Research Policy 40 (2011) 1113–1127

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Complements or substitutes? The role of universities and local context in supporting the creation of academic spin-offs

Riccardo Fini [a,b], Rosa Grimaldi [b,*], Simone Santoni [b], Maurizio Sobrero [b]

[a] Imperial College Business School, London, UK
[b] Department of Management, University of Bologna, Via Capo di Lucca 34, 40126 Bologna, Italy

ARTICLE INFO

Article history:
Received 30 July 2010
Received in revised form 31 January 2011
Accepted 28 April 2011
Available online 12 June 2011

JEL classification:
M13
O34
O38

Keywords:
Academic entrepreneurship
Academic spin-offs
University-level support mechanisms
Local-context support mechanisms
Technology transfer

ABSTRACT

In this paper, we analyze the extent to which University-Level Support Mechanisms (ULSMs) and Local-Context Support Mechanisms (LCSMs) complement or substitute for each other in fostering the creation of academic spin-offs. Using a sample of 404 companies spun off from the 64 Italian Science, Technology, Engineering, and Mathematics universities (STEM universities) over the 2000–2007 period, we show that the ULSMs' marginal effect on universities' spin-off productivity may be positive or negative depending on the contribution offered by different LCSMs. Specifically, in any given region, ULSMs complement the legislative support offered to high-tech entrepreneurship whereas they have a substitution effect with regard to the amount of regional social capital, regional financial development, the presence of a regional business incubator, regional public R&D expenses as well as the level of innovative performance in the region. Results support the idea that regional settings' idiosyncrasies should be considered for universities to develop effective spin-off support policies. This paper contributes to the debate on the evaluation of economic policies supporting entrepreneurship.

1. Introduction

The economic importance of New Technology-Based Firms (NTBFs) as key components of development and growth (Roberts, 1991; Schumpeter, 1912) has found consistent support over time and is recurrently cited in numerous positioning papers that set the agenda of governments around the world (Lerner, 2010). Academic spin-offs—i.e., companies created to exploit technological knowledge that originated within universities—represent a specific category of NTBFs (Shane, 2004). Such companies, especially in the last two decades, have received increasing attention from researchers and policymakers because of their ability to create wealth and to advance scientific knowledge (Mustar et al., 2006, 2008).

There are several reasons for their growing economic importance. First, the increasingly rapid evolution of knowledge fields as well as their multidisciplinarity—which is core to new disciplines like, for example, nanotechnologies (Gibbons, 1994)—requires access to multiple research environments, which may be offered by academic spin-offs (Shane, 2004). Secondly, the organization of R&D activities in large firms in different industries has evolved toward more open models as part of which alliances with smaller and more dynamic firms with sophisticated scientific bases, such as academic spin-offs, become a central pillar for the pursuit of new technologies (Pisano, 2006; Zucker et al., 2002). Moreover, academic spin-offs have enjoyed increasing visibility and importance following legislative changes that have involved several countries across the world and have specifically targeted the creation of new firms by universities and, at the same time, provided a more liberal framework for academic institutions to pursue technology transfer activities.

With this specific regard, the Bayh-Dole Act is the first and most studied legislative change; it provided the framework for universities to patent inventions funded by federal agencies. Although its net effects have been questioned (Kenney and Patton, 2009), even the harshest critics recognize that it contributed to raising the overall awareness that US universities could play an active role in technology transfer, including licensing, patents, university–industry collaborations, the pursuit of research contracts with companies, and academic spin-offs (Mowery et al., 2004).

Following mid-1990s legislative reforms that pushed public research institutions toward greater proactiveness in commercializing their research results, universities in many parts of the

* Corresponding author. Tel.: +39 051 209 0207.
E-mail address: rosa.grimaldi@unibo.it (R. Grimaldi).

0048-7333/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.respol.2011.05.013

world have started to invest in the creation of internal mechanisms (organizational procedures, incentives, regulations, etc.) aimed at supporting academic entrepreneurship in its different forms (Baldini et al., 2006; Geuna and Rossi, this issue). These internal, university-level mechanisms and policies have contributed significantly to the professionalization of activities that encourage the exploitation of research results (Meyer, 2003; Siegel et al., 2003).

Yet, unlike in the US, where there has been a systematic effort to assess the impact of legislation (particularly, Bayh-Dole) and of the mechanisms/policies implemented by universities to support the commercial exploitation of research results, in Europe, both per se (Di Gregorio and Shane, 2003; Link and Siegel, 2005; Mowery et al., 2004; O'Shea et al., 2005) and conditional to local context specificities (Brunitz et al., 2008; Roberts and Malone, 1996), the effects of universities' interventions are still mainly anecdotal (for notable exceptions, see Degroof and Roberts (2004) and Rasmussen et al. (2011)).

Although several scholars have worked on either university patenting (e.g., Baldini, 2011a; Baldini et al., 2006; Breschi et al., 2008; Lissoni et al., 2008) or spin-off creation (e.g., Baldini, 2011b; Colombo et al., 2010; Fini et al., 2009; Lockett et al., 2005; Moray and Clarysse, 2005; Nosella and Grimaldi, 2009), there is a gap in the literature related to the joint impact that university and regional specificities might have on technology transfer activities in the European context and, more specifically, on how and to what extent each single university mechanism either complements or substitutes for various regional characteristics in fostering the creation of academic spin-offs. Therefore, considering the increasing attention devoted to these topics by several decision-making bodies in the EU and other parts of the world, we believe that a more systematic assessment of the impact of universities' interventions to support academic entrepreneurship in EU countries is timely and desirable.

In this study, we start filling this gap by focusing on one of the major European countries, Italy, and assessing the impact of universities' activities in fostering spin-off companies in a given regional setting. We look at the nature and role of University-Level Support Mechanisms (ULSMs) for the creation of academic spin-offs, and the way they interact with other forms of support mechanisms—which we call Local-Context Support Mechanisms (LCSMs)—that are generally available in the regional context in which universities operate. By focusing on a single country, we try to control for the national-level institutional setting and for the regulations to which all universities must adhere. Moreover, given the variety of support mechanisms across Italian regions, we assess the impact of university-level policies that depend on the specificities offered by regional contexts.

Using longitudinal data on the population of the 404 Italian university spin-offs that have originated from the 64 Italian Science, Technology, Engineering, and Mathematics universities (STEM) (www.nsf.gov/nsb/stem/) over the 2000–2007 time period, we adopt a set of multi-level specifications in order to disentangle the impact of ULSMs and LCSMs on university spin-off productivity. More specifically, we address the following research question. Do ULSMs and LCSMs complement or substitute for each other in fostering the creation of academic spin-offs?

Our results show that, in any given region, ULSMs complement the legislative support offered to high-tech entrepreneurship. Ceteris paribus, therefore, the higher the marginal productivity of the legislative support, the greater the marginal productivity of ULSMs. On the other hand, ULSMs have a substitution effect with respect to amount of regional social capital, regional financial development, presence of a regional business incubator, regional public R&D expenses as well as level of innovative performance in the region.

Our findings shed some light on how and to what extent universities' efforts complement or substitute local specificities in fostering academic entrepreneurship. They also support the belief that regional settings' idiosyncrasies should be taken into account in order for universities to develop effective spin-off-support policies.

The remainder of the paper is organized as follows. In Section 2, we focus our attention on the specific mechanisms that support academic spin-off creation and on their expected effects. In Section 3, we lay out the research design, describing the Italian normative contexts, our data, and the method. In Section 4, we present the results, discussing the empirical evidence that has emerged from our analyses. Section 5 concludes with implications for university technology-transfer activities and policy-making decisions.

2. Forms and sources of support mechanisms for academic spin-offs

Academic spin-offs, given their technology basis, combine both the traditional problems associated with the start-up of a new business and the difficulties associated with the development of new technologies (Oakey et al., 1996). According to several contributions that are core to the Economics of Innovation (Hall and Rosenberg, 2010; Stoneman, 1995), academic spin-offs are, therefore, particularly sensitive to various kinds of market failures that are typically associated with early stages of business.

First, they are both capital and credit rationed. On the capital side, academic entrepreneurs are prone to generating information asymmetries either due to inability to properly communicate key characteristics of the knowledge on which the new venture is based to investors, or because of unwillingness to share too many details of their technologies, fearing leakage/dissemination of information that they consider critical to the new venture's competitive advantage (Nerkar and Shane, 2003). Moreover, several studies show that financial markets are not equally developed around the world, thus oftentimes lacking the presence of specialists in the provisioning of risk capital or, when present, the necessary expertise (Rajan and Zingales, 1998). On the credit side, it has been well established that start-ups, and particularly high-tech ones, lack several elements that are key for signing debt-contracts: from regular cash flows needed to pay dividends and reimburse capital to collaterals and reputation (for a review see Hall, 2002).

Market failures also arise because of the appropriability characteristics of new technologies, which account for the higher risks associated with investing in academic spin-offs, and might not always be resolved by intellectual property rights. Moreover, academic spin-offs might not be able to appropriate the rents from their technologies because they may lack the complementary resources/technologies to exploit them and the resources to efficiently locate and involve partners able to provide them (Roberts, 1991; Roberts and Malone, 1996).

Several mechanisms and policies can therefore be devised to try to solve these market inefficiencies. In the following sections, we explore in greater detail these various mechanisms, distinguishing between those directly under the control of universities, and those more generally related to the presence of specific environmental (i.e., local context) conditions.

2.1. University-level support mechanisms (ULSMs)

The set of policies and instruments that can be put in place by universities to support academic spin-offs is quite varied, depending on the phase of intervention, the subjects targeted, the type of support provided, the nature and type of resources mobilized for the new entrepreneurial venture, and the institutional setting in which they operate.

