University support and the creation of technology and non-technology academic spin-offs

Michele Meoli[*] and Silvio Vismara
University of Bergamo, Italy
CCSE, University of Bergamo, Italy, and University of Augsburg, Germany

Abstract

The literature on academic entrepreneurship typically assumes that creating a supportive environment in a university can result in a higher rate of establishment of academic spin-offs in a relatively straightforward manner. In contrast, we argue that, at times, academics choose to launch an independent company vis-à-vis pursuing alternative business engagement activities when their university provides inadequate support. Drawing from hybrid entrepreneurship and necessity entrepreneurship, we model the individual decision to spin off as a reaction to the organizational characteristics of the parent university, rather than to its outcome. Through a longitudinal study of 559 spin-offs from 85 Italian universities from 1999 to 2013, we find that although stronger administrative support from the parent university leads academics to create more technology spin-offs, a U-shaped relationship instead exists between the number of administrative staff within a university and the rate of establishment of non-technology spin-offs. When the level of administrative staff is too low or too high relative to the fitted amount estimated using several university-level factors, academic staff reacts by establishing firms to achieve improved cash and human resource management.

Keywords: Academic entrepreneurship; Spin-offs; University; Technology transfer; hybrid entrepreneurship; necessity entrepreneurship.
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[*]Contact author: via Pasubio 7b, 24044 Dalmine (BG), Italy. Telephone: +39 035 2052093. Fax: +39 035 2052077. E-mail: michele.meoli@unibg.it

1. Introduction

Generally, the assumption is that academic entrepreneurship is facilitated by the parent university providing support, especially in presence of formal technology transfer mechanisms (Markman et al., 2005). Indeed, a common trait of the literature is the perception of the decision to launch an academic spin-off as a positive outcome that typically occurs in a supportive organizational environment. Although such a launch might be the case for most spin-offs, and in particular for technology-based ones, the decision to spin-out could also be motivated by inadequate institutional support for business engagement. A polar example, which initiated this study, is a non-technology spin-off created in 2004 in an Italian university. The academic founders list inadequate administrative support received from the parent university as a leading motivation to spin off. 'We [the academics] were frequently working with companies as consultants. Contracts were on behalf of the university, while we were burden with bureaucracy and received virtually no support. Now, though the spin-off, we still benefit from the affiliation with the university, but are much freer to manage the resources and cash flows of the business'. Ten years after the foundation, this spin-off is still run by the founding team of academics who retained their professorship, in addition to three young employees.

In this paper, we posit that establishing academic spin-offs might sometimes be stimulated by the administrative inadequacy of the parent university. The rationale follows two lines of arguments, one grounded at the individual level and the other at the organization level. First, contrary to most papers, we model the individual decision to spin off as a reaction to the organizational characteristics of the parent university rather than its outcome. We argue that, at times, academics choose to launch an independent company by pursuing alternative business engagement activities when the university provides inadequate support. Indeed, academic entrepreneurship is only one of the business engagement forms that academics can choose. Alternatives include licensing, patenting, contract research, consulting, and other personal-related activities with industrial partners. Among these forms, creating a firm is the one that entails a higher degree of freedom of activity. When support from the university to which they belong is inadequate, entrepreneurial academics may opt for a spin-off solution rather than for alternatives when striving for better management of both cash and human resources. In a context such as Italy, with its highly regulated state-funded higher education system (Donina et al., 2015), the vexing bureaucracy of universities may be among the motivations for becoming academic entrepreneurs (Fini et al., 2009). Facing inadequate administrative support, academics have incentives to spin out their initiatives through entrepreneurial ventures rather than be restrained by ties and fees on their external activity.

Second, at the organizational level, empirical evidence shows that the large increase in the creation of academic spin-offs is related to the pressure faced by universities to commercialize their research results in different forms, including spin-offs (Clarysse et al., 2011; Djokovic and Souitaris, 2008; Knockaert et al., 2011). Indeed, academic spin-offs have received significant attention from researchers and policy makers because of their potential ability to advance scientific knowledge and to contribute to regional economic growth (Audretsch at al., 2015). A series of policies have been adopted by national governments with the aim to create a supportive environment and foster the technology transfer process. As a result, the creation of academic spin-offs is increasingly being used as a performance indicator to evaluate public investments in universities and public research organizations (Moray and Clarysse, 2005). In some countries, university are incentivized by national policies to demonstrate being active in their 'third mission' by launching academic spin-offs. In Italy, for instance, universities are required to provide documentation of their technology transfer activities (through the SUA-RD, 'Yearly Unified Form for Research Activities at Department level', DM 47/2013) and typically report its content on their Internet sites, where they list their academic spin-offs and other aspects, such as patenting and licensing practices. Such incentives to launch spin-offs might generate the propensity to spin-off new companies, even with limited growth potential. Indeed, despite the benefit from an academic affiliation and access to university resources, academic spin-offs are well-documented as not outperforming other start-ups. Moreover, the number of very successful academic spin-offs is fairly limited (Bonardo et al., 2011; Siegel and Wright, 2015).

Although we aim to highlight the fact that the motivation to launch academic spin-offs might sometimes not be as growth-oriented as is frequently assumed, we clearly acknowledge that most spin-offs are genuine entrepreneurial endeavours. However, whereas the traditional view implicitly assumes that academic spin-offs are technology-based firms, a notable shift occurred and the nature of academic spin-offs increased in diversity (Shah and Pahnke, 2014). We believe that the heterogeneous nature of this type of entrepreneurial venture, and how it relates to the support provided by universities, has not been adequately investigated. Although a number of papers proposed taxonomies to identify and classify the different types of spin-offs (e.g. Druilhe and Garnsey, 2004; Fryges and Wright, 2014; Pirnay et al., 2003; Roberts, 1991), the study on the impact of institutional factors on spin-off activity was not fine-grained enough to consider such heterogeneity. We aim to fill this research gap. Specifically, we focus on how the administrative support received from the parent university affects spin-off activity and distinguish between technology and non-technology spin-offs.

Using a longitudinal study of 559 spin-offs launched from 85 universities from 1999 to 2013, we test whether the rate of creation of spin-offs (number of spin-offs per university per year) is affected by the administrative support from parent universities, originally measured as the deviation from the fitted amount of support estimated using several university-level determinants. We control for organizational and contextual factors and find that the support provided has a different effect on different types of spin-offs. Coherent with evidence from the Unites States and other countries, an increase in support from the university leads to an increase in the creation rate of spin-offs (Lerner, 2004). However, this relationship is driven by the positive impact of the higher availability of resources on the number of technology-based spin-offs. Instead, we find that the decision to establish non-technology spin-offs is more frequent when administrative support structures are either small or large. Indeed, a U-shaped relationship exists between the two. We argue that when institutional support is too low (weak support) or too high (excess bureaucracy), academics are more prone to engage in business through the creation of non-technology firms to achieve better resource management.

The paper unfolds along the following lines. We begin with a literature review and develop the two hypotheses subsequently tested. The third section of the paper describes the research design. Section 4 presents the empirical results. We finish with a discussion section and reflect on the conclusions from this study.

