianiodis, P.T. and Phan, P.H. (2008) 'Full-time faculty or part-time entrepreneurs', *Engineering Management, IEEE Transactions on*, Vol. 55, No. 1, pp.29–36.

Markman, G.D., Gianiodis, P.T., Phan, P.H. and Balkin, D.B. (2004) 'Entrepreneurship from the ivory tower: do incentive systems matter?', *The Journal of Technology Transfer*, Vol. 29, Nos. 3–4, pp.353–364.

Mellewigt, T. and Späth, D.H.J.F. (2002) 'Entrepreneurial teams – a survey of German and US empirical studies', *Gründungs-und Überlebenschancen von Familienunternehmen*, pp.107–126, Gabler Verlag.

Miner, A.S., Gong, Y., Ciuchta, M.P., Sadler, A. and Surdyk, J. (2012) 'Promoting university startups: international patterns, vicarious learning and policy implications', *The Journal of Technology Transfer*, Vol. 37, No. 2, pp.213–233.

Mueller, S.L. and Thomas, A.S. (2001) 'Culture and entrepreneurial potential: a nine country study of locus of control and innovativeness', *Journal of Business Venturing*, Vol. 16, No. 1, pp.51–75.

Mustar, P. (2001) 'Generating spin-offs from public research: trends and outlook', *Science Technology Industry Review*, *Special Issue on Fostering High Tech Spin-Offs: a Public Strategy for Innovation*, Vol. 26, pp.165–172.

Nicolaou, N. and Birley, S. (2003) 'Academic networks in a trichotomous categorisation of university spinouts', *Journal of Business Venturing*, Vol. 18, No. 3, pp.333–359.

O'Shea, R.P., Allen, T.J., Chevalier, A. and Roche, F. (2005) 'Entrepreneurial orientation, technology transfer and spinoff performance of US universities', *Research Policy*, Vol. 34, No. 7, pp.994–1009.

Perkmann, M., King, Z. and Pavelin, S. (2011) 'Engaging excellence? Effects of faculty quality on university engagement with industry', *Research Policy*, Vol. 40, No. 4, pp.539–552.

Porter, K., Whittington, K.B. and Powell, W.W. (2005) 'The institutional embeddedness of high-tech regions: relational foundations of the Boston biotechnology community', in Breschi, S. and Malerba, F. (Eds.): *Clusters, Networks and Innovation*, pp.261–296, Oxford University Press.

Powers, J.B. and McDougall, P.P. (2005) 'University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship', *Journal of Business Venturing*, Vol. 20, No. 3, pp.291–311.

Roberts, E.B. and Eesley, C.E. (2011) 'Entrepreneurial impact: the role of MIT', *Foundations and Trends in Entrepreneurship*, Vol. 7, Nos. 1–2, pp.1–149, Now Publishers Inc., Hanover, MA.

Roberts, E.B. and Malonet, D.E. (1996) 'Policies and structures for spinning off new companies from research and development organizations', *R&D Management*, Vol. 26, No. 1, pp.17–48.

Rogers, E.M., Takegami, S. and Yin, J. (2001) 'Lessons learned about technology transfer', *Technovation*, Vol. 21, No. 4, pp.253–261.

Rosenberg, N. and Nelson, R.R. (1994) 'American universities and technical advance in industry', *Research Policy*, Vol. 23, No. 3, pp.323–348.

Rothaermel, F.T., Agung, S.D. and Jiang, L. (2007) 'University entrepreneurship: a taxonomy of the literature', *Industrial and Corporate Change*, Vol. 16, No. 4, pp.691–791.

Saragossi, S. and de la Potterie, B.V.P. (2003) 'What patent data reveal about universities: the case of Belgium', *The Journal of Technology Transfer*, Vol. 28, No. 1, pp.47–51.

Saxenian, A. (1996) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Harvard University Press, Cambridge, MA.

Schmiemann, M. and Durvy, J.N. (2003) 'New approaches to technology transfer from publicly funded research', *The Journal of Technology Transfer*, Vol. 28, No. 1, pp.9–15.

Shane, S. (2001) 'Technology regimes and new firm formation', *Management Science*, Vol. 47, No. 9, pp.1173–1190.

Shane, S. (2002) 'Selling university technology: patterns from MIT', *Management Science*, Vol. 48, No. 1, pp.122–137.

Shane, S. (2004) *Academic Entrepreneurship*, Edward Elgar Publishing, Northampton, MA.

Shane, S. and Khurana, R. (2003) 'Bringing individuals back in: the effects of career experience on new firm founding', *Industrial and Corporate Change*, Vol. 12, No. 3, pp.519–543.

Shane, S. and Stuart, T. (2002) 'Organizational endowments and the performance of university start-ups', *Management Science*, Vol. 48, No. 1, pp.154–170.

Siegel, D.S., Veugelers, R. and Wright, M. (2007) 'Technology transfer offices and commercialization of university intellectual property: performance and policy implications', *Oxford Review of Economic Policy*, Vol. 23, No. 4, pp.640–660.

Slavtchev, V. (2013) 'Proximity and the transfer of academic knowledge: evidence from the spatial pattern of industry collaborations of East German professors', *Regional Studies*, Vol. 47, No. 5, pp.686–702.

Sorenson, O. (2003) 'Social networks and industrial geography', *Journal of Evolutionary Economics*, Vol. 13, No. 5, pp.513–527.