A first set of policies is targeted at the emergence of entrepreneurial ideas among faculty and students, to increase their awareness of the possibilities of starting a new business and pursuing an entrepreneurial career (Mustar and Wright, 2010). Among these there are mechanisms such as Business Plan Competitions and Technology Transfer Offices (TTOs) (Siegel et al., 2007). However, once new business ideas have been sufficiently developed so as to justify the attempt to start up a new business, the road to commercial distribution of products and services is still difficult and fraught with uncertainty. One set of support mechanisms for the early stages of start-ups is offered by a second set of tools, among which are the so-called university incubators (Mian, 1996; Rothaermel and Thursby, 2005). In this phase, TTOs can also create legitimacy for novel technologies (Jain and George, 2007). A specific monetary contribution can also be offered by University Venture funds, fully or partly funded with university resources that generally act as seed funds (Atkinson, 1994; Lerner, 2004).

Finally, there are additional policies aimed at structurally reinforcing the different ad-hoc policies reviewed above. First, there are the sets of rules and procedures that govern the possibility of exploiting university-assigned technologies. Preferential treatment of inventors who are willing to pursue their research toward the goal of commercialization or for university-affiliated entrepreneurs to license university technologies is a practical example of attempts to foster new businesses and lessen the natural frictions that have to be faced when marketing new technologies and ideas. Second, there is the provisioning of specific contractual arrangements with faculty members, often limited by the more general rules of the academic labor market. These include, for example, non-research-based leave of absence to the formally recognized approach of starting a new business, the possibility of temporarily freezing the tenure clock, or appropriate recognition in individual evaluations and compensation schemes. Such provisions encourage participation in various forms of technology transfer activities. Third, special rules and procedures govern access to R&D laboratories and scientific facilities, which could be particularly relevant for start-ups that are unable to afford an initial investment in capital and complex instrumentation, and for which accessing academic facilities is extremely valuable.

It is clearly impossible for universities to influence the general characteristics of the labor markets or the role, distribution, and ease of access to complementary assets alone. Yet, they can devise different micro-level policies in these areas, such as more flexible leave-of-absence schemes, pre-specified tracks for faculty who are willing to start a new business, dedicated offices to support the whole process, early-stage incubators with shared services, and subsidized facilities. Although such policies have been traditionally and idiosyncratically practiced by various universities in the US, these institutional interventions are becoming more widespread, even in much more rigid and conservative environments, such as in European countries (OECD, 2003) as well as in emerging economies like, for example, China (Huang et al., 2004), India (Khan, 2001), and South Korea (Yim and Kim, 2005).

2.2. Local-context support mechanisms (LCSMs)

The business environment within which universities operate can provide important resources for the establishment and growth of their spin-offs. The region in which a new venture operates may be seen as having a set of competencies and resources that are both tangible—physical infrastructure, corporate physical assets, and R&D laboratories—and intangible—human capital, routines, etc. (Niosi and Bas, 2001; Saxenian, 1996); furthermore, the region can also affect the ease of establishing and growing an NTBF.

There are various types of support mechanisms that have been developed in an effort to spur the creation of new companies although their success is not always clear. First, to mitigate financial constraints, financial support may be offered through specific regional programs aimed at fostering the creation of new ventures in high- tech sectors. In Europe, for example, the recent positioning paper called *Europe 2020* (European Community, 2010) specifically identifies the development of the venture capital industry as a general goal to be supported by local policies and the direct support of the European Central Bank. Often, funding schemes are made available—through local administrations and regional funding—in rich regions also with the objective of providing financial and non-financial support to would-be entrepreneurs and promoting university-to-industry technology transfer. Moreover, local contexts might develop specific entrepreneurial-support services directly targeted to help new ventures early in their lives. Examples of these services can be found in different initiatives launched by public agencies or local governments, ranging from training opportunities, small loans, and direct services to physical infrastructure, such as public incubators and science parks (Feldman, 2001).

In addition to support mechanisms specifically targeted and implemented to support the creation of new ventures, there are other factors associated with characteristics of the local context, which may contribute to the creation of an environment supportive to the establishment of high-tech ventures. First, different studies show that the level of financial development makes growth and expansion possible, and that these effects are particularly relevant for small, young firms (Beck et al., 2005; Love, 2003). Venture capital plays a critical role in both the direct financial support that is provided by capital investments and the additional support that is typically attached to early-stage investments. In several studies, venture capitalists emerge as critical for establishing connections with potential suppliers and customers, increasing the managerial competencies of the founding team, and recruiting additional managerial resources (Di Gregorio and Shane, 2003; Lee et al., 2001; MacMillan et al., 1986).

The characteristics of the industries present in the local context can also determine significant business opportunities (Klepper, 2007). The existence of companies that operate in the same or related sectors promotes the natural exchange of ideas through formal and informal networks among organizations. Closer interactions among companies help to create a social environment that allows and encourages individuals to share knowledge and ideas. Deeds et al. (1998) showed that firms located in a geographic area with a high concentration of similar firms have access to information, personnel, and support structures, and they enjoy benefits from their proximity. Additionally, Friedman and Silberman (2003) found that universities in locations that are characterized by a relatively high concentration of technology firms generate more licenses and license income.

2.3. 'University-level' and 'local-context' support mechanisms: Complements or substitutes?

The literature reviewed above suggests that academic spin-off creation can be enhanced by ULSMs but might also depend on the characteristics of the local context, which encompasses both factor endowments and specific policies targeted to support entrepreneurship. It is not clear, however, whether and to what extent ULSMs and LCSMs act as complements that offer a differentiated set of elements or as substitutes that inefficiently duplicate efforts and resources (Brunitz et al., 2008; Degroof and Roberts, 2004).

Recent advances in science- and technology-policy studies consider universities to be directly involved in local economic development (Etzkowitz, 2000). In particular, universities are considered critical in supplementing the different services in economic environments characterized by underdeveloped local context conditions. Academic incubators, university venture funds, and other services put in place by academic institutions are therefore highlighted as particularly important to raise the opportunity set of local entrepreneurs who face underdeveloped financial markets, high search costs, and disproportionate attention to the presence of collaterals rather than to business-growth opportunities. As a consequence, targeted instruments that support universities in facilitating academic spin-offs become policy mechanisms that are more easily and quickly applicable and that are considered to have a more direct impact on the local economy than more structured and long-term policies. According to this view, universities play an active role in turning academic knowledge into economic wealth, implementing their own mechanisms that are targeted at supporting new-venture creation and technology transfer.

However, some scholars have questioned the effectiveness of such policies; they are relatively easier to launch and cheaper with respect to other interventions though their effectiveness, conditional upon local support mechanisms, has not yet been formally assessed (Brunitz et al., 2008; Degroof and Roberts, 2004; Roberts and Malone, 1996). In this regard, extensive longitudinal case studies have documented that universities in particular and society at large can both benefit from the commercialization of advanced knowledge only when the local context in which they are settled is 'fertile' enough to leverage academic resources (Florida, 1999). The key argument is that communities surrounding universities must have the capabilities to absorb and exploit the science and knowledge that universities generate. Even if new knowledge is generated in many places, it is only those regions that can absorb and apply ideas that are able to turn it into economic wealth. As a consequence, universities are a necessary but not sufficient condition for regional economic development.

Florida (1999), for example, argues that Stanford did not turn the Silicon Valley area into a high-tech powerhouse on its own, but that regional actors built the local infrastructure that the economy needed. The same happened in Boston and Austin (Texas), where regional leaders undertook aggressive measures to create local opportunities for the commercial exploitation of academic knowledge, ranging from incubator facilities to venture capital and outdoor amenities to attract and retain knowledge workers, and to facilitate knowledge and experience sharing. Accordingly, it is in situations in which local contexts are well-developed and rich in opportunities that universities are more likely to turn their knowledge into economic wealth. In these contexts, it becomes easier for them to create their own support mechanisms and find internal incentives for academic spin-offs by leveraging positive network externalities.

Building on this idea, Roberts and Malone (1996) developed a typology of two entrepreneurial dimensions to analyze spin-off policies. The low-support–low-selectivity policy consists of spinning off many ventures but with little support. It reduces the cost of spinning off but seeks safety in numbers. By contrast, the high-support–high-selectivity strategy consists of spinning off a few well-supported ventures by picking potential winners and supporting them to increase their chances as much as possible. This view is reinforced and complemented by both Degroof and Roberts (2004) and Brunitz et al. (2008) who, when analyzing the contribution of universities to regional development, support a contingent-based perspective of academic entrepreneurship whereby low-support—low-selectivity policies fit entrepreneurially developed environments and high-support—high-selectivity policies fit entrepreneurially underdeveloped environments.

Overall, these arguments raise interesting questions with regard to when, where, and to what extent universities should get involved in creating ad-hoc mechanisms to support the creation of new ventures, promote complementarity, and avoid duplication. And yet, despite the aforementioned notable contributions, the complementary vs. substitutive effects still cannot be convincingly modeled in favor of either.

To explore this issue, in the next section, we present an empirical analysis based on Italian data that contrasts the relevance of ULSMs and LCSMs for start-ups, disaggregating and comparing ULSMs and LCSMs one-by-one under different levels of local economic development.

