Complements or Substitutes?

The Role of Universities and Local Context in Supporting the Creation of Academic Spin-offs

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Abstract

In this paper we analyze the extent to which University-Level Support Mechanisms (ULSMs) and Local-Context Support Mechanisms (LCSMs) complement or substitute 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. In any given region, ULSMs complement the specific legislative support offered to high-tech entrepreneurship at regional level, whereas they have a substitution effect with regard to the amount of regional social capital, to the regional financial development, to the presence of a regional business incubator, and to the regional public R&D expenses as well as to the level of innovative performance in the region. Our results show that regional settings' idiosyncrasies should be taken into account in order to develop effective spin-off support policies by universities.

Key words: Academic entrepreneurship, Academic spin-offs, University-level support mechanisms, Local-context support mechanisms, Technology transfer.

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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 setting the agenda of governments around the world (Lerner, 2010). Academic spin-offs, companies created to exploit technological knowledge originated within universities, represent a specific category of NTBFs. Such companies, especially in the last two decades, have received increasing attention from researchers and policy makers because of their ability to create wealth and to advance scientific knowledge (Mustar et al., 2006; Mustar et al., 2008; Shane, 2004).

Several studies have documented the growing importance of such firms. First, the increasingly rapid evolution of knowledge fields as well as their multidisciplinarity, which is core to new disciplines alike, 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 towards more open models, where 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 received increasing visibility and importance following legislative changes that have interested 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. The Bayh-Dole Act is the first and most studied legislative change (Kenney and Patton, 2009), providing the framework for universities to patent inventions funded by federal agencies. While its net effects are questioned, even the harshest critics would recognize that it contributed to raising the overall awareness that US universities could have an active role in technology transfer. They benefit from pursuing more aggressively the commercialization of academic knowledge in a variety of ways, including university patents, university-industry collaborations, research contracts to companies, and, last but not least, academic spin-offs (Mowery et al., 2004).

During the nineties, following legislative reforms pushing public research institutions toward greater proactiveness in commercializing their research results (Baldini et al., 2006; Geuna and Rossi, this issue), in many parts of the world universities have started to invest in the creation of internal mechanisms (organizational procedures, incentives, regulations, etc.) aimed at supporting academic entrepreneurship in its different forms. These internal university-level mechanisms and policies have contributed significantly to the professionalization of activities encouraging the exploitation of research results (Meyer, 2003; Siegel et al., 2003).

Yet, unlike in the US, where there has been a systematic effort in assessing the impact of legislative changes (particularly of Bayh-Dole) and of the mechanisms/policies implemented by universities themselves to support the commercial exploitation of their research results (Di Gregorio and Shane, 2003; Link and Siegel, 2005; Mowery et al., 2004; O'Shea et al., 2005), the effect of universities' intervention, following new laws and governmental regulations aimed at favoring technology transfer, is still anecdotal in many European countries. More specifically, there is still scant evidence on the joint impact that university-level mechanisms and regional specificities have on technology transfer activities in the European context.

Indeed, to the best of our knowledge, the scant evidence available in this regard is based on the impact of university intervention on university patenting (Baldini, 2011a; Baldini et al., 2006; Breschi et al., 2008; Geuna et al., 2006; Lissoni et al. 2008) and on spin-off creation (Baldini, 2011b; Colombo et al., 2010; Fini et al., 2009; Lockett and Wright, 2005; Moray and Clarysse, 2005; Nosella and Grimaldi, 2009). However, despite the relevance of such efforts, studies based on systematic and longitudinal datasets remain almost unknown in the EU context (for notable exceptions, refer to Rasmussen et al., 2011) and are nonexistent as regards the Italian landscape. It follows that a more systematic assessment of the impact of universities' intervention to support academic entrepreneurship in EU countries is timely and desirable. In such an exercise, not only is it important to consider differences across regulatory systems of EU countries (Geuna and Rossi, this issue), but it is also important to account for other country-level specificities that may affect the success of university policies aimed at favoring the commercial exploitation of their research results (Degroof and Roberts, 2004; Feldman, 2001; Lerner, 2004; Siegel et al., 2007).

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. 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), available at large in the context in which academic spin-offs operate. By focusing on one single country we try to control for the national level institutional setting and for the regulatory environment to which all universities must adhere. Italy has been interested, over the last 20 years, in legislative regulations that have fostered universities activities in regard to the commercialization of their research results. Italy is an interesting setting also for the variety across its regions, from the north all the way to the south, which makes it possible to assess the impact of university-level policies depending on the specificities offered by local contexts.

Using the population of the 404 Italian university spin-offs 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 two research questions: in which type of local context is the contribution of specific ULSMs most relevant in fostering the creation of academic spin-offs? Do ULSMs and LCSMs complement or substitute each other in this process?