2. Hypotheses development

2.1. Impact of administrative support on the creation of technology spin-offs

When studied in the realm of academics, the decision to become an entrepreneur has a number of specificities (Aldridge and Audretsch, 2010). Most importantly, researchers involved in creating new ventures may not be motivated solely by an entrepreneurial vision, since they are likely to implement their intentions acting in accordance with the academic institutional environment to which they belong (Bercovitz and Feldman, 2008; Fini and Toschi, 2015; Sauermann and Stephan, 2013). For example, researchers may be attracted to the prospect of enhancing their position (Meyer, 2003) or may be motivated by the need for achievement (Roberts, 1991) or aspirations for independence and challenge (Hessels et al., 2008). Other individual motives include seeking recognition by peers and the desire to be socially useful (Hayter, 2011). Therefore, the creation of academic spin-offs is motivated by a broader set of goals. Unfortunately, the pursuit of non-economic motivations often preludes disappointing post-entry performances (Vivarelli, 2004). Empirical evidence shows that most academic spin-offs often do not outperform other innovative start-up companies (Colombo et al., 2010). Only a few of them are successful enough to gain the attention of new stakeholders, whether industrial partners, venture capitalists, or the stock market, to allow convenient exits for founders and parent universities (Rasmussen et al., 2011;

Shane and Stuart, 2002). In Europe, in particular, despite the significant increase in the number of spin-offs since the 1990s, remarkably successful ones are very few in number (Bonardo et al., 2010).

Although diversified, the aforementioned individual motivations to become an academic entrepreneur share a common trait. Scientists that create a spin-off do not cease to be scientists; typically, they initiate their ventures and retain their academic positions (and wages). Because the decision to become a hybrid entrepreneur is found to be distinct from pure entrepreneurship in terms of both motivations and outcome (Folta et al., 2010), investigating the organizational environment in which such decisions are made is worthwhile. This investigation requires a shift in the study of academic entrepreneurship from a serendipitous and individual perspective to a contextualized organizational approach.

Existing studies on the institutional determinants of academic entrepreneurship focused on the role played by technology transfer offices (TTOs) and universities (Link and Scott, 2005; Siegel et al., 2003), as well as local-context support mechanisms and regional conditions (Audretsch et al., 2012; Fini et al., 2011; Meoli et al., 2013). A large body of literature focused on how TTOs can create a structural environment that fosters the creation of academic spin-offs (see e.g. Wright et al., 2007). Although some studies originally found a positive role of TTOs in driving academics to start new ventures (Clarysse et al., 2005), more recent evidence shows that the presence and size of TTOs play only a marginal role (for a review, see Siegel and Wright, 2015). Instead, the organization and policy of a university is found to affect its technology transfer capacities (Di Gregorio and Shane, 2003). Indeed, recent empirical literature focused on the importance of university-level contexts to explain the entrepreneurial behaviour of individual academics (Stuart and Ding, 2006). Di Gregorio and Shane (2003) showed that institutional characteristics, such as the reward systems and IP policies, stimulate the creation of spin-offs. Stuart and Ding (2006) highlighted that specific normative beliefs at the departmental and university level about entrepreneurial activity affect the spin out rate of universities.

Some universities have extensively invested in creating a supportive environment for setting up entrepreneurial ventures (Lockett et al., 2003). For instance, they offer incubation services and a variety of advice and coaching activities, and even organize pre-seed capital to be invested in potential spin-offs (Clarysse et al., 2011). The difficulties in creating a spin-off are presumably lower in such universities. However, other universities simply have better resources at their disposal to help technology transfer activities. Smaller universities might not even have a formal TTO or have only recently settled one. When a university's resources are scarce, the technology transfer activity as a third, non-core mission is frequently sacrificed (Swamidass and Vulasa, 2009). TTOs composed of a handful of members (in our sample, TTOs employ a median of four persons) – regardless of how organized and motivated – will find it difficult to provide customized support to spin-offs and will be probably lack specific expertise, such as industry knowledge or legal skills and the 'networked' boundary spanning individuals that would make them more effective. TTOs will also have difficulty creating the supportive environment to stimulate a higher propensity for scientists to become entrepreneurs. Consequently, undersized administrative and technical staff will result in low support for technology transfer activities. Therefore, we hypothesize that universities with a small administrative and technical staff will find it difficult to foster and support academic spin-offs. In contrast, when administrative support increases, we expect an increase in the creation of spin-offs.

As noted in the introduction, policy makers have resorted to subsidizing technology transfer operations at universities, driving an organizational focus at universities on the formal mechanisms of commercialization and, in particular, academic entrepreneurship (Perkman et al., 2013). The rationale for establishing such policies typically lies in the assumption that the development of innovative technologies generates social benefits in excess of private returns (Mustar and Wright, 2009). Even if universities are unlikely to directly generate major shifts in macroeconomic performance, their indirect effects on technology-using sectors is significant. By fostering the commercialization of academic research in science and engineering, policy makers are focused on such a type of technology spin-off, whose positive externality on the economy at large is expected to be high (Bozeman, 2000). Relatedly, in terms of substantive benefits, universities deliver to affiliated firms access to physical resources, such as laboratories and libraries (Quintas et al., 1992). More broadly, they provide affiliated firms with intangible advantages, such as a window into international research, networks, and emerging technologies (Cattaneo et al., 2015). For instance, everything else held equal, a university with a larger number of lab technicians will equip entrepreneurial academics with stronger assets to use to face the competition. Therefore, increased administrative and technical support in a university is expected to be relevant for technology spin-offs. These arguments lead to the development of Hypothesis 1.

Hypothesis 1: A positive relationship exists between the amount of administrative support in a university and the rate of creation of technology firms.

2.2. Impact of administrative support on the creation of non-technology spin-offs

The third mission of universities has become more important in the eyes of policy makers than it used to be up to two decades ago (Perkman et al., 2013). Coherently, most universities in developed countries have settled TTOs (Siegel et al., 2004). Together with the number of patent applications filed and the level of income through contract research, the general output measures of TTOs include the number of spin-offs created (Wright et al., 2007). Even in higher education systems for which the role of state financing is dominant, as in continental Europe, higher expectations of industry engagement and technology transfer activities have induced universities to devote attention to this aspect and to publicize their outreach activities and achievements in technology transfers (Geuna and Muscio, 2009). For instance, in Italy, all universities have a webpage of their institutional website dedicated to technology transfer on which they list their spin-offs' names. In a similar context, Meyer (2003) showed that these initiatives, although possibly not having led to the creation of growth-oriented spin-offs, have increased their number and, in general, the entrepreneurial intent of academics. The conclusion is that this accent on technology transfer, regardless of whether it has been able to create more successful companies, has supported the creation of an environment in which academics feel more comfortable in undertaking entrepreneurial activities. Coherently, the studies mentioned in the previous section share a common assumption, i.e. creating a supportive environment can result in higher levels of academic entrepreneurial activity in a relatively straightforward manner.