3. Research design

3.1. The Italian university system

The Italian university system has, for quite some time, been a typical example of a fully public and highly centralized governance structure with low autonomy at the university level and a key role being played by the state. In 1989, Law 168 endorsed the self-regulation principle and increased universities' administrative autonomy. Law 537 further elaborated on this new institutional framework, in 1993, by introducing greater freedom for universities in the use of funds coming from the Ministry, and the possibility of attracting external funding. Following the ministerial decree on the 9th of February 1996, which gave full application to Law 168, universities started to elaborate on their own statutes and internal regulations, which gradually expanded to include different possibilities for leveraging their internal resources and competencies. Still, the fundamental leverages of selection procedures and remuneration remained under the control of the government through the Ministry of University and Education.

The most important legislative change related to academic spin-offs was Law 297 from 1999, which introduced the possibility for public researchers to be formally involved in the creation of a spin-off or in other technology-transfer projects between a university and a firm while keeping their university position and wage (up to eight years). The law also identified special financial provisioning to support innovation projects associated with academic spin-offs. According to the law and the autonomy of universities previously established, its implementation through local regulations was left to institutions themselves.

Finally, a third legislative change, albeit more general in scope and content, was the constitutional reform of 1999, which, for the first time, assigned legislative power in several domains that had previously been reserved for the national government to regional governments. Among these domains was that related to innovation policies. As a consequence, in the following decade, several regional governments approved specific regulations that were intended to promote innovation activities.

3.2. Sample

To address the aforementioned research question, we gathered university-level data: names of institutions, departments, and schools, as well as their regional localization—from 2006 to 2010—through the official website of the Italian Ministry of Instruction, University and Research (MIUR; http://nuclei.miur.it/sommario/). Out of the overall population of 94 universities, we retained only the 64 with technical departments and/or schools that included science, technology, engineering, and mathematical fields (i.e., STEM universities).

Given our interest in high-technology entrepreneurship, we then focused on the number of spin-off companies that had been established by academics who were affiliated with these institutions, and that were operating in high-tech industries according to the OECD definition[1]. We define an academic spin-off as a company that has either a university or at least one academic (full, associate, or assistant professor; or Ph.D. candidate, research fellow, or technician) among the founders, regardless of the presence of a formal commitment from the parent university (Fini et al., 2009). Our definition excludes firms that had been based on university-owned knowledge that had been licensed to external entrepreneurs (Radosevich, 1995).

To collect information on the population of academic spin-offs that had been established in Italy during the last decade, we adopted a two-pronged approach. First, moving from the 64 Italian STEM universities' websites, we gathered information on TTOs, when available, identifying a key informant for each institution, who was contacted to gather data. TTOs were first contacted in November 2006, and the list of spin-off companies was then updated on a yearly basis through May 2010.

Second, in order to gather information on those firms that had been established without passing through the formal disclosure procedure and to control for related biases (Fini et al., 2010), we combined different sources. Every year, starting from November 2006, we accessed the websites of all of the 12 Italian university incubators. Moreover, in 2008, we were given access to the RITA database (Colombo et al., 2004), the only existing Italian database focused on high-technology entrepreneurship and which contains information on more than 400 companies, including academic spin-offs in high-technology industries that had been established after 1980. RITA provides longitudinal information on start-ups' general characteristics, market and technological performances, and shareholding compositions.

Overall, in our sample, we had 404 academic spin-offs that had been established between 2000 and 2007 and were the result of technology transfer activities stemming from the 64 STEM Italian universities. Data were codified in the IRIS database[2]. We start our observations in 2000 because, as illustrated above, in 1999, the National Law 297 redefined the rules and practices in support of scientific and technological research, explicitly introducing new authorization procedures for academic spin-offs. Although we do not have the exact figure for the number of Italian academic spin-offs, relying on national assessments carried out by NETVAL (2009) as well as on some extant research (Colombo and DelMastro, 2002; Fini et al., 2009; Piccaluga and Balderi, 2007), we are confident that our sample accounts for the vast majority of the population of such firms.

3.3. Dependent variable

The dependent variable of our study is the number (count) of academic spin-offs from a given university in a given year.

3.4. Independent variables

We identified three sets of independent, time-variant variables as predictors of university spin-off activity. For the first set, which we labeled university-level control variables, we refer to university characteristics and focus on university size as measured by the total number of faculty members (MIUR, www.miur.it) as well as on university entrepreneurial eminence, which we gauge by the number of spin-offs established before 1999 and the cumulative number of spin-offs established after 1999. We also collected data on university patenting activity, focusing on the stock of patent families granted before 1999 and on the cumulative number of patent families granted after 1999. In order to do so, we focused on the information stored in the PATIRIS (Baldini et al., 2006) and ORBIT (www.orbit.it) databases. Finally, we addressed university research eminence by coding the amount of government funds awarded to each university within competitive calls managed by the Italian Ministry for University and Education, the largest funder of basic research in the country (www.miur.it).

Second, we addressed ULSMs by gathering information on university incentive structures for faculty to engage in external commercialization activities. In particular, we collected all external collaboration, spin-off, and patent regulations issued by Italian universities, downloading these from university websites when available. To gather information about previous regulations (or to check for the existence of a regulation if not posted on the website) we contacted a key informant for each institution—namely the head of the research office or, if not available, the head of the legal office (or any other individual in charge of research administration)—by email and telephone. Moreover, the absence of a specific regulation was also cross-checked by contacting each university's Rector's office so as to minimize the possibility that some regulations remained undetected. We also targeted the university resources that supported technology transfer. We accessed the MIUR website and, for each university, we gathered information on the presence of a formal university TTO, coding its year of establishment. We also contacted the Network for the Valorization of University Research (NETVAL, www.netval.it)[3] to access information on which universities participated in the network (i.e., TTO affiliation to NETVAL) as well as the number of academic, administrative, and technical personnel who had participated in NETVAL professional training courses (i.e., TTO human capital endowment).

The third set of independent variables refers to the local-context support mechanisms (LCSMs). First, we gathered information on the regional social capital, which—consistent with previous empirical works conducted within the Italian context (Micucci and Nuzzo, 2005)—has been conceptualized in terms of the expectation that a market transaction is subject to free-riding behaviors. We relied on archival data from the Italian National Institute of Statistics (ISTAT, www.istat.it) to gather fine-grained information on crime rates, bankruptcy rates, forgery rates, and commercial frauds. These items were transformed into standardized scores to get scale-free values and then were combined into a single index (Cronbach alpha of 0.91), which we labeled the "Social capital index." Then, we addressed the regional financial development by coding, for each region, the "Financial development index" developed by Guiso et al. (2004). The index estimates the regional effect on the probability that, ceteris paribus, a household is shut off from the credit market. We also focused on regional-governmental support for high-technology entrepreneurship. We accessed the website of each regional governmental office and gathered information on the existence and the issue year of the regional policies that supported the creation of NTBFs. We labeled this variable "Regulation for NTBF formation". As for the infrastructural support offered to high-tech entrepreneurship, we retained information on the number of business incubators that operated in each region and their year of establishment (in addition to the already identified university ones). We coded such information in a variable that

[1] Aerospace, Biomedical, Biotechnology, Chemistry, Electronics, Environment and Energy, ICT, Material and Acoustics, Mechanics and Automation, Pharmaceutical, Sensors, and Diagnostics.

[2] IRIS stands for Italian Research Innovation System (http://iris.unibo.it).

[3] NETVAL was established to address the difficulties in developing a valorization strategy tailored to the characteristics of each university, the scant resources to be devoted to IP-related activities, the scarcity of trained personnel, the absence of places to socialize previous experiences, and the difficulties in generating revenue from IP. Since its inception, the network has offered 34 courses and trained about 1000 individuals on IP-related matters.

Table 1
Variables included in the study.

Class	Domain	Variable	Type of variable	Time of assessment	Time span	Description	Data source
(a)							
Dependent variable	University spin-off activity	Academic spin-off foundation events	Continuous	*t*	2000–2007	Number of academic spin-offs established in year *t*	Collected by authors
University-level control variables	University size	Number of academics (hundreds)	Continuous	*t*	2002–2007	Number of faculty members in year t	MIUR
	University entrepreneurial eminence	Stock of spin-offs	Continuous	1998	–	Stock of academic spin-offs established before 1999	Collected by authors
		Cumulative number of spin-offs	Continuous	*t* – 1	1999–2006	Cumulative number of academic spin-offs established after 1999 in year t-1	Collected by authors
	University patenting activity	Stock of patent families[a]	Continuous	1998	–	Stock of patent families granted before 1999	PATIRIS and ORBIT
		Cumulative number of patent families[a]	Continuous	*t* – 1	1999–2006	Cumulative number of patent families granted after 1999 in year *t* – 1	PATIRIS and ORBIT
	University research eminence	MIUR research funds (ln)	Continuous	*t*	2002–2007	Governmental funds awarded to STEM universities in year t	MIUR
University-level support mechanisms (ULSMs)	University external engagement regulation	External collaboration regulation	Dummy	*t*	2000–2007	Existence of the regulation ruling external collaborations in year *t*	Collected by authors
		Spin-off regulation	Dummy	*t*	2000–2007	Existence of the regulation ruling spin-off formation in year t	Collected by authors
		Patenting regulation	Dummy	*t*	2000–2007	Existence of the regulation ruling patenting in year t	Collected by authors
	University support for technology transfer activities	TTO	Dummy	t	2000–2007	Existence of the technology transfer office in year *t*	MIUR
		TTO affiliation to NETVAL	Dummy	*t*	2002–2007	University affiliation to the NETVAL network in year t	NETVAL
		TTO human capital endowment	Continuous	*t*	2002–2007	Number of individuals trained by NETVAL in year t	NETVAL
(b)							
Local-context support mechanisms (LCSMs)	Regional social capital	Social capital index	Continuous	*t*	2000–2007	Indicator of regional social capital	ISTAT
	Regional financial development	Financial development index	Continuous	2004	–	Indicator of the probability that a household is shut off from the credit market	Guiso et al. (2004)
	Regional normative support to entrepreneurship	Regional regulation for NTBF formation	Dummy	*t*	2000–2007	Existence of a regional regulation supporting the establishment of NTBF in year t	Collected by authors
	Regional infrastructural support to entrepreneurship	Business incubator	Dummy	*t*	2000–2007	Existence of a business incubator in year t	Collected by authors
	Regional knowledge spillovers	Government R&D expenses (mil €)	Continuous	*t*	2000–2005	Millions of euro of R&D expenses in the government sector in year *t*	Eurostat
	Regional innovative performance	Innovativeness index	Continuous	*t*	2004–2007	Indicator of regional innovative performance	PRO INNO EU

NTBF, new technology-based firm; TTO, technology transfer office; NETVAL, network for the valorization of university research; STEM university, science, technology, engineering and mathematics university; MIUR, Italian ministry of instruction, university and research.
(a) University-level variables included in the study. (b) Context-level variables included in the study.
[a] Where more than one university is among the assignees, we assigned the patent to each of them.