The rest of the paper is organized as follows. In Section 2 we focus our attention on the specific mechanisms to support academic spin-off creation and the effects that they are likely to have on the successful creation of academic spin-offs. 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 and commenting on the empirical evidence emerging from our analysis. 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 additional difficulties associated with the development of new technologies (Oakey, 1996). According to several contributions in the Economics of Innovation tradition, they are therefore particularly sensitive to various kinds of market failures that characterize the early stages of business development. First, they are both capital and credit rationed. On the capital side, academic entrepreneurs are prone to generate information asymmetries either for a lack of expertise in properly communicating to investors key characteristics of the knowledge on which the new venture is based, or for the 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 lacking oftentimes the presence of specialists in the provisioning of risk capital or, when present, the necessary expertise. On the credit side, it is 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 to 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, firms wishing to innovate must gain access to complementary assets, such as manufacturing and distribution, or to complementary technologies (Teece, 1986).

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 will 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 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 where 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). Once new business ideas have been developed sufficiently to justify the attempt to start up a new business, the road to commercial distribution of product and services is still very difficult, and fraught with uncertainty. One set of support mechanisms for the very early stages of life in 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 and generally acting 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 governing the possibility of exploiting university-assigned technologies. The presence of preferential treatments for inventors willing to industrially pursue their research, 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, and ranging, for example, from 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 to see reflected in individual evaluations and compensation schemes the participation in various forms of technology transfer activities. Third, there are the sets of rules and procedures governing access to R&D laboratories and scientific facilities, which could be particularly relevant for start-ups 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 alone to influence the general characteristics of the labor markets or the role, distribution, and ease of access to complementary assets. Yet, they can devise different micro-level policies in these areas, such as more flexible leave-of-absence schemes, pre-specified tracks for faculty willing to start a new business, dedicated offices to support the whole process, early stage incubators with shared services and subsidized facilities. While traditionally and idiosyncratically practised by various universities in the US, these institutional interventions are becoming more widespread, even in much more rigid and conservative environments, such as in different European countries (OECD, 2003), as well as in emerging economies, like, for example, China (Huang et al., 2004), India (Khan, 2000), and South Korea (Yim et al., 2005).

2.2 Local-Context Support Mechanisms (LCSMs)

The business environment within which universities are located can provide very important resources for the establishment and growth of their spin-offs. The region in which a new venture decides to operate may be seen as having a set of competencies and resources that are both tangible – physical infrastructure, corporate physical assets, R&D laboratories, and intangible – human capital, routines, etc. (Niosi and Bas, 2001; Saxenian, 1996) that can affect the ease of establishing and growing a 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 so 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. Very often, funding schemes are made available also in rich regions, through local administrations and regional funding, with the objective of providing financial and non-financial support to would-be entrepreneurs, promoting university-to-industry technology transfer, etc. 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 young small firms (Beck et al., 2005; Love, 2003). Venture capital plays a critical role, in both the direct financial support provided by capital investments, and the additional support typically attached to early stage investments. In several studies, venture capitalists emerge as critical for establishing connections with potential suppliers and customers, increase the managerial competencies of the founding team, and help recruit 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 availability of companies operating in the same or in 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, support structure, and they enjoy benefits from their proximity. 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 so far reviewed suggests that academic spin-off creation can be enhanced by university-level support mechanisms but is also dependent upon the characteristics of the local context, which encompasses both factor endowments and specific policies targeted to support entrepreneurship. It is not clear, however, if and to what extent university-level and local-context support mechanisms act as complements offering a differentiated set of elements, or as substitutes, inefficiently duplicating efforts and resources (Breznitz et al., 2008; Degroof and Roberts, 2004).

Recent advances in science and technology policy studies consider universities as directly involved in local economic development (Etzkowitz et al., 2000). In particular, universities are considered critical in supplementing the provisioning of different services in economic environments characterized by underdeveloped local context conditions. Academic incubators, venture funds, and other kinds of services are therefore highlighted as particularly important to raise the opportunity set of local entrepreneurs facing 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 supporting universities in facilitating academic spin-offs become policy mechanisms more easily and quickly applicable and are considered to have a more direct impact in the local economy, than more structured and long-term oriented policies. According to this view, universities can and should play an active role in turning academic knowledge into economic wealth, and it makes sense that they implement their own mechanisms targeted at supporting new venture creation and technology transfer. However, one might also argue that such policies might simply be easy to launch, cheaper with respect to other types of intervention, and that there's no real indication of their comparative effectiveness.