Although the literature on academic entrepreneurship is typically grounded in opportunity entrepreneurship, an exception is provided by Horta at al. (2015), who applied the necessity entrepreneurship framework to propose 'a recession-push hypothesis' to spin-off creation. They showed that the relative skilled unemployment level is positively related to the probability of academic spin-off creation. Relatedly, Vismara and Meoli (2015) found that a lack of academic job positions at a regional level results in a higher propensity to establish academic spin-offs. We extend this view and argue that changes in the rate of establishment of academic spin-offs are related to contextual factors also in a reactive manner. At a descriptive level, we observe that the increase in the number of academic spin-offs in Italy has been primarily driven by non-technology spin-offs. This phenomenon is so evident that, over the last years, the number of academic spin-offs established in Southern Italy has been greater than the number of innovative start-ups (Bolzani et al., 2014) [1].

To explain this trend, we maintain that because the establishment of non-technology firms requires less support from the parent university (Pirnay et al., 2003), such an academic engagement form may act as a resource mobilization device that

[1] In Italy, independent innovative companies that are less than four years old can register as 'startup innovative' and, thereby, be entitled to a series of benefits, such as tax credits, flexible labor arrangements, and easier access to financial instruments (e.g. Law 221/2012).

results in fewer available resources. Everything else equal, the lower the administrative support granted by a university, the higher the aim of affiliated academics to establish a non-technology spin-off. Scarce or virtually null support for in-house knowledge transfer activities will stimulate researchers to 'go out' and spin off. By spinning off, they can enjoy greater flexibility at the expense of losing already weak support from the university. Therefore, non-technology spin-offs might represent a way to compensate for administrative inadequacy and, to some extent, function as a substitute for other forms of internally managed technology transfer activities. Consequently, we expect higher rates of creation of non-technology spin-offs when and where administrative support is weak.

The propensity to create non-technology spin-offs might also be strong in highly bureaucratic environments. The degree of complexity of the administrative and bureaucratic procedures increases with size, with the risk that the large presence of administrative staff deteriorates, rather than improves, the speed and flexibility of the procedures required to create successful spin-offs. This bureaucratic burden may stimulate academics to seek more flexible alternatives to manage their industry collaborations and technology transfer activities. Therefore, we expect a U-shape relationship between the level of administrative support and spin-off propensity. When the ratio between administrative and academic staff is too low or too high, the staff may react by establishing non-technology firms to achieve better resource management and to fulfil the activities left unsatisfied by lacking or an excessively bureaucratic administrative staff.

On the basis of these arguments, we formulate the following hypothesis.

Hypothesis 2: A U-shape relationship exists between the amount of administrative support in a university and the rate of creation of non-technology firms.

3. Research design

3.1 Sample

In Italy, the academic spin-off phenomenon has increased significantly starting from the 1990s (Fini et al., 2009), following the introduction of a new dedicated regulatory framework focused on supporting scientific and technological research, knowledge transfer, and researchers' mobility (Law 297/1999 and Ministerial Decree 593/2000). Since then, public researchers can be involved in technology-transfer projects while keeping their university positions and wages. Today, the creation of academic spin-off companies is a consolidated phenomenon in the country, as the attention to science- and technology-based entrepreneurship now plays a significant role in Italian policy orientations aimed at promoting growth. Therefore, investigating the determinants of this rapid increase in the rate of establishment of academic spin-offs over the last two decades in this empirical setting is of interest (Iacobucci and Micozzi, 2014).

In our analysis, the sample is comprised of spin-offs from Italian universities established from 1999 to 2013. We started from 1999 because of the aforementioned Law 297/1999. The dataset is built using information available from university websites, where universities are required to list their affiliated spin-offs.[2] Our choice to trace academic spin-offs through university web pages has the advantage of including all and only 'official' academic spin-offs founded by university personnel. The dataset also comprehends spin-offs in which universities do not hold equity positions, but ignores spin-off activity that occurs 'through the back door' or 'outside the system', i.e. companies founded by academic without being disclosed to university administrators (Aldridge and Audretsch, 2010; Fini et al., 2010). We believe that this sample is representative; however, with a more inclusive definition of academic spin-offs, Bolzani et al. (2014) registered 813 spin-offs in the same period in Italy. Using data from the Italian Ministry of Education, University and Research (MIUR), we identify 96 universities in Italy. All of them are considered in our analysis, with the exception of 11 distance-learning

[2] For a more detailed description of this dataset, see Horta et al. (2014) and Vismara and Meoli (2015).

only universities because they are not engaged in any technology transfer activity. Overall, our sample is composed of 559 spin-offs established between 1999 and 2013 from 56 universities out of a population of 85 universities.

3.2. Technology and non-technology academic spin-offs

We classify academic spin-offs in technology and non-technology firms. According to the OECD classification, technology spin-offs are unambiguously identified as firms in high- and medium-high technology sectors. Hence, firms in Aerospace, Computers, Electronics-communications, Pharmaceuticals, Scientific instruments, Motor vehicles, Machinery, Chemical, and Transport equipment are considered technology spin-offs. All spin-offs belonging to other industries are classified as non-technology spin-offs.

Subsequently, we exemplify our classifications of spin-offs using the name of the spin-off, its parent university, year of foundation, and a brief description of the business.

Technology Spin-offs:

- Insono (University of Firenze, 2011) supplies electronic optical devices for process control in the pharmaceutical, petrochemical, and food industry;
- Microtech (University S. Anna of Pisa, 2000) produces medical devices for micro-invasive surgery; and,
- In3diagnostic (University of Torino, 2012) produces diagnostic reagents for veterinary purposes.

Non technology Spin-offs:

- Ius (University of Perugia, 2006) offers training and legal support for local institutions;
- Mint Publishing (University S. Anna of Pisa, 2000) delivers services to support publishing and teaching activities in the juridical field; and,
- Wel.Co.Me. (University of Bari, 2012) supports social cooperatives and public institutions by providing general counselling and organizing social and educational events.

Table 1 reports the number of spin-offs per year in our sample and the number of technology and non-technology spin-offs. Out of 559 spin-offs, 416 are technology-based firms (74.4%). Most of the spin-offs, in particular technology ones, are located in the richer North of Italy. At a national level, an increase in spin-off activity has occurred over time, with most spin-offs being created during 2004–2009. A lower number of firms were established during 2010–2013, arguably because of the effects of the economic crisis.

[INSERT HERE TABLE 1]

3.3 Model and explanatory variable

To perform our longitudinal study, we use negative binomial regressions for panel data, for which the dependent variable is the total number of spin-offs per university per year, or the number of technology or non-technology spin-offs. We measure the effect of our independent variables on 1,275 university-year observations (85 universities observed for 15 years between 1999 and 2013).