Table 2
Spin-off foundation events.

Year	Number of events by university				Proportion of zero count (%)	Total number of events
	Mean	Median	Min	Max		
2000	0.39	0	0	5	75.00	25
2001	0.38	0	0	6	81.25	24
2002	0.39	0	0	8	81.25	25
2003	0.97	0	0	7	68.75	62
2004	1.31	0	0	10	54.69	84
2005	1.25	0	0	10	53.13	80
2006	0.73	0	0	4	59.38	47
2007	0.89	0	0	6	57.81	57
Total						404

we labeled "Business incubator." As for the regional knowledge spillovers, instead, we retrieved the regional public expenditures for R&D as the net of higher education sector expenditures, which was coded into the variable "Government R&D expenses," from Eurostat (http://epp.eurostat.ec.europa.eu). Finally, to assess an indicator of the regional innovation performance, we relied on the regional "Innovativeness Index" calculated by PROINNO Europe (www.proinno-europe.eu), which is based on the Community Innovation Survey and Eurostat archival data.

Table 1a and b summarize the domains and variables that were used in our study and provide information on their characterization and source. We also report whether the variable is either time-variant or cross-sectional.

3.5. Estimation and model specification

We use a Poisson multi-level model to analyze the number of companies that spun-off at each university in a given year. Several factors have led to this choice. First, no conceptual or empirical argument seems to be inconsistent with the Poisson distributional assumption that events occur at a constant incidence rate per time interval. Furthermore, we select a Poisson model rather than event history techniques (Shane, 2002) because the calendar year is an adequate period of time to explore patterns of spin-off foundations, without imposing particular restrictions. Finally, multi-level techniques allow us to control for overdispersion, which may affect count data (please also refer to Section 4).

Moreover, because we sought to model the joint effects of university and regional support mechanisms on spin-off creation, we had to deal with the non-independence of observations: namely the within-university autocorrelation due to repeated observations across years as well as the between-university autocorrelation due to the presence of more than one university located in several regions. Such non-independence of observations, however, might be seen more as an opportunity than a threat. The presence of repeated measures across time, indeed, offers a unique chance to model university-level unobserved heterogeneity. Similarly, the presence of multiple universities in several regions allows us to model the effectiveness of alternative university-level policies for given environmental conditions.

For the aforementioned reasons, we decided to adopt a multi-level Poisson specification, including fixed effects and random effects at both university and regional levels (Rabe-Hesketh and Skrondal, 2008). Random predictors have been specified as both random intercepts (i.e., university-specific abilities that support the creation of academic spin-offs, and regional-effects that foster the creation of academic spin-offs), and random coefficients (i.e., conditional slopes, which vary across universities, to capture the

Table 3
Descriptive statistics for variables included in the regression models.

Variable	Obs	Mean	Std. dev.	Min	Max
University-level control variables					
Number of academics (hundreds)	512	8.62	9.67	0.14	54.32
Stock of spin-offs	512	0.81	1.48	0.00	7.00
Cumulative number of spin-offs	512	4.02	7.42	0.00	51.00
Stock of patent families	512	2.14	3.87	0.00	16.00
Cumulative number of patent families	512	9.59	16.27	0.00	105.00
MIUR research funds (ln)	512	8.16	2.95	0.00	16.29
ULSMs					
External collaboration regulation	512	0.43	0.50	0.00	1.00
Spin-off regulation	512	0.28	0.45	0.00	1.00
Patenting regulation	512	0.43	0.50	0.00	1.00
TTO	512	0.36	0.48	0.00	1.00
TTO affiliation to NETVAL	512	0.45	0.50	0.00	1.00
TTO human capital endowment	512	0.93	2.75	0.00	26.00
LCSMs					
Social capital index	512	−0.02	0.84	−1.88	1.13
Financial development index	512	0.32	0.18	0.00	0.59
Regulation for NTBF formation	512	0.22	0.42	0.00	1.00
Business incubator	512	0.42	0.49	0.00	1.00
Government R&D expenses (mil €)	512	123.21	99.62	1.00	380.00
Innovativeness index	512	0.43	0.16	0.17	0.73

TTO, technology transfer office; ULSMs, University-level support mechanisms; LCSMs, Local-context support mechanisms.

Table 4
Poisson random-intercept model with mixed effects.

Dependent variable: Number of spin-off foundation events						
	Random effect for university		Random effect for region		Nested model	
	(1a)	(2a)	(1b)	(2b)	(1c)	(2c)
Fixed part						
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
University-level control variables						
Number of academics (hundreds)		1.016		1.004		1.016
		0.013		*0.008*		*0.013*
Stock of spin-offs		1.163*		1.060		1.163*
		0.099		*0.041*		*0.099*
Cumulative number of spin-offs		1.037***		1.059****		1.037***
		0.014		*0.009*		*0.014*
Stock of patent families		1.101**		1.021		1.101**
		0.041		*0.023*		*0.041*
Cumulative number of patent families		0.982***		0.993		0.982***
		0.006		*0.005*		*0.006*
MIUR research funds (ln)		1.005		1.012		1.005
		0.027		*0.024*		*0.027*
ULSMs						
External collaboration regulation		1.251		1.089		1.251
		0.228		*0.147*		*0.228*
Spin-off regulation		2.491****		2.542****		2.491****
		0.468		*0.378*		*0.468*
Patenting regulation		1.171		1.683****		1.171
		0.239		*0.248*		*0.239*
TTO		1.523		1.795****		1.523
		0.289		*0.290*		*0.289*
TTO affiliation to NETVAL		1.717***		1.652***		1.717***
		0.355		*0.289*		*0.355*
TTO human capital endowment		0.990		0.962		0.990
		0.018		*0.017*		*0.018*
Random part						
Random intercept for university	1.657	0.666			1.461	0.666
	0.226	0.147			0.233	0.147
95% confidence interval	[1.26;2.16]	[0.43;1.02]			[1.07;2.00]	[0.43;1.02]
Random intercept for region			1.019	0.279	0.735	0.000
			0.215	0.139	0.326	0.610
95% confidence interval			[0.67;1.53]	[0.10;0.74]	[0.30; 1.75]	[0.00;0.00]
Number of observations	512	512	512	512	512	512
Parameters	9	21	9	21	10	22
Fixed effects	8	20	8	20	8	20
Random effects	1	1	1	1	2	2
Ll	−485.277	−453.605	−600.411	−467.600	−484.233	−453.605
Chi2	75.840	184.890	75.837	346.200	75.838	184.890
H0: region variance component = 0					Rejected $p < 0.0001$	Not rejected $p > 0.1$

Standard errors in italics. Number of universities: 64. Number of regions: 19. ULSMs, University-level support mechanisms.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.
**** $p<0.001$.

heterogeneity in the marginal contribution of a specific support mechanism)[4].

We start by assuming that all variance is explained by random-effects only, and model the spin-off-creation phenomenon as a result of university-level random effects (Model 1a), of regional-level random effects (Model 1b), and of both university- and regional-level random effects (Model 1c). These estimates show the extent to which unobserved university and regional effects influence the ability of a university to spin-off companies as well as to explore the extant relationship between the distinct domains of support.

We add to Models 1a, 1b, and 1c both controls and explanatory covariates at the university level in order to unveil the impact of observable university-level characteristics on the spin-off creation. In Model 2a, we include both university fixed effects and university-level random effects. Model 2b, instead, specifies the university fixed effects as well as the regional-level random effect whereas Model 2c contains all of the university predictor variables plus university- and regional-level random effects. Models 2a and 2b are meant to assess whether the random effects become insignificant once the full list of university fixed covariates is in place. Model 2c, by contrast, is meant to be compared with Model 2a in order to disentangle the impact of regional context on the academic spin-off creation rate. More specifically, we test the null hypotheses that the variance component explained by regional effects is equal to zero (for both Models 2c vs. 2a and Models 1c vs. 1a).

In the third step, we specify a new set of models to disentangle the impact that specific facets of the local context have on spin-off

[4] We do not lag the independent variables because we expect that current-year independent variables, rather than past-year independent ones, influence start-up decisions. This is coherent with previous studies (e.g., Di Gregorio and Shane, 2003).

Table 5
Poisson random coefficient model with LCSM mixed effects.