Scholars have also 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 on academic resources. The key is that communities surrounding universities must have the capabilities to absorb and exploit the science and knowledge that universities generate. As a consequence, universities are a necessary but not sufficient condition for regional economic development. The rationale is that, even though new knowledge is generated in many places, it is only those regions that can absorb and apply ideas that are able to turn them into economic wealth. 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.

According to this view, it is in situations where 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 on positive network externalities.

Breznitz et al. (2008), in a study analyzing the contribution of universities to regional development, support a contingent-based perspective of academic entrepreneurship, whereby low support–low selectivity policies are more fitted to entrepreneurially developed environments, whereas high support–high selectivity policies are more efficient in entrepreneurially underdeveloped environments. Their findings are in line with Roberts and Malone (1996), who develop 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. The high support–high selectivity strategy consists of spinning off a few well-supported ventures. It relies on picking potential winners and supporting them to increase their chance as much as possible (Degroof and Roberts, 2004).

Overall these arguments raise interesting questions, with regard to when, where, and to what extent universities should get involved in creating ad-hoc mechanisms supporting the creation of new ventures, to promote complementarity and avoid duplication. And yet, the complementary vs. substitutive effects cannot be convincingly modeled in favor of either of them. In the next sections we present an empirical analysis contrasting the relevance of university-level and local-context support mechanisms for start-ups under different levels of local economic development, to investigate this issue.

3. Research design

3.1 The Italian university system

The Italian university system has for long been a typical example of a fully public and highly centralized governance structure, with low autonomy at the university level and a key role played by the state. In 1989, Law 168 endorsed the self-regulation principle and increased the universities' administrative autonomy. Law 537, further elaborated 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 of 9th February 1996, which gave full application to Law 168, universities started to elaborate their own statutes and internal regulations, which gradually expanded to include different possibilities for leveraging their internal resources and competencies. Yet, 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 is Law 297/1999 which introduced the possibility for public researchers being formally involved in the creation of a spin-off or in other technology transfer projects between a university/PRO 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 the single institutions.

Finally, a third legislative change, albeit more general in scope and content, is the constitutional reform of 1999, which assigned to Regional Government for the first time the legislative power in several domains previously reserved to the national government. Among these domains stands out the one related to innovation policies. As a consequence, in the following decade several regional governments approved specific regulations targeted to promote innovation activities and initiatives.

3.2 Sample

In order to address the aforementioned research questions, we started by gathering university-level data related to names, departments, and schools, as well as their regional localization, from 2006 to 2010, through the official web site 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 operating in science, technology, engineering, and mathematical fields (STEM universities).

Given our interest in high-technology entrepreneurship, we then focused on the number of spin-off companies established by academics affiliated to these institutions, operating in high-tech industries according to the OECD definition[1]. We define an academic spin-off as a company that has either the university or at least one academic (full, associate, assistant professor, PhD student, research fellow or technician) among the founders, regardless of the presence of a formal commitment of the parent university (Fini et al., 2009). Moreover, our definition excludes firms based on a university technology licensing established by surrogate academic entrepreneurs (Radosevich, 1995).

To collect information on the population of academic spin-offs established in Italy in the last decade, we adopted a two-pronged approach. First, moving from the

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

64 Italian STEM universities' websites, we gathered information on TTOs, where available, identifying a key informant for each institution, who was contacted to gather data. TTOs were first contacted in November 2006 and the spin-off list of companies was then updated on a yearly basis up to May 2010.

Second, in order to gather information on those firms established without passing through the formal disclosure procedure, and control for the 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, which contains information on more than 400 companies, including academic spin-offs established after 1980, operating in high-technology industries. RITA provides longitudinal information on start-ups' general characteristics, their market and technological performances, and shareholding compositions.

Overall, in our sample we count 404 academic spin-offs, established between 2000 and 2007, as a result of technology transfer activities stemming from the 64 STEM Italian universities. Data were codified in the Spin-off IRIS[2] database. We use the year 2000 because, in 1999, the national Law 297 redefined the rules and the 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, we are confident that our sample accounts for the vast majority of the population of such firms.

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

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-varying, variables as predictors of university spin-off activity. For the first set, we refer to university characteristics, focusing on university size dimensions, such as the total number of faculty members (MIUR, www.miur.it), as well as on university entrepreneurial eminence, assessing the stock 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 complemented the information stored in the PATIRIS (Baldini et al., 2006) and ORBIT (www.orbit.it) databases. Finally, we addressed the university research eminence, coding the amount of government funds awarded to each university. This information was downloaded from the MIUR website (www.miur.it).