The main explanatory variable in our analysis of spin-off creation is the level of administrative support offered by the non-academic staff in a university, including both administrative and technical staff.[3] Most previous studies reviewed the administrative support for spin-off creation by focusing on direct support mechanisms, such as the presence of a TTO and its size, and controlled for size, patenting activity, and research eminence as potential additional sources for spin-off creation (see, for instance, Fini et al., 2011). A noteworthy exception is that of Landry et al. (2006), who mapped all resources available in the university context and verified whether each affects spin-off activity. Because our goal is to review the impact of the support provided by the entire non-academic staff, the mere analysis of TTO size is likely to be a too narrow approach. In contrast, the inclusion of a variable that directly measures the size of the non-academic staff is too simplistic because this measure depends on several aspects, including the number of functions that the university is carrying out internally, the number of students, and others. In turn, these functions depend on factors such as the institution's geographical location, the mix of scientific subjects offered, and so on. Additionally, our variable would not be able to capture organizational differences, such as outsourcing certain activities. In summary, each university is endowed with a certain quantity of non-academic staff, which is a function of several conditions. Only when all of these aspects are efficiently controlled, one can define whether the level of administrative support is lacking, good, or excessive. Therefore, to account for this phenomenon in our analysis, we estimate the quantity of 'normal' staff by regressing the actual number of staff against: university size, university age, faculty/student ratio, STEM (science, technology, engineering, and mathematics) faculty ratio, publications per faculty, university patenting activity, TTO size, Private university, a set of dummy variables for the presence of different fields of study (human studies and arts; science and technology; medicine; social sciences), and time dummies. The outcome of this regression is then employed to predict the 'normal' number of administrative staff enrolled each year in a university, whereas the variable we use in our analysis – defined as administrative support – is the deviation between the actual and the fitted value, with a zero mean by construction and standardized to have a unitary variance.[4]

We determine that our approach – a novelty in the literature and although still an approximation of reality – allows us to overcome many of the limitations associated with using the number of non-academic staff. On the one hand, the university-specific effects should capture all local factors that determine the ordinary endowment of non-academic staff at a certain university, as well as internal organizational choices such as service outsourcing, or potential local biases such as inefficient recruitment in certain areas. On the other hand, time dummies are likely to capture contextual changes that might jointly affect these aspects for all universities at the national level.

The variable we constructed in such a fashion allows us to take a longitudinal perspective, with an independent variable that varies across individual (i.e. universities) and years.[5] To test whether the relationship between the amount of administrative support and the academic spin-off activity is U-shaped, we also add the squared value of administrative support. Both variables are included in our model with their lagged value because the creation of spin-offs is likely affected by the level of service available at the beginning of each period.

3.4 Control variables

[3] Technical staff might indeed support technology spin-offs but may hardly benefit non-technology ones. Therefore, coherently with our first hypothesis, an increase in the level of administrative (including technical staff) support positively affects the rate of creation of technology academic spin-offs.

[4] The results of this estimation are reported in the first column of Table 1.

[5] For instance, the size of the TTOs does not vary significantly over time. Therefore, we treat this factor as a control variable rather than as an alternative for our main variable in the paper.

In accordance with recent literature on the determinants of academic spin-off creation, and with a specific reference to the Italian context (see, for instance, Fini et al. 2011), we identify two sets of control variables as predictors of spin-off activity. These variables account for the features of the university-specific and the local context, which are all included in our model with their lagged values.

The first category is composed of university-level control variables: university size (number of students, including Bachelor, Master, PhD, and specialization courses) is included as a general proxy of the organizational assets available; university age (number of years since foundation) controls for the differences in the organization, resources, and culture of older and younger institutions; the faculty/students ratio (ratio between total number of faculty and the total number of students) measures the endowment of academic staff with respect to institutional size; the STEM faculty ratio (number of academic staff in science, technology, engineering, and mathematics divided by the total number of academic staff) controls for the weight of the academic staff in the disciplines acknowledged by the literature as the sources of knowledge for spin-off activity; Publication per faculty (number of papers published in a year by all faculty of a university according to the Scopus database divided by the number of professors) controls for research productivity as a measure of research eminence; university patenting activity (number of patents) accounts for the output of research activity that might fuel spin-off creation; the size of the TTO[6] (number of full-time employees) measures the direct support of the administrative staff for spin-off creation; and Private university is a dummy variable equal to one for private universities and zero otherwise and accounts for the different business model and, potentially, the spin-off orientation of non-public organizations.

The second category of contextual factors groups regional level control variables, identified in Fini et al. (2011) and Horta et al. (2015). This category includes regional GDP growth (in percentage) to account for the higher probability of setting up a business in a region experiencing a favourable economic cycle; regional patenting activity (number of patents at the regional level), since locally available competences shape the patterns of technological diversification (Colombelli et al., 2014); percentage of graduates in STEM relative to the number of total graduates because of the better opportunities to find human capital to be employed; and regional R&D expenditures (regional R&D expenditures over regional GDP) as a measure of public support for the innovation activity.

In addition to all controls presented, we include a set of dummy variables related to the Italian macro regions to account for of all potential unobservable differences between these areas. We also include time dummies to control for unobservable time-varying factors.

Our sources of the control variable data are the MIUR (Italian Ministry for University and Research) for information on academic staff, the SCOPUS database for university publications and patenting data, and the CRUI (Conference of Rectors of Italian Universities) for TTO size. The data that refer to the local context are collected from the ISTAT (Italian National Institute of Statistics). Details on the variable definitions and their sources are reported in Table 2, and the correlation matrix is reported in the Appendix. The last two columns of Table 2 report the descriptive statistics for the 1,275 university-year observations employed for our empirical analysis. The average Italian university enrols approximately 31,000 students, with a faculty per student ratio of 3.6%. Although not all Italian universities in Italy have a TTO (66 out of 85 universities identify a specific TTO on their Internet sites), almost all universities link this activity to a certain office. The average number of full-time employees fully dedicated to technology transfer activity is 4.4. R&D

[6] Although a number of papers control for both the presence and the size of the TTO, we prefer to drop the first variable. Although only 66 out of 85 Italian universities report the activity of a proper TTO on their Internet size, in practice all of them link this activity to some other office, potentially biasing the effect of such a variable. Our variable, TTO size, accounts for the staff dedicated to technology transfer activity.

expenditures for public administrations, universities, and private and public enterprises account for only 1.1% of the GDP of Italy.

[INSERT HERE TABLE 2]

4. Results

Table 3 reports the estimates of negative binomial panel regressions on the number of spin-offs created per year by the 85 Italian universities (Models 1-6), and the coefficients for the estimate of the 'normal' level of administrative support (Model 7). For each spin-off variable, we report the result of two regressions: the first model includes the effect of administrative support, and the second model tests for the existence of a (reverse) U-shape effect of administrative support adding the quadratic term. The dependent variables employed are the following: total number of academic spin-offs by university per year (Models 1 and 2) and the number of technology (Models 3 and 4) and non-technology spin-offs (Models 5 and 6) as identified in Section 3.2. In all models, we include all university-level and context-level control variables, and a set of dummies to control for macro-regional effects.

Model (1) reports evidence that stronger administrative support enhances the probability of observing spin-off creation in general. Model (2) reports a non-significant coefficient for the quadratic term for administrative support, neglecting the possibility of a curvilinear relationship. Most control variables confirm the expectations. A larger university size increases the probability of spin-offs, with the exception of non-technology. A positive regional context in terms of GDP growth, R&D activity, and STEM graduates is also correlated to a higher rate of spin-off establishment, with no statistical significance in the case of non-technology spin-offs. No significant effect exists for the other control variables. Using Models 3 and 4, we focus on technology spin-offs, whose creation is linearly and positively affected by administrative support. Interestingly, the magnitude of the administrative support coefficient is larger for this subgroup of spin-offs. These results support Hypothesis 1.