Dependent variable: Number of spin-off foundation events						
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)
Fixed part						
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
University-level control variables						
Number of academics (hundreds)	1.003	1.044**	1.030	1.030	1.042*	1.034*
	0.001	*0.021*	*0.019*	*0.019*	*0.023*	*0.021*
Stock of spin-offs	1.251*	1.327**	1.330**	1.260*	1.366**	1.381**
	0.170	*0.183*	*0.164*	*0.150*	*0.184*	*0.184*
Cumulative number of spin-offs	1.021	1.010	1.023	1.050***	1.007	1.012
	0.016	*0.014*	*0.016*	*0.019*	*0.015*	*0.015*
Stock of patent families	1.166***	1.109*	1.151***	1.143**	1.191***	1.141**
	0.065	*0.062*	*0.062*	*0.060*	*0.071*	*0.066*
Cumulative number of patent families	0.983**	0.984**	0.984**	0.978***	0.985**	0.983**
	0.007	*0.007*	*0.007*	*0.008*	*0.007*	*0.007*
MIUR research funds (ln)	0.998	0.998	0.990	1.005	0.994	0.996
	0.027	*0.027*	*0.028*	*0.029*	*0.027*	*0.027*
LCSMs						
Social capital index	1.582*					
	0.388					
Financial development index		11.921**				
		14.365				
Regulation for NTBF formation			1.770**			
			0.502			
Business incubator				1.135		
				0.280		
Government R&D expenses (mil €)					0.995**	
					0.002	
Innovativeness index						1.509
						1.846
Random part						
University random intercept	1.084	0.928	1.152	1.086	1.002	1.063
	0.217	0.412	0.209	0.191	0.334	0.554
95% confidence interval	[0.73;1.60]	[0.01;20.54]	[0.80;1.64]	[0.76;1.53]	[0.52;1.92]	[0.38;2.95]
University random slope	0.715	0.616	0.722	0.733	0.002	0.384
	0.350	1.102	0.228	0.219	0.003	1.128
95% confidence interval	[0.27;1.86]	[0.01;20.54]	[0.38;1.34]	[0.40;1.31]	[0.001;0.027]	[0.001;21.75]
Number of observations	512	512	512	512	512	512
Parameters	18	18	18	18	18	18
Fixed effects	15	15	15	15	15	15
Random effects	3	3	3	3	3	3
Ll	−468.595	−467.553	−465.435	−465.225	−468.133	−471.043
Chi2	108.764	109.926	107.786	116.743	104.940	105.834

Standard errors in italics. Number of universities: 64. Number of regions: 19. ULSMs, University-level support mechanisms.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.
**** $p<0.001$.

creation, always including university-level fixed effects and adding, one at a time, additional regional-level variables that correspond to various facets of the local context support. The influence of each facet is evaluated as a fixed effect (i.e., the effect that is shared by all universities in the sample) and a random effect (i.e., the portion of the influence that is unique to each university), capturing the differences in the marginal contribution of local support mechanisms. This occurs as a result of specific interactions of local context attributes and university attributes. Regional context is defined by the regional "Social capital index" in Model 3a, the regional "Financial development index" in Model 3b, the presence of a regional "Regulation for NTBFs formation" in Model 3c, the presence of a regional "Business Incubator" in Model 3d, the regional "Governmental R&D Expenses" in Model 3e, and the regional "Innovativeness Index" in Model 3f. The random intercept at the regional level is excluded, thus assuming that university-specific abilities do not reflect homogenous region effects, in accordance with the model comparison test that was performed in the second step.

In the fourth step, we re-introduce university-level fixed effects as well as university-level random ones. Accordingly, both fixed effects and random effects are associated with each facet of university support. However, in this case, the random coefficient represents the marginal productivity of the specific support mechanism in any given university.

Finally, following a consolidated approach in multi-level modeling (Rabe-Hesketh and Skrondal, 2008), we use random-effects-related information to illustrate the ability of any given university to spin-off companies—conditional on local- and university-support characteristics—by plotting each university-level support characteristic against all regional-level support mechanisms. The coordinates for each university are the unique marginal contributions of the local and university support mechanisms to the spin-off rate. In the next section, we present our results.

4. Results

Table 2 reports descriptive information on the spin-off activity between 2000 and 2007. This variable is skewed because the proportion of universities with a zero-count of spin-offs is, in all

Table 6
Poisson random coefficient model with ULSM mixed effects.

Dependent variable: Number of spin-off foundation events						
	(4a)	(4b)	(4c)	(4d)	(4e)	(4f)
Fixed part						
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
University-level control variables						
Number of academics (hundreds)	1.035*	1.016	1.021	1.034*	1.032*	1.031**
	0.018	*0.015*	*0.018*	*0.019*	*0.019*	*0.015*
Stock of spin-offs	1.278*	1.248**	1.205	1.215	1.160	1.112**
	0.161	*0.133*	*0.141*	*0.166*	*0.157*	*0.059*
Cumulative number of spin-offs	1.015	1.039***	1.028*	1.036**	1.018	1.051****
	0.013	*0.015*	*0.017*	*0.019*	*0.014*	*0.012*
Stock of patent families	1.121**	1.090**	1.149***	1.105*	1.146***	0.994
	0.055	*0.046*	*0.057*	*0.061*	*0.057*	*0.034*
Cumulative number of patent families	0.986**	0.989	0.982**	0.984**	0.982***	0.989*
	0.007	*0.007*	*0.007*	*0.008*	*0.007*	*0.006*
MIUR research funds (ln)	0.994	1.020	1.001	1.003	0.993	1.049
	0.027	*0.031*	*0.028*	*0.032*	*0.027*	*0.034*
ULSMs						
External collaboration regulation	2.149**					
	0.684					
Spin-off regulation		3.728****				
		1.154				
Patenting regulation			1.976*			
			0.734			
TTO				2.114**		
				0.773		
TTO affiliation to NETVAL					2.101***	
					0.601	
TTO human capital endowment						1.107***
						0.038
Random part						
University random intercept	1.461	0.931	1.395	1.122	1.273	1.299
	0.244	0.218	0.259	0.221	0.266	0.203
95% confidence interval	[1.05;2.02]	[0.58;1.47]	[0.97;2.00]	[0.76;1.65]	[0.84;1.91]	[0.95;1.76]
University random slope	0.523	0.981	0.907	0.565	0.313	0.154
	0.230	0.260	0.378	0.272	0.283	0.031
95% confidence interval	[0.22;1.23]	[0.58;1.65]	[0.40;2.05]	[0.22;1.45]	[0.05;1.85]	[0.10;0.23]
Number of observations	512	512	512	512	512	512
Parameters	18	18	18	18	18	18
Fixed effects	15	15	15	15	15	15
Random effects	3	3	3	3	3	3
Ll	−467.553	−465.435	−465.225	−468.595	−468.133	−471.043
Chi2	109.928	107.786	116.743	108.764	104.943	105.835

Standard errors in italics. Number of universities: 64. Number of regions: 19. ULSMs, University-level support mechanisms.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.
**** $p<0.001$.

cases, higher than 50% in each year. Table 3, instead, presents the summary statistics for all the variables included in the regression models.

Table 4 exhibits the first set of regressions reporting two multi-level Poisson specifications for each model[5]: a null one, with no variables predicting the spin-off activity rather than the random intercepts (Models 1a, 1b and 1c), and a fully specified model, encompassing the whole set of predictors plus the random intercepts (Models 2a, 2b, and 2c). Results show a decrease in the significance of random-effect coefficients once university predictors have been fully specified. Moreover, when Models 1a and 1c are compared, we can reject the hypothesis that no variance is explained by regional effects; by contrast, after specifying the full set of control and ULSMs variables, the null hypothesis of no variance explained by regional effects cannot be rejected (Models 2a vs. 2c; $\chi(1) = 0$; $p > .1$). This result is particularly informative. Once ULSMs are introduced in the model, no regional effect (i.e., a structural predisposition toward entrepreneurship at regional level) is assessed, calling for a more fine-grained analysis at the regional level: that is, to "unpack" the effects of local-context support by focusing on specific facets of support separately (see Table 5).

Controlling for a set of university-level fixed characteristics, we show how much each university leverages each specific regional dimension when creating academic spin-offs. For each of the six reported specifications, we present incident ratios and standard errors[6]. Models 3a, 3b, and 3c show a positive effect of the social

[5] To check if our dependent variable suffered from "overdispersion," we specified Model 2a as both longitudinal Poisson and longitudinal Negative Binomial. Both models are single-level models in which we included fixed effects so as to capture unobserved heterogeneity at the university level. Then we compared the two models with the test of Cameron and Trivedi (1998) to test the null hypothesis of the equality of the mean and the variance (required condition for implementing a multi-level Poisson specification). After comparing the two specifications, we cannot reject the hypothesis. We can, therefore, use a Poisson specification rather than a Negative Bionomial one because the data do not suffer from overdispersion.

[6] Incidence ratios (IR) are the exponentiated form of regression slopes that are achieved in the estimation process. Their interpretation is in terms of the expected variation in the probability of generating an additional spin-off (an IR equal to 1.00 means that the expected change in the probability due to a unitary change in the covariate is zero).

capital and the financial development regional indices as well as of the regional innovation policy on the start-up rate. Conversely, we assess a negative impact of governmental R&D on our dependent variable. This means that universities negatively leverage the governmental R&D regional expense for spinning-off new technology-based firms. Both regional incubator and regional innovative performances are positively (but not significantly) related to the academic spin-off rate. Among the controls, both patent and entrepreneurial-eminence variables are significant throughout all of the specifications. Conversely, university size as well as research eminence have limited impact on the academic spin-off creation rate.