Second, we addressed the university-level support mechanisms (ULSMs). We started by gathering information on university incentive structures for faculty to engage in external commercialization activities. In particular we collected all patent, spin-off and external collaboration regulations issued by Italian universities, downloading them from their websites, where available. In order to gather information about previous regulations (or to check for the existence of the regulation, if not posted on the website) we contacted by email and telephone 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 management). 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 then targeted the university resources supporting technology transfer. We accessed the MIUR website and, for each university, we gathered information on the presence of a formal university technology transfer office (TTO), coding its year of establishment. We also contacted the Network for the Valorization of University Research (NETVAL, www.netval.it)[3], created in 2002 by the Polytechnic of Milan, to access information on which universities participated in the network, as well as the number of academic, administrative, and technical personnel that participated in NETVAL professional training courses.

Finally, we focused on the local-context support mechanisms (LCSMs). We first gathered information on the regional social capital that, consistent with previous empirical works conducted on 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 of 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 have been transformed into standardized scores, in order to get scale-free values. Then we combined the scores into a single index (Cronbach alpha of .91), which we labeled "Social capital index". Second, we addressed the regional financial development, coding, for each region, the "Financial development index" developed by Guiso et al.

[3] NETVAL was established in order 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 1,000 individuals on IP-related matters.

(2004). The index estimates the regional effect on the probability that, ceteris paribus, a household is shut off from the credit market. Third, we focused_on the regional governmental support to high-technology entrepreneurship; we accessed the website of each regional governmental office, gathering information on the existence and the issue year of the regional policy supporting the creation of NTBFs. We labeled this variable "Regulation for NTBF formation". Fourth, we turned to the infrastructural support offered to high-tech entrepreneurship and we retained information on the number of business incubators operating in each region and their year of establishment (in addition to the already identified university ones). We coded such information in a variable we labeled "Business incubator". As for the regional knowledge spillovers, instead, we retrieved from Eurostat (http://epp.eurostat.ec.europa.eu) the regional public expenditure in R&D as the net of higher education sector expenditures, which was coded into the variable "Government R&D expenses". Finally, in order to assess an indicator of the regional innovative performance, we relied on the regional "Innovation index" calculated by PRO INNO Europe (www.proinno-europe.eu). This index is a synthetic indicator of regional innovative performance, including information gathered using the Community Innovation Survey and Eurostat archival data.

In Tables 1a and 1b, we describe the domains and variables used in our study, providing information on their characterization and source. We also report if the variable is time-varying or cross-sectional.

Insert Tables 1a and 1b about here

3.5 Estimation and model specification

We use a Poisson multi-level model to analyze the count of companies 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), as 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 over-dispersion, which may affect count data (please also refer to Section 4).

Moreover, as we want to model the joint effect of university and regional support mechanisms on spin-off creation, we have to deal with the non-independence of observations, facing within-university autocorrelation due to repeated observations across years, as well as between-university autocorrelation due to the presence of more than one university localized 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 under stable environmental conditions.

Because of the aforementioned reasons, we have therefore 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 in supporting 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 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 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, while Model 2c contains all the university predictor variables plus university- and regional-level random effects. Models 2a and 2b are meant to assess whether or not the random effects become insignificant once the full list of university fixed covariates is in place. Model 2c, instead, is meant to be compared with Model 2a in order to disentangle the role of the 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 (i.e. Model 2a is nested within Model 2c).

In the third step of our study, we specify a new set of models to disentangle the role that specific facets of the local context have on spin-off creation, including in

[4] We do not lag the independent variables because we expect that the 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).

all of them university-level fixed effects, and adding, one at a time, additional regional-level variables, corresponding to various facets of the local context support. The influence of each facet is evaluated in terms of 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 is as a result of specific interactions of local context attributes and university attributes. The 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 "Innovative index" in Model 3f. The random intercept at regional level is excluded, thus assuming that the university-specific abilities do not reflect homogenous region effects, in accordance with the model comparison test performed in the second step.

In the fourth step, we re-introduce the university-level fixed effects as well as the 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 characteristics 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, as the proportion of universities with a zero-count of spin-offs is, in all cases, higher than 50% in each year. Table 3, instead, presents the summary statistics for all the variables included in the sample.

Insert Tables 2 and 3 about here

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 are fully specified. Moreover, once Models 2a and 2c are compared, the null hypothesis of no variance explained by regional effects cannot be rejected ($\chi(1)=0$; $p>.1$). This result calls for a more fine-grained analysis at the regional level, which is presented in Table 5.

[5] In order 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), in order 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, as the data does not suffer from overdispersion.

Insert Table 4 about here

Controlling for a set of university-level fixed characteristics, we show how much each university leverages each specific regional dimension in 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 capital and the financial development regional index, 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 performance 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 the specifications. Conversely, university size as well as university research eminence have limited impact on the academic spin-off creation rate.