Using Models 5 and 6, we investigate whether the same relationships apply to non-technology spin-offs. The results are quite different from those observed on the full sample and on the sample of pure technology spin-offs. Model 5 does not provide adequate evidence to support the existence of a negative linear relationship, whereas Model 6 suggests a U-shaped effect on non-technology spin-off activity. These results support Hypothesis 2. At low levels of administrative support, a negative relationship exists between administrative support and non-technology spin-off activity, which points to the academic staff founding spin-offs also to supplement staff deficiencies. In contrast, when the administrative support is very high, non-technology spin-offs might be responsive to a high degree of complexity in the administrative and bureaucratic procedure.

[INSERT HERE TABLE 3]

The different role played by administrative support in creating different types of spin-offs is made explicit in Figure 1. We plot the marginal effects on the number of technology (solid line) and non-technology spin-offs (dashed line) created per year by Italian universities during 1999–2013, as estimated by the negative binomial panel regressions reported in Table 3, Models (3) and (6), respectively. The marginal effects are estimated for administrative support values from –0.7 to +0.7, eliminating approximately 2.5% of the lowest and highest values. The plotted lines show the constant increase in the prediction of the number of technology spin-offs created with the increase in administrative support. In contrast, the strongest boost for creating non-technology spin-offs is given by a low level of administrative support when the current number of non-academic staff is below the ‘normal’ level (academic support<0). Given an increase in such a variable, the number of expected spin-offs decreases to the minimum estimated when administrative support equals 0.2. For administrative support higher than 0.2 (corresponding to approximately 25% of the university-year observations in our sample), the effect on non-technology spin-off creation becomes positive. Indeed, this effect is not likely related to staff deficiencies but rather to excess bureaucracy. Because the non-academic staff is at its ‘normal’ level, as fitted by our model, when administrative support equals zero, we infer that an initial low level of extra staff still reduces the generation of non-technology spin-offs. In contrast, when the value is particularly high – possibly causing the development of an excessively bureaucratic environment – the academic staff might be prone to spin off non-technology firms to avoid slow and redundant internal procedures.

4.1 Robustness tests

The line of arguments on administrative deficiencies and excess bureaucracy is further tested as follows. First, although our analysis attempts to control for a number of factors in both the process of determining the ‘normal’ level of academic staff and the creation of spin-offs, we acknowledge that a potential source of bias is related to our inability to control for some non-quantitative but potentially relevant phenomena. An example is that of the formal and informal governance mechanisms that could be at work in a university to support the staff involved in the creation of spin-offs, which former studies attempt to address by referring to the survey data (Fini et al., 2011). Still, when analysing the Italian context, one should consider that the Italian university system has been traditionally characterized by a high degree of isomorphism at the institutional level, particularly because all state universities had to adapt to a set of tight rules set by the central government (Capano, 2008). Indeed, the institutional governance of Italian universities was recently revised through the so-called Gelmini reform that – notwithstanding a rhetoric claim of change towards higher autonomy – actually tightened up central regulation (Donina et al., 2015) and failed to allow for a high degree of governance diversification.

In our previous analysis, we controlled for the potential difference between public and private universities by including a ‘private’ dummy variable in all specifications. In general, this aspect could be addressed by including fixed effects in our analysis, although doing so implies the technical exclusion from our analysis of all universities with no spin-offs during the sample period. We include the results obtained by estimating our models with fixed effects on the subsample of universities with at least one spin-off during the sampling period.[7] Interestingly, although minor changes occurred with respect to the significance of some control variables, all of the models confirmed our results on the role of administrative support. In terms of significance, the result of non-technology spin-offs is likely to be affected by the smaller sample dimension.

[INSERT HERE TABLE 4]

Second, as a further robustness check, we split our sample of university-year observations according to the level of administrative support to identify the minimum level of expected non-technology spin-off creation. We identify university-year observations for which the administrative support is below (administrative support<0) and higher than

[7] This model is specified by eliminating some variables from the previous list because the fit either perfectly or are almost collinear with the fixed effects. These variables are university age, TTO size, private university, and macro-region dummies.

‘normal’ (administrative support>0), and repeat our estimations on the total number of spin-offs and the number of technology and non-technology spin-offs. The results are reported in Table 4.[8] Models (1), (2), and (3) are negative binomial panel regressions on the total number of spin-offs, technology spin-offs, and non-technology spin-offs, respectively. These models are run on the subsample of universities with weak administrative support. Models (4), (5), and (6) report the same analyses for universities with strong administrative support. We find that the total number of spin-offs and the number of technology spin-offs simply increase with the level of administrative support, although the coefficient’s magnitude is much stronger for the first subsample. The number of non-technology spin-offs decreases in the first subsample, consistent with the view that they surrogate administrative support when this function is lacking. In contrast, for a strong level of administrative support, their numbers increase, possibly because of excess bureaucracy at the institutional level.

[INSERT HERE TABLE 5]

5. Conclusions

Through a longitudinal study of 559 spin-offs launched from 85 Italian universities from 1999 to 2013, this paper extends the scope of the determinants that establish academic spin-offs to consider the contingent effects of bureaucratic inadequacies within the university system. Our results show that, although sufficient administrative support is generally required to boost spin-off activity – particularly true for technology spin-offs – the parent university’s administrative inadequacy leads to a larger number of non-technology spin-offs. We find evidence of a stimulus to ‘go out’ and establish this type of spin-off when university support for technology transfer activity is particularly inadequate, either because it is insufficient or highly bureaucratic. In particular, by using non-technology spin-offs as a surrogate for administrative support, academics might be prone to create firms to enjoy higher flexibility and more freedom to manage human and cash resources.

Our finding contributes to explaining why some studies find that TTO activities play only a marginal role in driving academics to start new ventures. The relationship between university support and the rate of establishment of academic spin-offs is indeed (1) not independent from the nature of spin-offs and (2) not linear. The incentive to create certain types of spin-offs is indeed in place when university support is inadequate, which means either weak or too bureaucratic. Therefore, we point to an incomplete understanding of the motivations leading to the creation of academic spin-offs and the related policies to possibly sustain them. Given that their post-entry performance is typically weak, policy makers should not implicitly assume that the creation of academic spin-offs is per se important and that ‘more is better’. Although the opportunity for staff and students to experience entrepreneurship is positive, it is indeed not part of the third mission of a university. Further research in this direction will allow policy makers to derive considered judgments regarding the behaviors to promote.

We believe that our contribution directly affects potential academic managers and policy makers. First, this paper provides university managers with evidence that satisfactory spin-off activity is not necessarily related to outstanding performance in the university ‘third mission’, whereas administrative deficiencies may exist at the basis of such results. Second, we shed some light on the decision to become an entrepreneur. The peculiarity of this decision in academia needs to be considered in light of its nature of hybrid entrepreneurship and related to the alternative business engagement possibilities

[8] Non-technology spin-offs are eliminated from these robustness tests because the limited number of spin-offs in the two subsamples does not allow for the convergence of model estimates.

offered within the university. Third, our results are relevant for policy makers: whereas the attention on academic spin-offs has been frequently motivated by the potential ability to advance scientific knowledge and to contribute to regional economic growth, we show the importance of non-financial motivations in creating academic spin-offs. In fact, our results are of interest for the stream of research that highlights the poor performance records of academic spin-offs because their establishment is often not driven by pure growth orientation. This phenomenon ultimately casts doubt on the appropriateness of public incentives to establish spin-offs and on their short-term metrics.