Estimates of the random parameters (see the lower section of Table 5) show that unobserved heterogeneity at the university level accounts for a significant proportion of the variance across all specifications, and that the conditional slope varies significantly across

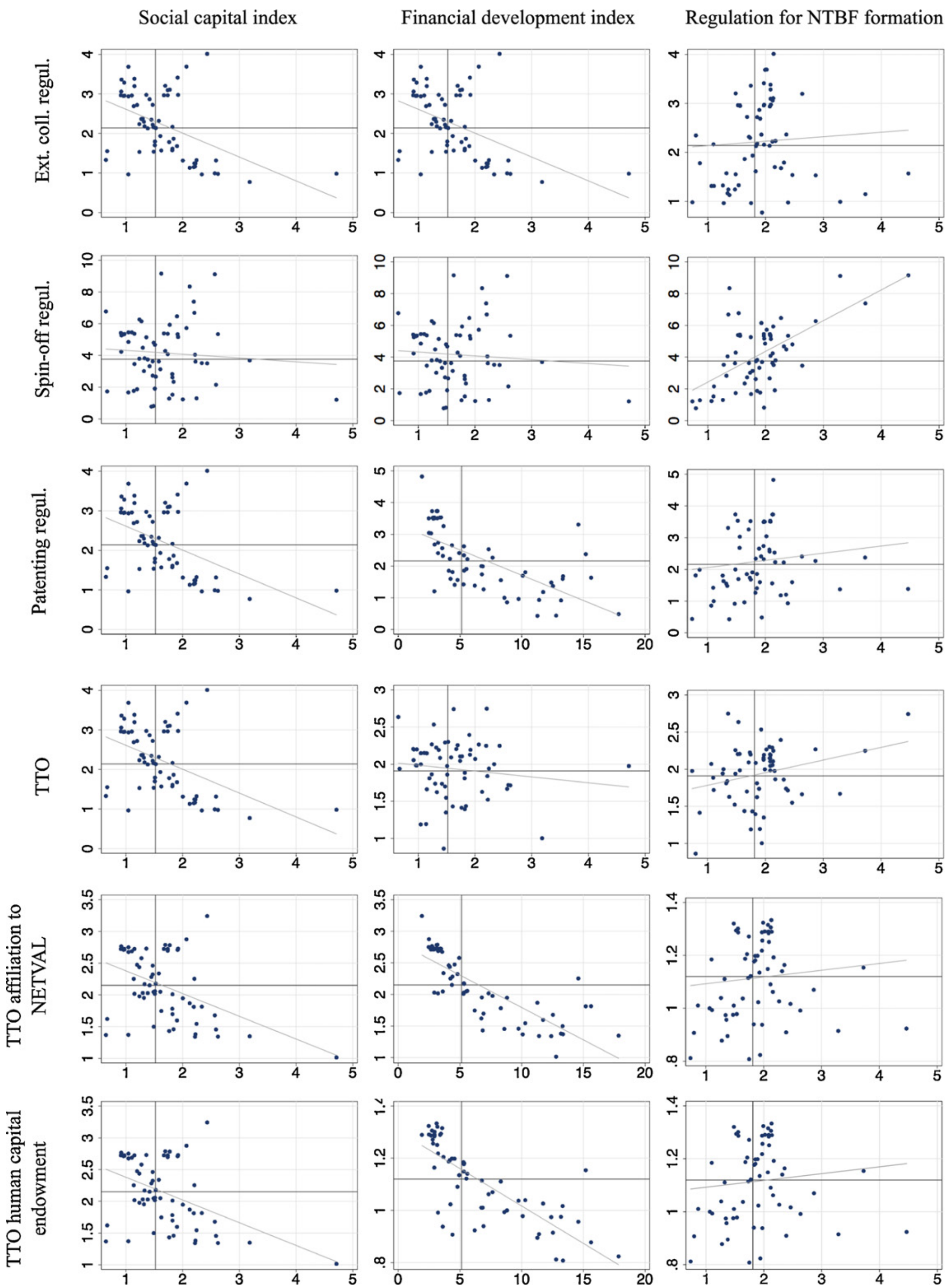

Fig. 1. Relationship of the productivity among different support mechanisms. Note: LCSMs' marginal productivity is reported along the *x*-axis; ULSMs' marginal productivity is reported along the *y*-axis. Marginal productivities are conditional to each university and are expressed as incidence ratios. Reference lines are set to average effects.

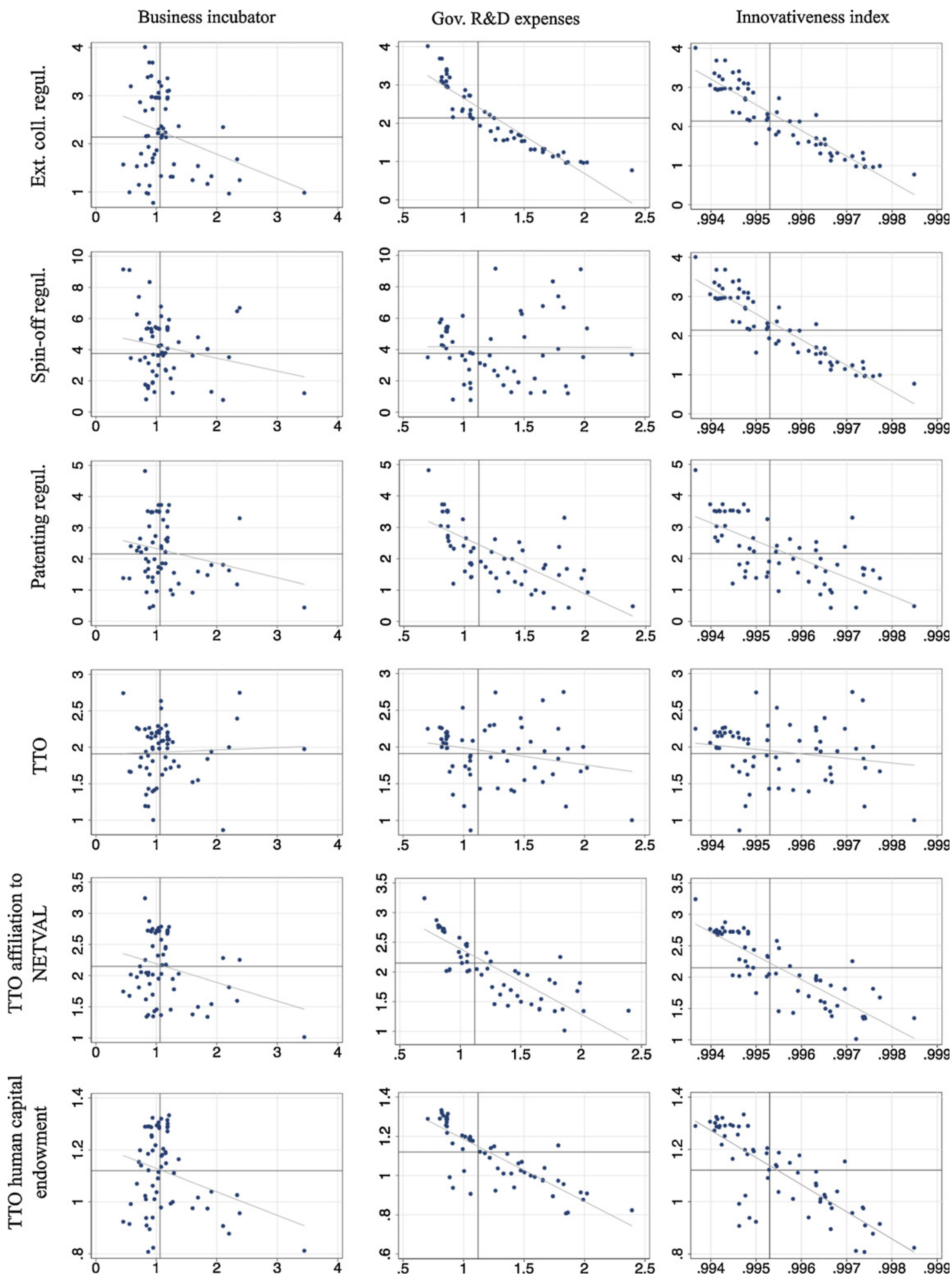

Fig. 1. (*Continued*)

universities. This highlights the presence of a differentiated impact of all of the context support facets. The latter result calls for a deeper investigation of the combinations of regional and university attributes.

In Table 6, we take into account university-level fixed and random effects. We specify six models, introducing the different facets of university support mechanisms one at a time. In all specifications, any given mechanism is significant, with the spin-off regulation having the highest impact (Model 4b). The presence of external collaborations and patent regulations (Models 4a and 4c) as well as the existence of a TTO (Model 4d) have a positive and significant impact on the spin-off creation rate. Finally, both dimensions related to the participation in NETVAL (affiliation and human capital endowment) strongly predict spin-off activity (Models 4e and 4f). Our results show that, once in place, with the exception of patent regulations, the support mechanisms account for the greatest magnitude as well as for the highest significance if compared with the other covariates.

As for the random effects, our results show that universities have idiosyncratic abilities in spin-off generation (as shown by random intercepts reported in the lower section of Table 6), and that universities have heterogeneous productivity when they put in place support mechanisms (as shown by random slopes reported in the lower section of Table 6), especially when spin-off and patent regulations are introduced[7]. These results are coherent with those of previous studies, such as Kenney and Goe's (2004) work—which compared UC Berkley and Stanford–and Bercovitz and Feldman's (2008) work—which highlighted the heterogeneity in entrepreneurial activity at the department level.