Estimates of the random parameters 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 universities, thus highlighting the presence of a differentiated impact of all the context support facets. The latter result calls for a deeper investigation of the combinations of regional and university attributes.

[6] Incidence ratios (IR) are the exponentiated form of regression slopes 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 means that the expected change in the probability due to a unitary change in the covariate is zero).

Insert Table 5 about here

In Table 6, we take into account university-level fixed and random effects. We specify six models, introducing one at a time the different facets of university support mechanisms. In all specifications, any given mechanism is significant, with the spin-off regulation having the highest impact (Model 4c). The presence of external collaboration and patent regulations (Models 4b and 4d), as well as the existence of a TTO (Model 4a), 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) predict spin-off activity strongly (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, and that universities have heterogeneous productivity when they put in place support mechanisms, especially when the spin-off regulation and patent regulations are introduced, as shown by the standard errors of the random slopes. These results are coherent with the one provided by previous studies, as Kenney and Goe's work (2004), comparing UC Berkley and Stanford, and Bercovitz and Feldman's work (2008) that highlights the heterogeneity in entrepreneurial activity at department level.

Insert Table 6 about here

Finally, in Figures 1a and 1b, 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 conditional on the marginal contributions that both the university and regional support mechanisms have 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, and the regional governmental R&D expenses, as well as with the regional innovativeness index. In this specific case, instead, university mechanisms are substituting for regional-level support mechanisms.

Insert Figures 1a and 1b about here

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5. Conclusions

Our results indicate that any given ULSM (spin-offs, external collaborations and patent regulations, as well as the existence of a TTO and participation in NETVAL) turns out to have a significant impact on universities' spin-off productivity. Universities, therefore, in order to foster the generation of spin-off companies 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, while there is a positive and significant effect of the regional social capital index, of the regional financial development index, as well as of the regional regulation for NTBF formation, universities are negatively affected by the government R&D expenses in the region. 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.

When we consider the joint effect of ULSM and LCSM, 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 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 are 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 the spin-off productivity (and this finding holds for all the different ULSMs taken into account in our analysis) decreases in contexts where the social capital index, the regional innovativeness index (level of innovative performance in the region), the government R&D expenses in the region, the regional financial development index and the presence of a regional incubator, all have a positive marginal contribution to spin-off productivity (substitution effect). In these contexts universities are better off not pursuing incremental investments (no more than they usually do) and not putting additional efforts in fine-tuning existing ULSMs.

This suggests two important things: 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, more specifically of the support offered by universities and by the regions in which companies are settled. Second, since there are different forms of support that can be offered by both the universities and the regions sides, it is advisable to disentangle the effect 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.

Overall our results suggest that universities should be particularly active in creating internal support mechanisms for spin-offs in contexts where 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 where 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.), since their additional contribution might not foster additional spin-off creation.

The Bayh-Dole Act, and other 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 on their internal policies and level of commitment, but also on the local specificities of the context in which they are settled and which inevitably influence the way they behave and operate.

This calls for more attention to the interaction between different determinants, operating 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). In this regard, within-university case studies should be developed in order to better identify policies that are operational and fine grained, by taking into account how each specific ULSM interacts with the specificities of the region in which they operate.

Our study suffers from various limitations. First of all, we have focused our attention on spin-off creation, and not on spin-off performance. Future research should consider, with firm-level data, their effective contributions to economic growth and the extent to which such effects could be related to university-level policies, following legislative regulations in Italy. More generally, this is a reasonable way to assess the impact of legislative and institutional changes aimed at creating the conditions to favor the successful (bringing benefits to countries) commercialization of research results.

In addition to that, while we have tried to control for possible confounding effects at the contextual level and for potential endogeneity effects, we could not disentangle precisely the magnitude of the effects considered. While it is always difficult to express in discrete terms the expected effects of policy instruments, 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 or Germany, it still holds many relevant differences, even after the implementation of the most recent law affecting universities, that of 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. While 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. 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 relevant theme of the alignment between decisions and incentives, a particularly relevant subject for all those systems where public resources are transferred to universities depending upon certain goals or targets. While 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.