We acknowledge that our analysis is not without limitations, which offer several avenues for further research. First, the significant increase in spin-off activity, particularly of non-technology firms, can be specific to the Italian context that we selected for our analysis. Thus, caution should be paid in generalizing the implications. Theories and practices developed in a single institutional setting do not necessarily hold across countries, regions, and cultures (e.g. Munari et al., 2015; Rasmussen et al., 2014). Therefore, comparative studies are needed at the crossroad between entrepreneurial finance and technology transfer (Audretsch et al. 2016). Second, our analysis is limited to observing spin-off activity but does not investigate their performance. We believe that whether spin-off activity that is generated by a lack of administrative efficiency ultimately ends in growth or simply limits the efficacy of solving contingent academic needs is worth investigating. Nevertheless, to provide more robust results, future research should consider their performance. Third, other 'second-best' motivations may exist that lead to the creation of academic spin-offs. For instance, young scientists could sometimes become academic entrepreneurs because of shortcomings in the market for knowledge. In particular, although the number of Ph.D. students is increasing, public support for universities in many countries is decreasing and is evolving towards improving the efficiency of research organizations rather than increasing research expenditures (Mangematin, 2000). In these conditions, an entrepreneurial career through the foundation of an academic spin-off can give a doctorate holder satisfactory exploitation of advanced knowledge in a certain field of expertise. Overall, we believe that research on academic entrepreneurship benefits from recognizing the highly heterogeneous nature of spin-offs, and the related different motivations, aims, and – consequently – outcomes.

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Table 1. Sample. Table 1 reports the number of academic spin-offs that occurred in Italy from 1999 to 2013. Technology spin-offs are firms in high- and medium-high technology sectors according to the OECD classification.

	Spin-offs		Technology	
Year	No.	%	No.	%
1999	15	2.7	13	86.7
2000	9	1.6	8	88.9
2001	7	1.3	6	85.7
2002	7	1.3	5	71.4
2003	31	5.5	23	74.2
2004	50	8.9	36	72.0
2005	43	7.7	34	79.1
2006	46	8.2	31	67.4
2007	78	14.0	54	69.2
2008	71	12.7	55	77.5
2009	57	10.2	43	75.4
2010	38	6.8	32	84.2
2011	40	7.2	28	70.0
2012	41	7.3	29	70.7
2013	26	4.7	19	73.1
Total	559	100.0	416	74.4

Table 2. Variable Definition. MIUR is the Italian Ministry of Research and Education; SCOPUS is an abstract and citation database by Elsevier; CRUI is the Conference of the Rectors of Italian Universities; and ISTAT is the Italian National Statistical Institute. University-level control variables are measured per year and per university; Context-level control variables per region per year.

Variable	Definition	Source	Mean	Std dev
Administrative support	Deviation between actual and fitted value for the number of people in the administrative staff of a university in a year. The fitted value is obtained from a first-stage model, in which the actual number of staff is estimated against university size, university age, faculty/students ratio, STEM faculty ratio, publications per faculty, university patenting activity, TTO size, private university, a set of dummy variables for the presence of different fields of studies (human studies and arts; science and technology; medicine; social sciences), and time dummies. In all of the regression analyses, the value is standardized to a zero mean and unitary standard deviation.[1]	MIUR	1,132.1	1,186.4
University-level control variables				
University size	Number of students, including Bachelor, Master, PhD, and specialization courses (logarithms are used in regressions)	MIUR	31.2	27.5
University age	Number of years from foundation	MIUR	293.0	315.1
Faculty/students ratio	Ratio of the number of academics to the number of students	MIUR	3.6	2.9
STEM faculty ratio	Ratio of the number of academics in science, technology, engineering, and mathematics to the total number of professors	MIUR	29.1	19.1
Publications per faculty	Ratio of the total number of papers published by the faculty of a university in a certain year to the total number of professors	SCOPUS	0.8	0.7
University patenting activity	Number of patents granted per year per university	SCOPUS	4.7	7.4
TTO size	Number of employees in TTOs	CRUI	4.4	2.8
Private university	Dummy variable equal to one for private university and zero otherwise	MIUR	17.6	38.1
Context-level control variables				
Regional GDP growth	Growth rate of regional gross domestic product	ISTAT	0.1	3.3
Regional patenting activity	Number of patents granted by the European Patent Office (per million people)	ISTAT	71.1	55.4
STEM graduates	Number of graduates in science, technology, engineering, and mathematics between 20 and 29 years old (per thousand people)	ISTAT	10.6	4.6
R&D expenditure	Percentage of GDP of R&D expenditures for public administrations, universities, and private and public enterprises	ISTAT	1.1	0.4

[1] In all empirical analyses, we use the 'Administrative support' variable, defined as the deviation from a 'normal' level of administrative staff. By construction, 'Administrative support' has a zero mean on the full sample (because it is the error term from a regression analysis). In the regression analyses, 'Administrative support' is standardized to have a unitary volatility. The mean and standard deviation reported in this table refer to the number of academic staff.

Table 3. Regressions on the number of spin-offs per year. Table 3 reports the results of negative binomial panel regressions on the total number of spin-offs created per year by all Italian universities (excluding distance learning-only institutions) during 1999–2013. In Models 1 and 2, the dependent variable is the total number of spin-offs; in Models 3 and 4, the number of technology spin-offs; and in Models 5 and 6, the number of non-technology spin-offs. Models 1–6 include controls for the geographic area (North, Central, South) and time dummies. Model 7 is the OLS regression of administrative staff as a function of all university level controls. The estimated residuals of this regression are standardized to unitary variance and used as measure for 'administrative support' in the other models. This model includes controls for disciplinary fields (human studies and arts; science and technology; medicine; social sciences), macro-regions (North, Central, and South), and time dummies. In all models, all independent variables are one-period lagged. ***, **, and * indicate significance at the 1, 5, and 10 per cent levels, respectively.