Finally, in Fig. 1, we report the extant relationships between university-level and regional-level support mechanisms. In each scatter diagram, our 64 universities are each associated with a point in the plan for which the coordinates are the marginal contributions of regional- (x-axis) and university-level support mechanisms (y-axis) on universities' spin-off productivity. Our results show that the marginal productivity of the university-level support mechanisms is positively related to the availability of a regional regulation supporting NTBF formation. University support mechanisms are, in this case, complementing regional ones. Conversely, the marginal productivity of university support mechanisms is negatively correlated with the regional social capital index, the regional financial development index, the presence of a business incubator, the regional governmental R&D expenses, and the regional innovativeness index. In this specific case, instead, university mechanisms substitute for regional-level support mechanisms.

5. Conclusions

Although we acknowledge the importance of individual-level characteristics (Fini et al., 2011) as determinants of new-venture-creation processes, in this contribution, we focus on the role that academic institutions and the environments in which they are settled play in spinning off new research-based ventures. More specifically, we look at university-level dimensions (i.e., ULSMs)—such as those examined in previous research by Di Gregorio and Shane (2003), O'Shea et al. (2005), and Bercovitz and Feldman (2008)—and contextual-level dimensions (i.e., LCSMs)—as proposed by Feldman (2001) and Shane (2004).

Our results indicate that ULSMs (spin-offs, external collaborations, patent regulations, the existence of a TTO, and participation in NETVAL) have a significant impact on universities' spin-off productivity. Therefore, in order to foster the generation of spin-off companies, universities have to invest in both ad-hoc mechanisms and policies, including TTOs and spin-off regulations, and other related activities that might complement them, such as external collaboration regulations and patent regulations.

As for LCSM, our results show that, although there is a positive and significant effect of the regional social capital index, the regional financial development index, and the regional regulation for NTBF formation, universities are negatively affected by regional governmental R&D expenses. In those settings where government R&D expenses do not have a positive impact on universities' ability to spin-off new ventures, universities should invest in creating internal support mechanisms, given the positive marginal effect that they have on their spin-off productivity.

[7] Given our aim of estimating the between-universities variance of the marginal productivity of each individual mechanism, we introduced the regressors one at a time. In each regression model, we account for the effect of the $n-1$ mechanisms in the random slope. We checked for multicollinearity among the regressors, and no major issues seemed to emerge. Time variant, multi-level correlation tables are available from the authors.

When we consider the joint effects of ULSMs and LCSMs, we show that the marginal effect offered by ULSMs to spin-off productivity may be positive or negative (complement vs. substitute) depending on the contribution offered by different LCSMs. More specifically, the marginal effect of ULSMs on the spin-off productivity of each university (and this finding holds for all of the different ULSMs taken into account in our analysis) increases in contexts where regional normative support to high-tech entrepreneurship (which has been operationalized as the presence of a regional regulation for NTBF formation) have a positive marginal effect on universities' spin-off productivity (complementary effect). In these contexts, universities would be better off pursuing incremental investments in the creation of internal ad-hoc support mechanisms (specific to spin-off creation) and putting additional efforts into fine-tuning existing ones.

Conversely, the marginal effect of ULSMs on spin-off productivity (and this finding holds for all of the different ULSMs taken into account in our analysis) decreases in contexts where the social capital index, the regional financial development index, the presence of a regional incubator, the government R&D expenses in the region, and the regional innovativeness index all have a positive marginal contribution to spin-off productivity (substitution effect). In these contexts, universities would be better off not pursuing incremental investments in ULSMs.

Two important conclusions emerge from these results. First, when addressing the issue of how to incentivize the creation of academic spin-offs, it is important to consider the joint impact of different forms of support (i.e., the support offered by universities and by the regions in which companies are settled). Second, because different forms of support can be offered by both the universities and the regions, it is advisable to disentangle the effects coming from different forms of support mechanisms without relying on aggregate indicators of support, which do not provide fine-grained information on the efficacy of each support mechanism.

Universities should be particularly active in creating internal support mechanisms for spin-offs in contexts in which there are structural conditions (regional regulation for NTBFs) that are likely to favor innovation more generally. The same universities should limit their investments in the creation of internal support mechanisms in contexts in which there is a significant contribution offered by ad-hoc regional support mechanisms (designed specifically to support high-tech entrepreneurship, including incubators, financial incentives to start-ups, etc.) because their additional contribution might not foster additional spin-off creation.

The Bayh-Dole Act and other governmental regulations implemented in other countries with the objective of favoring the commercialization of research results represent legislative changes aimed at creating institutional conditions to enhance the technological and economic growth of countries. They create the boundaries of a legal framework in which several other actors (including universities and regional/local context institutions) are active in different ways and at different levels of analysis. The extent to which universities are concretely successful in the commercialization of public research, under the general legal framework created by governmental regulations, depends not only on their internal policies and levels of commitment but also on the local specificities of the context in which they are settled and that inevitably influence the way that they behave and operate.

This calls for more attention to the interaction between different determinants that operate at different levels of analysis: namely, the system level (e.g., governmental laws and country specificities) and the organizational level (e.g., universities' internal organization) (Grimaldi et al., introduction to this special issue). Moreover, especially in the context of the formation of the EU 8th Framework program as part of which the emphasis on regional areas and systems is clearly relevant, the overall governance and coordination of innovation policies emerge as key points for attention with clear short- and long-term implications.

Our results should also be considered in light of some possible limitations. First, we have focused our attention on spin-off creation and not on spin-off performance. Future research should consider their effective contributions to economic growth and the extent to which such effects could be related to university-level policies. We see this as an opportunity to assess the impact of legislative and institutional changes aimed at creating the conditions to favor the successful commercialization of research results.

In addition, although we have tried to control for possible confounding effects at the contextual level and for potential endogeneity effects, we could not precisely disentangle the magnitude of the effects considered (random effects models, indeed, impose restrictions in the number of predictors to be accounted for). Although it is always difficult to express the expected effects of policy instruments in discrete terms, it would clearly be extremely important for any decision maker to show the expected outcome of any resource allocation to sustain entrepreneurship, especially in the current times of shrinking public budgets.

Moreover, we decided to focus on one single country to hold the university regulatory context constant. Although the Italian system has many similarities with other civil-code countries such as Spain, France, and Germany, it still holds many relevant differences, even after the implementation of the most recent law affecting universities in December 2010. One relevant aspect that we were not able to consider in our study is the quality level of faculty and university-level recruiting policies. Although mostly still out of the control of the single university in Italy, these policies could indirectly offer as much support to the creation of spin-offs as dedicated policies such as the ones examined in this paper. Many studies, in fact, show a high correlation between science-oriented and industry-oriented activities, suggesting that 'star' scientists are simply good at many things, and any attempt to improve the quality level of faculty will most likely be reflected in higher performance on both grounds (Di Gregorio and Shane, 2003). More research is needed in this direction to rule out the opposite view of rivalry between scientific and entrepreneurial activities with a level of detail that is not present in our data set at present.

Finally, one might wonder why universities should improve their performance in supporting the creation of new firms at all. This brings up the theme of the alignment between decisions and incentives, a particularly relevant subject for all of those systems as part of which public resources are transferred to universities depending upon certain goals or targets. Although such elements were not incorporated in the government-funding mechanisms of Italian universities during our analysis–and are minimal even in more recent years with a compounded effect accounting for not more than 1–3% on average—in other countries such as, for example, the UK, they have determined a consistent shift of resources.

Notwithstanding all of these possible extensions, we believe that this study, by empirically testing some conceptual arguments already available in the extant literature (Degroof and Roberts, 2004; Roberts and Malone, 1996), contributes to the debate on how and to what extent university-level mechanisms interact with contextual-level ones, thus laying the groundwork for future research in this field.

Acknowledgments

The authors thank Massimo Monesi (University of Bologna) and Chiara Del Balio (NETVAL) for research support.