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Exhibits

Table 1a: University-level variables included in the study

Class	Domain	Variable	Type of variable	Time of Assessment	Time span	Description	Source
Dependent variable	University spin-off activity	Academic spin-off foundation events	Continuous	t	2000-2007	Number of academic spin-offs established in year t	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	Authors
		Cumulative number of spin-offs	Continuous	t-1	1999-2006	Cumulative number of academic spin-offs established after 1999 in year t-1	Authors
	University patenting activity	Stock of patent families[1]	Continuous	1998	-	Stock of patent families granted before 1999	PATIRIS and ORBIT
		Cumulative number of patent families[1]	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	University external engagement regulation	External collaboration regulation	Dummy	t	2000-2007	Existence of the regulation ruling external collaborations in year t	Authors
		Spin-off regulation	Dummy	t	2000-2007	Existence of the regulation ruling spin-off formation in year t	Authors
		Patenting regulation	Dummy	t	2000-2007	Existence of the regulation ruling patenting in year t	Authors
	University support to technology transfer activities	Technology Transfer Office (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

Note: [1]Where more than one university is among the assignees, we assigned the patent to each of them

Table 1b: Context-level variables included in the study

Class	Domain	Variable	Type of variable	Time of Assessment	Time span	Description	Source
Local-context support mechanisms	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 high-tech entrepreneurship	Regional regulation forNTBF[1] formation	Dummy	t	2000-2007	Existence of a regional regulation supporting the establishment of NTBF in year t	Authors
	Regional infrastructural support to high-tech entrepreneurship	Business incubator	Dummy	t	2000-2007	Existence of a business incubator in year t	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

Note: [1]NTBF = New Technology Based Firm

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

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
Technology Transfer Office (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

Table 4: Poisson random-intercept model with mixed effects

Dep. Var.: 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*
ULSM						
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*
Technology Transfer Office (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	21
Fixed effects	8	20	8	20	8	20
Random effects	1	1	1	1	2	1
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	not rejected
					p<.0001	p>.1

Standard errors in italic; ‡p<0.1, •p<0.05, •• p<0.01 •••p<.001; Number of universities: 64; Number of regions: 19

Table 5: Poisson random coefficient model with LCSM mixed effects

	Dep. Var.: 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*
LCSM						
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	
Innovatiness 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

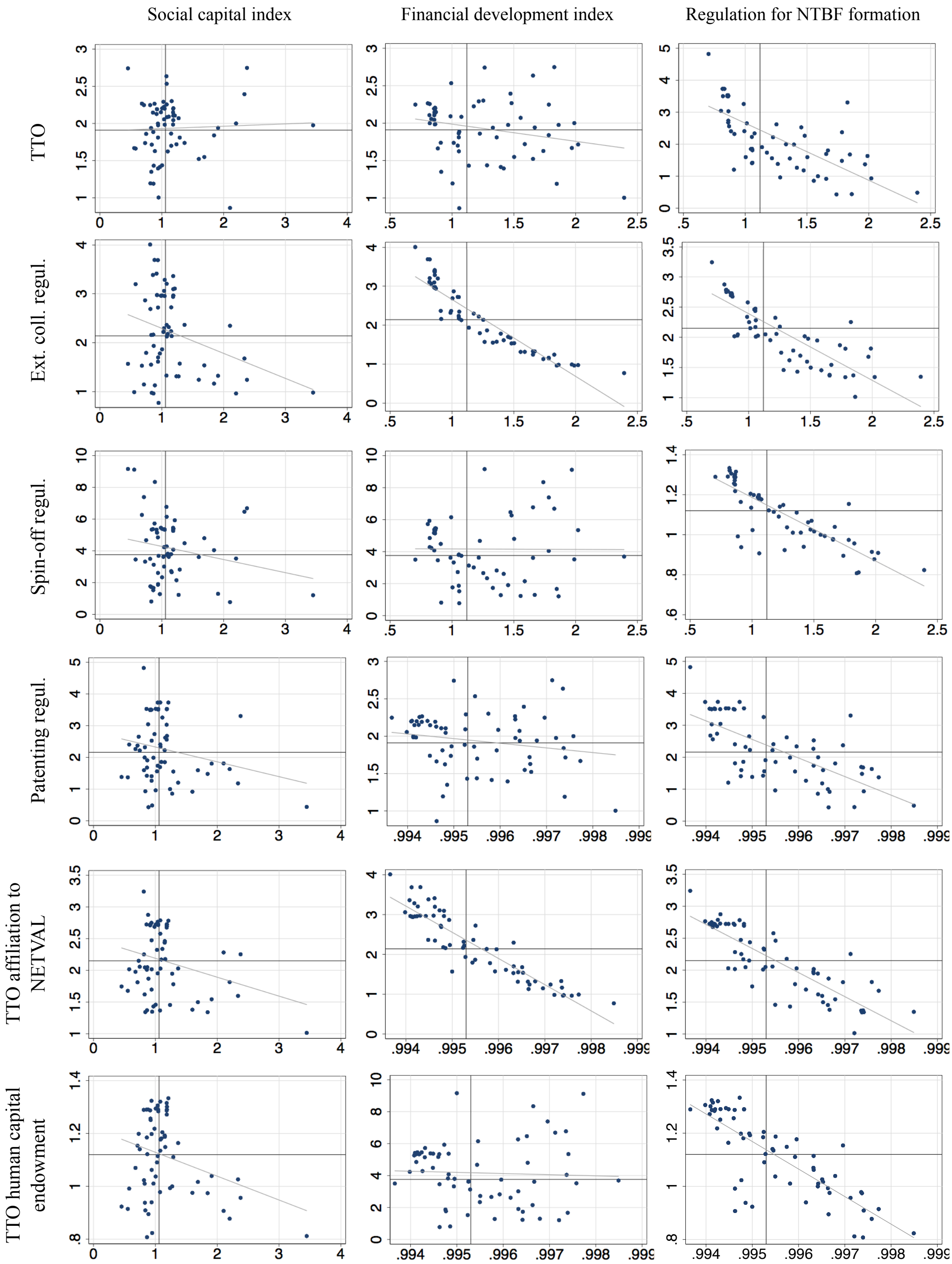
Standard errors in italic; ‡p<0.1, •p<0.05, •• p<0.01 •••p<.001; Number of universities: 64; Number of regions: 19