	Spin-offs		Technology Spin-offs		Non-Technology Spin-offs		Administrative Support
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Administrative support	0.129***	0.119***	0.138***	0.126***	–0.132	–0.511**	
	(0.047)	(0.043)	(0.048)	(0.045)	(0.151)	(0.213)	
Administrative support (squared)		0.057		0.069		0.287***	
		(0.048)		(0.048)		(0.100)	
University size	0.488***	0.398**	0.518***	0.411**	–0.233	–0.331	0.999***
	(0.171)	(0.184)	(0.170)	(0.182)	(0.337)	(0.331)	(0.021)
University age	–0.001	–0.001	–0.001	–0.001*	–0.000	–0.000	0.21***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.004)
Faculty/students ratio	–1.832	–1.437	–1.871	–1.395	0.408	0.736	–3.259***
	(1.550)	(1.562)	(1.566)	(1.572)	(3.029)	(2.927)	(0.176)
STEM faculty ratio	–0.186	0.081	–0.182	0.145	1.715	1.870*	0.086
	(0.609)	(0.631)	(0.611)	(0.630)	(1.091)	(1.048)	(0.069)
Publications per faculty	0.134	0.084	0.245	0.185	–0.608	–0.864	–0.021
	(0.375)	(0.371)	(0.373)	(0.368)	(0.777)	(0.773)	(0.057)
University patenting activity	0.001	0.004	–0.001	0.002	0.032*	0.037**	0.001
	(0.009)	(0.010)	(0.009)	(0.010)	(0.019)	(0.019)	(0.002)
TTO size	0.026	0.031	0.029	0.036	–0.042	–0.025	–0.006
	(0.040)	(0.038)	(0.039)	(0.037)	(0.067)	(0.065)	(0.004)
Private university	–1.238	–1.132	–1.142	–1.015	2.119	1.750	0.480***
	(0.837)	(0.824)	(0.834)	(0.816)	(1.301)	(3.351)	(0.088)
Regional GDP growth	3.341*	3.319*	3.748**	3.699**	–0.905	–1.750	
	(1.761)	(1.758)	(1.787)	(1.783)	(3.332)	(3.351)	
Regional patenting activity	0.001	0.002	0.001	0.002	–0.003	–0.003	
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	
STEM graduates	0.161***	0.160***	0.153***	0.152***	0.249***	0.240***	
	(0.029)	(0.029)	(0.029)	(0.029)	(0.066)	(0.066)	
R&D expenditure	1.345***	1.272***	1.288***	1.202***	2.303***	2.032***	
	(0.325)	(0.325)	(0.324)	(0.322)	(0.722)	(0.703)	
Constant	–5.889***	–5.113***	–5.249***	–5.586***	1.932	2.710	–4.528***
	(1.825)	(1.905)	(1.175)	(1.253)	(3.597)	(3.523)	(0.222)
Observations	1,275	1,275	1,275	1,275	1,275	1,275	1,275
Log-likelihood	–852.5	–851.3	–859.5	–858.9	–627.8	–624.6	–12.23

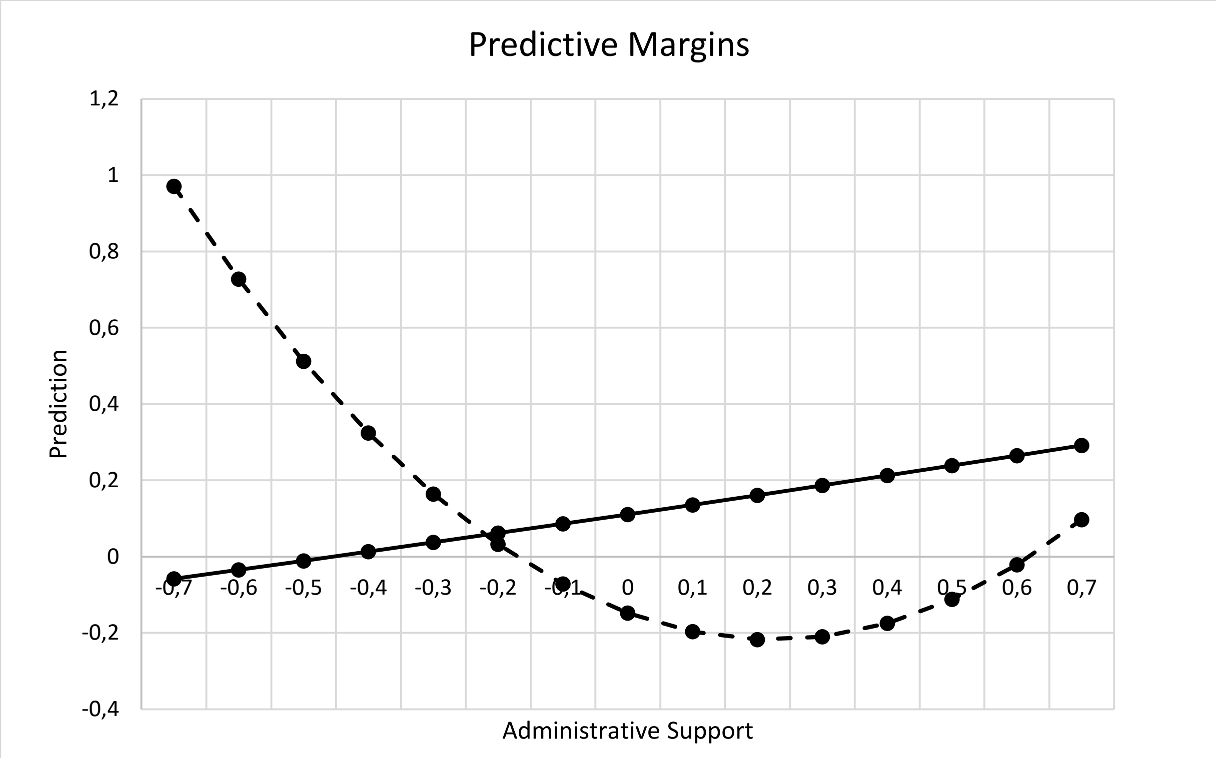
Table 4. Fixed effects regressions on the number of spin-offs per year. Table 4 reports the results of negative binomial panel regressions (with fixed effects) on the total number of spin-offs created per year by all Italian universities with at least one spin-off during 1999–2013. In Models 1 and 2, the dependent variable is the total number of spin-offs (54 universities with at least one spin-off); in Models 3 and 4, the number of technology spin-offs (54 universities with at least one spin-off); in Models 5 and 6, the number of non-technology spin-offs (31 universities with at least one spin-off). University age, TTO size, private university, and the macro-region dummies are excluded from this analysis because of collinearity with the fixed effects. Time dummies are included in all regressions. All independent variables are one-period lagged. ***, **, and * indicate significance at the 1, 5, and 10 per cent levels, respectively.