References

Atkinson, S.H., 1994. University affiliated venture capital funds. Health Affairs 13, 158–175.
Baldini, N., 2011a. Implementing Bayh-Dole-like laws: Faculty problems and their impact on university patenting activity. Research Policy (forthcoming).
Baldini, N., 2011b. University spin-offs and their environment. Technology Analysis and Strategic Management (forthcoming).
Baldini, N., Grimaldi, R., Sobrero, M., 2006. Institutional changes and the commercialization of academic knowledge: A study of Italian universities' patenting activities between 1965 and 2002. Research Policy 35, 518–532.
Beck, T., Demirg-Kunt, A., Maksimovic, V., 2005. Financial and legal constraints to growth: does firm size matter? The Journal of Finance 60, 137–177.
Bercovitz, J., Feldman, M., 2008. Academic entrepreneurs: organizational change at the individual level. Organization Science 19, 69–89.
Breschi, S., Lissoni, F., Montobbio, F., 2008. University patenting and scientific productivity: a quantitative study of Italian academic inventors. European Management Review 5, 91–109.
Brunitz, S.M., O'Shea, R.P., Allen, T.J., 2008. University commercialization strategies in the development of regional bioclusters. Journal of Product Innovation Management 25, 129–142.
Cameron, A., Trivedi, P., 1998. Regression Analysis of Count Data. Cambridge University Press, New York.
Colombo, M., D'Adda, D., Piva, E., 2010. The contribution of university research to the growth of academic start-ups: an empirical analysis. Journal of Technology Transfer 35, 1–25.
Colombo, M., DelMastro, M., 2002. How effective are technology incubators? Evidence from Italy. Research Policy 31, 1103–1122.
Colombo, M., DelMastro, M., Grilli, L., 2004. Entrepreneurs' human capital and the start-up size of new technology-based firms. International Journal of Industrial Organization 22, 1183–1211.
Deeds, D., DeCarolis, D., Coombs, J., 1998. Firm-specific resources and wealth creation in high-technology ventures: evidence from newly public biotechnology firms. Entrepreneurship: Theory and Practice 22, 55–56.
Degroof, J., Roberts, E., 2004. Overcoming weak entrepreneurial infrastructures for academic spin-off ventures. The Journal of Technology Transfer 29, 327–352.
Di Gregorio, D., Shane, S., 2003. Why do some universities generate more start-ups than others? Research Policy 32, 209–227.
Etzkowitz, H., 2000. Tech transfer, incubators probed at Triple Helix III. Research-Technology Management 43, 4–5.
European Community 2020 Strategy, 2010. EU website. http://ec.europa.eu/europe2020 (accessed 20.04.10).
Eurostat Statistics Database. http://epp.eurostat.ec.europa.eu (accessed 14.04.09).
Feldman, M., 2001. The entrepreneurial event revisited: firm formation in a regional context. Industrial and Corporate Change 10, 861–881.
Fini, R., Grimaldi, R., Marzocchi, G.L., Sobrero, M., 2011. The determinants of corporate entrepreneurial intentions within small and newly established firms. Entrepreneurship Theory and Practice (forthcoming).
Fini, R., Grimaldi, R., Sobrero, M., 2009. Factors fostering academics to start up new ventures: An assessment of Italian founders' incentives. Journal of Technology Transfer 34, 380–402.
Fini, R., Lacetera, N., Shane, S., 2010. Inside or outside the IP system? Business creation in academia. Research Policy 39, 1060–1069.
Florida, R., 1999. The role of the university: leveraging talent, not technology. Issues in Science and Technology 15, 67–73.
Friedman, J., Silberman, J., 2003. University technology transfer: do incentives, management, and location matter? The Journal of Technology Transfer 28, 17–30.
Gibbons, M., 1994. The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies. Sage Publications Ltd, London.
Guiso, L., Sapienza, P., Zingales, L., 2004. Does local financial development matter? Quarterly Journal of Economics 119, 929–969.
Hall, B., 2002. The financing of research and development. Oxford Review of Economic Policy 18, 35–50.
Hall, B.H., Rosenberg, N., 2010. Handbook of the Economics of Innovation. Amsterdam, North Holland.
Huang, C., Amorim, C., Spinoglio, M., Gouveia, B., Medina, A., 2004. Organization, programme and structure: an analysis of the Chinese innovation policy framework. R&D Management 34, 367–387.
ISTAT. Italian National Institute of Statistics. www.istat.it (accessed 15.04.09).
Jain, S., George, G., 2007. Technology transfer offices as institutional entrepreneurs: the case of Wisconsin Alumni Research Foundation and human embryonic stem cells. Industrial and Corporate Change 16, 535–567.
Kenney, M., Goe, W.R., 2004. The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford. Research Policy 33, 691–707.
Kenney, M., Patton, D., 2009. Reconsidering the Bayh-Dole Act and the current university invention ownership model. Research Policy 38, 1407–1422.
Khan, M.U., 2001. Indicators of techno-management capability building in Indian computer firms. Journal of Scientific Industrial Research 60, 717–723.
Klepper, S., 2007. Disagreements, spinoffs, and the evolution of Detroit as the capital of the US automobile industry. Management Science 53, 616–631.
Lee, C., Lee, K., Pennings, J.M., 2001. Internal capabilities, external networks, and performance: a study on technology-based ventures. Strategic Management Journal 22, 615–640.

Lerner, J., 2004. The university and the start-up: lessons from the past two decades. The Journal of Technology Transfer 30, 49–56.

Lerner, J., 2010. Boulevard of Broken Dreams: Why Public Efforts to Boost Entrepreneurship and Venture Capital Have Failed – and What to Do About It. Princeton University Press, Princeton, New Jersey.

Link, A.N., Siegel, D.S., 2005. University-based technology initiatives: quantitative and qualitative evidence. Research Policy 34, 253–257.

Lissoni, F., Llerena, P., McKelvey, M., Sanditov, B., 2008. Academic patenting in Europe: new evidence from the KEINS database. Research Evaluation 17, 87–102.

Lockett, A., Siegel, D., Wright, M., Ensley, M.D., 2005. The creation of spin-off firms at public research institutions: managerial and policy implications. Research Policy 34, 981–993.

Love, I., 2003. Financial development and financing constraints: international evidence from the structural investment model. Review of Financial Studies 16, 765–780.

MacMillan, I.C., Siegal, R., Subbarashima, P.N., 1986. Criteria used by venture capitalists to evaluate new venture performance. Journal of Business Venturing 1, 119–128.

Meyer, M., 2003. Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanism. R&D Management 33, 107–115.

Mian, S.A., 1996. Assessing value-added contributions of university technology business incubators to tenant firms. Research Policy 25, 325–335.

Micucci, G., Nuzzo, G., 2005. Measuring Social Capital: Evidence from Italy, Working Paper Banca D'Italia. www.bancaditalia.it (accessed 20.04.09).

MIUR. Italian Ministry of Instruction, University and Research. www.miur.it (accessed 17.04.09).

Moray, N., Clarysse, B., 2005. Institutional change and resource endowments to science-based entrepreneurial firms. Research Policy 34, 1010–1027.

Mowery, D., Nelson, R., Sampat, B., Ziedonis, A., 2004. Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act in the United States. Stanford University Press, Stanford, CA.

Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B., Moray, N., 2006. Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy. Research Policy 35, 289–308.

Mustar, P., Wright, M., 2010. Convergence or path dependency in policies to foster the creation of university spin-off firms? A comparison of France and the United Kingdom. The Journal of Technology Transfer 35, 42–65.

Mustar, P., Wright, M., Clarysse, B., 2008. University spin-off firms: Lessons from ten years of experience in Europe. Science and Public Policy 35, 67–80.

National Science Foundation. www.nsf.gov (accessed 14.04.10).

Nerkar, A., Shane, S., 2003. When do start-ups that exploit patented academic knowledge survive? International Journal of Industrial Organization 21, 1391–1410.

NETVAL, 2009. Settimo Rapporto NetVal Sulla Valorizzazione della Ricerca nelle università italiane. Technical Report, Milan, Italy.

Niosi, J., Bas, T.G., 2001. The competencies of regions: Canada's clusters in biotechnology. Small Business Economics 17, 31–42.

Nosella, A., Grimaldi, R., 2009. University level mechanisms supporting the creation of new companies: an analysis of Italian academic spin-offs. Technology Analysis and Strategic Management 21, 679–698.

O'Shea, R.P., Allen, T.J., Chevalier, A., Roche, F., 2005. Entrepreneurial orientation, technology transfer and spinoff performance of U.S. universities. Research Policy 34, 994–1009.

Oakey, R.P., Hare, P.G., Balazs, K., 1996. Strategies for the exploitation of intelligence capital: evidence from Hungarian research institutes. R&D Management 26, 67–82.

OECD, 2003. Turning Science into Business. Patenting and Licensing at Public Research Organizations. OECD, Paris.

Piccaluga, A., Balderi, C. 2007. Consistenza ed evoluzione delle imprese spin-off della ricerca pubblica in Italia. Technical Report Finlombarda, Milan, Italy.

Pisano, G., 2006. Science Business: The Promise, the Reality and the Future of Biotech. Harvard Business Press, Boston Mass.

PROINNO. www.proinno-europe.eu/ (accessed 20.04.09).

Rabe-Hesketh, S., Skrondal, A., 2008. Multilevel and Longitudinal Modeling Using Stata. StataCorp LP, College Station, Texas.

Radosevich, R., 1995. A model for entrepreneurial spin-offs from public technology sources. International Journal of Technology Management 10, 879–893.

Rajan, R.G., Zingales, L., 1998. Financial dependence and growth. American Economic Review 88, 559–588.

Rasmussen, E., Mosey, S., Wright, M., 2011. The evolution of entrepreneurial competencies: a longitudinal study of university spin off venture emergence. Journal of Management Studies (forthcoming).

Roberts, E., 1991. Entrepreneurs in High Technology: Lessons from MIT and Beyond. Oxford University Press, USA, Oxford.

Roberts, E.B., Malone, D.E., 1996. Policies and structures for spinning off new companies from research and development organizations. R&D Management 26, 17–48.

Rothaermel, F.T., Thursby, M., 2005. University-incubator firm knowledge flows: assessing their impact on incubator firm performance. Research Policy 34, 305–320.

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

Schumpeter, J.A., 1912. The Theory of Economic Development. Harvard University Press, Cambridge, Mass.

Shane, S., 2002. Selling university technology: patterns from MIT. Management Science 48, 122–137.

Shane, S., 2004. Academic Entrepreneurship: University Spinoffs and Wealth Creation. Edward Elgar Publishing, Aldershot, UK.

Siegel, D.S., Waldman, D., Link, A., 2003. Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study. Research Policy 32, 27–48.

Siegel, D.S., Wright, M., Lockett, A., 2007. The rise of entrepreneurial activity at universities: organizational and societal implications. Industrial and Corporate Change 16, 489–504.

Stoneman, P., 1995. Handbook of the Economics of Innovation and Technological Change. Blackwell, Oxford.

Yim, D.S., Kim, W.D., 2005. The evolutionary responses of Korean Government Research Institutes in changing national innovation system. Science, Technology Society 10, 1–10.

Zucker, L.G., Darby, M.R., Armstrong, J.S., 2002. Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology. Management Science 48, 138–153.