Table 6: Poisson random coefficient model with ULSM mixed effects

Dep. Var.: 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)	1.034 ‡	1.035 ‡	1.016	1.021	1.032 ‡	1.031 •
	0.019	*0.018*	*0.015*	*0.018*	*0.019*	*0.015*
Stock of spin-offs	1.215	1.278 ‡	1.248 •	1.205	1.160	1.112 •
	0.166	*0.161*	*0.133*	*0.141*	*0.157*	*0.059*
Cumulative number of spin-offs	1.036 •	1.015	1.039 ••	1.028 ‡	1.018	1.051 •••
	0.019	*0.013*	*0.015*	*0.017*	*0.014*	*0.012*
Stock of patent families	1.105 ‡	1.121 •	1.090 •	1.149 ••	1.146 ••	0.994
	0.061	*0.055*	*0.046*	*0.057*	*0.057*	*0.034*
Cumulative number of patent families	0.984 •	0.986 •	0.989	0.982 •	0.982 ••	0.989 ‡
	0.008	*0.007*	*0.007*	*0.007*	*0.007*	*0.006*
MIUR research funds (ln)	1.003	0.994	1.020	1.001	0.993	1.049
	0.032	*0.027*	*0.031*	*0.028*	*0.027*	*0.034*
ULSM						
Technology Transfer Office (TTO)	2.114 •					
	0.773					
External collaboration regulation		2.149 •				
		0.684				
Spin-off regulation			3.728 •••			
			1.154			
Patenting regulation				1.976 ‡		
				0.734		
TTO affiliation to NETVAL					2.101 ••	
					0.601	
TTO human capital endowment						1.107 ••
						0.038
Random part						
University random intercept	1.122	1.461	0.931	1.395	1.273	1.299
	0.221	0.244	0.218	0.259	0.266	0.203
95% confidence interval	[0.76;1.65]	[1.05;2.02]	[0.58;1.47]	[0.97;2.00]	[0.84;1.91]	[0.95;1.76]
University random slope	0.565	0.523	0.981	0.907	0.313	0.154
	0.272	0.230	0.260	0.378	0.283	0.031
95% confidence interval	[0.22;1.45]	[0.22;1.23]	[0.58;1.65]	[0.40;2.05]	[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	-468.595	-467.553	-465.435	-465.225	-468.133	-471.043
Chi2	108.764	109.928	107.786	116.743	104.943	105.835