Sorenson, O. and Stuart, T.E. (2001) 'Syndication networks and the spatial distribution of venture capital investments', *American Journal of Sociology*, Vol. 106, No. 6, pp.1546–1588.

Steffensen, M., Rogers, E.M. and Speakman, K. (2000) 'Spin-offs from research centers at a research university', *Journal of Business Venturing*, Vol. 15, No. 1, pp.93–111.

Stephan, P.E., Gurmu, S., Sumell, A.J. and Black, G. (2007) 'Who's patenting in the university? Evidence from the survey of doctorate recipients', *Economics of Innovation and New Technology*, Vol. 16, No. 2, pp.71–99.

Stuart, T.E. and Sorenson, O. (2003a) 'Liquidity events and the geographic distribution of entrepreneurial activity', *Administrative Science Quarterly*, Vol. 48, No. 2, pp.175–201.

Stuart, T.E. and Sorenson, O. (2003b) 'The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms', *Research Policy*, Vol. 32, No. 2, pp.229–253.

Thornton, P.H. (1999) 'The sociology of entrepreneurship', *Annual Review of Sociology*, Vol. 25, No. 1, pp.19–46.

Thursby, J., Fuller, A.W. and Thursby, M. (2009) 'US faculty patenting: inside and outside the university', *Research Policy*, Vol. 38, No. 1, pp.14–25.

Thursby, J.G. and Kemp, S. (2002) 'Growth and productive efficiency of university intellectual property licensing', *Research Policy*, Vol. 31, No. 1, pp.109–124.

Tornatzky, L.G. (2001) 'Benchmarking university–industry technology transfer: a six year retrospective', *The Journal of Technology Transfer*, Vol. 26, No. 3, pp.269–277.

US News & World Report (2009) [online] http://www.colleges.usnews.rankingsandreviews.com/best-colleges/rankings/national-universities.

US News Report National Universities Rankings (2009) [online] http://www.colleges.usnews.rankingsandreviews.com/best-colleges/rankings/national-universities.

Van Looy, B., Callaert, J. and Debackere, K. (2006) 'Publication and patent behavior of academic researchers: Conflicting, reinforcing or merely co-existing?', *Research Policy*, Vol. 35, No. 4, pp.596–608.

Vedovello, C. (1997) 'Science parks and university-industry interaction: geographical proximity between the agents as a driving force', *Technovation*, Vol. 17, No. 9, pp.491–531.

Weterings, A. and Koster, S. (2007) 'Inheriting knowledge and sustaining relationships: What stimulates the innovative performance of small software firms in the Netherlands?', *Research Policy*, Vol. 36, No. 3, pp.320–335.

Wright, M., Lockett, A., Clarysse, B. and Binks, M. (2006) 'University spin-out companies and venture capital', *Research Policy*, Vol. 35, No. 4, pp.481–501.

Zelekha, Y., Avnimelech, G. and Sharabi, E. (2014) 'Religion institutions and entrepreneurship', *Small Business Economics*, Vol. 42, No. 4, pp.747–767.

Zhang, J. (2009) 'The performance of university spin-offs: an exploratory analysis using venture capital data', *The Journal of Technology Transfer*, Vol. 34, No. 3, pp.255–285.

Zook, M. (2008) *The Geography of the Internet Industry: Venture Capital, Dot-Coms, and Local Knowledge*, Blackwell Publishing, Malden, MA.

Zook, M.A. (2002) 'Grounded capital: venture financing and the geography of the internet industry, 1994–2000', *Journal of Economic Geography*, Vol. 2, No. 2, pp.151–177.

Zook, M.A. (2004) 'The knowledge brokers: venture capitalists, tacit knowledge and regional development', *International Journal of Urban and Regional Research*, Vol. 28, No. 3, pp.621–641.

Zucker, L., Darby, M. and Brewer, M. (1998) 'Intellectual human capital and the birth of US biotechnology enterprises', *American Economic Review*, Vol. 88, No. 1, pp.290–305.

Zucker, L.G. and Darby, M.R. (1996) 'Star scientists and institutional transformation: patterns of invention and innovation in the formation of the biotechnology industry', *Proceedings of the National Academy of Sciences*, Vol. 93, No. 23, pp.12709–12716.

Zucker, L.G. and Darby, M.R. (2001) 'Capturing technological opportunity via Japan's star scientists: Evidence from Japanese firms' biotech patents and products', *The Journal of Technology Transfer*, Vol. 26, Nos. 1–2, pp.37–58.

Zucker, L.G. and Darby, M.R. (2007) *Star Scientists, Innovation and Regional and NATIONAL Immigration (No. w13547)*, National Bureau of Economic Research, Cambridge, MA.

Notes

1 *Linkedin* is used by its members to expand and manage their professional networks; thus it is mainly used in positions in which business networks are important, such as high level managerial and entrepreneurial positions.

2 This is consistent with the finding regarding the radius of venture capital and business angel investments from their offices (see Gompers and Lerner, 2004; Harrison and Mason, 2000) and the literature on academic spin-off location (Chiesa and Piccaluga, 2000).

3 Such definition is not new as it was used by some empirical studies but most of these were based on relatively small databases (such as Colombo et al., 2010).

4 We included only universities in which we had all the independent variables.

5 We want to thank Saul Lach and Mark Schankerman for letting us use their data on royalties share.

6 We conducted two searches in *Linkedin* (on March and on September 2013) and subtracted the result of the first search from the results of the second search.