	Spin-offs		Technology Spin-offs		Non-Technology Spin-offs	
	(1)	(2)	(3)	(4)	(5)	(6)
Administrative support	0.112***	0.106***	0.119***	0.109***	–0.158	–0.518**
	(0.040)	(0.38)	(0.042)	(0.039)	(0.152)	(0.231)
Administrative support (squared)		0.042		0.027		0.257**
		(0.073)		(0.075)		(0.113)
University size	0.163	0.243	0.162	0.212	–1.521**	–1.618**
	(0.288)	(0.324)	(0.292)	(0.325)	(0.759)	(0.770)
Faculty/students ratio	2.763	2.454	3.187	2.984	0.569	0.835
	(2.014)	(2.086)	(2.061)	(2.136)	(4.824)	(4.737)
STEM faculty ratio	–0.286	–0.517	–0.543	–0.694	1.957	2.165
	(1.057)	(1.133)	(1.064)	(1.145)	(2.976)	(2.887)
Publications per faculty	–0.497	–0.462	–0.299	–0.276	–1.329	–1.894
	(0.541)	(0.547)	(0.547)	(0.552)	(1.262)	(1.320)
University patenting activity	0.008	0.006	0.007	0.006	0.031*	0.036*
	(0.010)	(0.011)	(0.010)	(0.011)	(0.019)	(0.021)
Regional GDP growth	2.448	2.442	2.938	2.941	–1.453	–2.262
	(1.815)	(1.815)	(1.846)	(1.846)	(3.364)	(3.388)
Regional patenting activity	0.006	0.005	0.006*	0.006*	–0.009	–0.011
	(0.004)	(0.004)	(0.004)	(0.004)	(0.009)	(0.010)
STEM graduates	0.210***	0.212***	0.199***	0.200***	0.430***	0.434***
	(0.035)	(0.035)	(0.035)	(0.035)	(0.111)	(0.114)
R&D Expenditure	1.664***	1.688***	1.638***	1.656***	3.422**	3.026**
	(0.502)	(0.512)	(0.507)	(0.515)	(1.456)	(1.492)
Costant	–1.242	–1.974	–1.117	–1.570	15.071*	16.068*
	(3.055)	(3.357)	(3.100)	(3.372)	(8.372)	(8.535)
Observations	810	810	810	810	465	465
Log-likelihood	–488.8	–488.6	–478.5	–478.4	–234.4	–232.1

Table 5. Splitting universities with weak and excess administrative support. This table shows the results of negative binomial panel regressions on the number of spin-offs created per year, splitting the sample between universities with negative and positive values for Administrative support. Models 1 to 3 report the results for the sample of Universities-Year observations with a weak administrative support (Administrative support is lower than 0), respectively on the total number of spin-offs, on technology and non-technology spin-offs. Models 4 to 6 report the results for the sample of Universities-Year observations with strong administrative support (administrative support is greater than zero), respectively on the total number of spin-offs, on technology and non-technology spin-offs. Controls for the geographic area (North, Central, South) and time dummies are included in all regressions. All independent variables are one-period lagged. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

	Weak administrative support			Excess of administrative support		
	(1) All spin-offs	(2) Technology spin-offs	(3) Non-technology spin-offs	(4) All spin-offs	(5) Technology spin-offs	(6) Non-technology spin-offs
Administrative support	0.444***	0.450***	–0.127***	0.241***	0.278***	0.068**
	(0.115)	(0.115)	(0.090)	(0.080)	(0.090)	(0.033)
University size	0.204	0.234	–0.473	0.594	0.570	0.732
	(0.218)	(0.219)	(0.357)	(0.416)	(0.406)	(0.991)
University age	–0.001	–0.001*	0.001*	–0.001	–0.001	–0.001
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.003)
Faculty/students ratio	–0.642	–0.626	3.098	2.818	3.294	–2.636
	(1.749)	(1.767)	(2.877)	(3.921)	(3.963)	(8.800)
STEM faculty ratio	0.908	1.061	2.739**	0.505	0.423	–0.008
	(0.924)	(0.924)	(1.117)	(0.941)	(0.911)	(2.121)
Publications per faculty	–0.325	–0.240	–0.167	0.807	0.965	–0.171
	(0.485)	(0.486)	(0.856)	(0.745)	(0.737)	(1.909)
University patenting activity	0.008	0.006	0.051**	–0.017	–0.019	0.005
	(0.012)	(0.012)	(0.022)	(0.015)	(0.016)	(0.030)
TTO size	0.096*	0.100*	0.022	–0.085	–0.063	–0.074
	(0.055)	(0.055)	(0.065)	(0.065)	(0.065)	(0.130)
Private university	0.211	0.229	2.577**	–3.774***	–3.473**	–0.785
	(0.886)	(0.885)	(1.115)	(1.376)	(1.356)	(2.497)
Regional GDP growth	2.800	2.741	–1.202	0.171	1.767	0.380
	(2.079)	(2.088)	(4.243)	(3.671)	(3.915)	(6.473)
Regional patenting activity	0.004*	0.004*	–0.001	0.001	0.002	–0.007
	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.011)
STEM graduates	0.180***	0.173***	0.143**	0.152***	0.141**	0.336**
	(0.037)	(0.037)	(0.067)	(0.056)	(0.057)	(0.141)
R&D Expenditure	1.917***	1.871***	2.522***	1.434**	1.464**	1.611
	(0.431)	(0.433)	(0.805)	(0.701)	(0.693)	(1.543)
Constant	–2.661	–3.033	4.336	–6.700*	–6.911*	–7.947
	(2.380)	(2.394)	(3.704)	(3.868)	(3.684)	(9.040)
Observations	675	675	675	600	600	600
Log-likelihood	–524.7	–512.2	–197.3	–339.3	–336.5	–192.1

Figure 1. Figure 1 reports the marginal effects of administrative support on the number of technology (solid) and non-technology spin-offs (dashed) created per year by all Italian universities (excluding distance learning-only institutions) during 1999–2013, as estimated by the negative binomial panel regressions reported in Table 3, Model (3) and (6) respectively. The marginal effects are estimated for values of extra support from to 0.7 and 2.1, and eliminating 2.5% of the lowest and highest values.



Appendix. Correlation matrix. This table shows the correlation matrix for the variables used in the empirical analysis. * indicates significance at the 1 per cent level.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Spin-offs	1.000														
2	Technology spin-offs	0.992*	1.000													
3	Non-technology spin-offs	0.502*	0.433*	1.000												
4	Administrative support	0.001	0.003	–0.031	1.000											
5	University size	0.206*	0.206*	0.109*	0.260*	1.000										
6	University age	0.206*	0.203*	0.107*	0.000	0.499*	1.000									
7	Faculty/student ratio	–0.017	–0.015	–0.033	0.093	–0.598*	0.382*	1.000								
8	STEM faculty ratio	0.133*	0.131*	0.105*	0.069	0.230*	0.070	0.088	1.000							
9	Publications per faculty	0.033	0.032	0.000	–0.029	–0.423*	0.272*	0.826*	0.032	1.000						
10	University patenting activity	0.297*	0.291*	0.160*	0.153*	0.305*	0.266*	0.007	0.212*	0.142*	1.000					
11	TTO size	0.260*	0.266*	0.134*	0.182*	0.392*	0.258*	0.092	0.209*	0.106*	0.364*	1.000				
12	Private university	–0.177*	–0.175*	–0.085	0.165*	–0.269*	–0.300*	–0.020	–0.170*	–0.124*	–0.218*	–0.417*	1.000			
13	Regional GDP growth	–0.042	–0.043	–0.025	0.008	–0.134*	–0.109*	–0.011	0.028	–0.044	–0.036	–0.093	0.248*	1.000		
14	Regional patenting	0.122*	0.118*	0.048	–0.060	–0.006	0.197*	0.171*	0.127*	0.136*	0.233*	0.120*	0.017	0.245*	1.000	
15	STEM graduates	0.154*	0.153*	0.068	0.021	–0.106*	0.179*	0.177*	0.070	0.287*	0.260*	0.000	0.159*	0.196*	0.361*	1.000
16	R&D expenditure	–0.028	–0.025	–0.068	0.224*	–0.120*	–0.082	0.135*	0.020	0.153*	0.122*	–0.092	0.385*	0.241*	0.209	0.567*