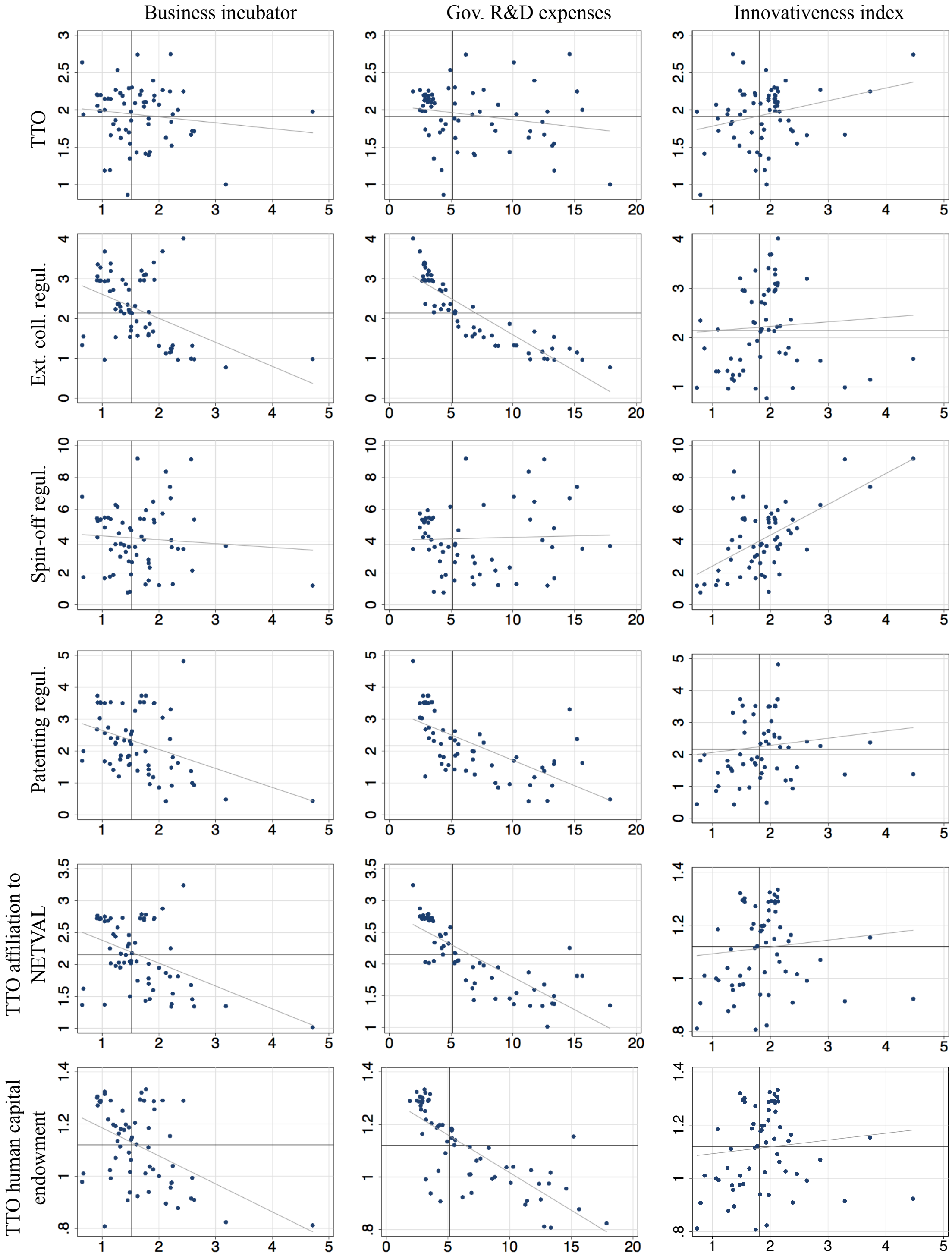
Standard errors in italic; ‡p<0.1, •p<0.05, •• p<0.01 •••p<.001; Number of universities: 64; Number of regions: 19

Figure 1a: 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.

Figure 1b: 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.

Appendix

Table A1: Descriptive statistics for ULSMs' productivity

Variable	Obs	Mean	Std. Dev.	Min	Max
External collaboration regulation	64	2.22	0.84	0.77	4.01
Spin-off regulation	64	4.16	1.95	0.78	9.16
Patenting regulation	64	2.26	1.00	0.43	4.82
Technology Transfer Office (TTO)	64	1.94	0.38	0.86	2.75
TTO affiliation to NETVAL	64	2.15	0.52	1.01	3.24
TTO human capital endowment	64	1.12	0.15	0.81	1.33

Observations refer to universities. Productivity is expressed in terms of incidence ratios.

Table A2: Relationship of the productivity among different support mechanisms

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
ULSMs											
[1] Technology Transfer Office (TTO)											
[2] External collaboration regulation	0.85										
[3] Spin-off regulation											
[4] Patenting regulation	0.79	0.79									
[5] TTO affiliation to NETVAL	0.86	0.90		0.84							
[6] TTO human capital endowment	-0.83	-0.95		-0.73	-0.87						
LCSMs											
[7] Social capital index	-0.46	-0.46		-0.38	-0.44	0.55					
[8] Financial development index	-0.77	-0.88		-0.65	-0.80	0.94	0.57				
[9] Regulation for NTBF formation			0.61								
[10] Business incubator	-0.29	-0.30			-0.28	0.31	0.48	0.40	-0.50		
[11] Government R&D expenses (mil €)	-0.80	-0.92		-0.68	-0.85	0.97	0.53	0.93		0.31	
[12] Innovativeness index	-0.83	-0.93		-0.71	-0.84	0.99	0.58	0.96		0.32	0.96

Observations refer to universities. Productivity is expressed in terms of incidence ratios.
Values refer to full correlations. Correlations reported are statistically significant at $p<0.05$