The relationship between university management practices and the growth of academic spin-offs

Mario Benassi

Department of Economics,Management and Quantitative Methods, University of Milan, Italy

mario.benassi@unimi.it

Matteo Landoni

ICRIM, Università Cattolica del Sacro Cuore, Milan, Italy

matteo.landoni@unicatt.it

Francesco Rentocchini

Department of Economics, Management and Quantitative Methods, University of Milan, Italy

francesco.rentocchini@unimi.it

Abstract

There is a paucity of studies which have analysed the role of internal processes for academic spinoffs in a systematic way. We focus on a specific nuance of internal processes which relate to the management practices that universities can put in place to influence the growth of academic spinoffs. Building upon recent literature on the empirical economics of management, we investigate whether and how different forms of management practices contribute to the growth of academic spin-offs. We collect survey data on universities' management practices by focusing on technology transfer offices, as well as drawing on a longitudinal sample of 790 Italian university spin-offs founded by 42 different Italian universities, which were observed over the period of 2006 to 2014. Our findings show that management practices help to explain the growth of academic spin-offs, although their effect varies across management practices. Supporting operations in the form of patenting and training as well as the existence of incentives are found to have a positive association with spinoff growth. A negative association is instead found for target setting (spinoff growth targets) and hiring of external management with private sector experience. We provide an explanation of these results by pointing to a combination of adverse selection, short-termism and weak enforceability by universities. Drawing on our results, the adoption of management practices by university managers and policy makers should be carefully considered, as they might have unintended consequences on the growth of academic spin-offs.

Keywords: Management practices; Academic spin-offs**;** Spin-offs Growth**;** Internal processes

JEL Codes: M13; O30; M21; R11

1. Introduction

Academic spin-offs – defined as companies where either a founder is affiliated with the university or the university itself holds a share in the company[1] – have gained increasing attention from scholars in recent decades (Rasmussen, Moosey and Wright, 2011, Mathisen and Rasmussen, 2019; for a systematic review, see Rothaermel et al., 2007; Schmitz et al., 2016).

Within the large body of literature investigating academic entrepreneurship, two main areas of research have gained prominence. A first stream of the literature has focused on the antecedents of academic entrepreneurship, attempting to address the main drivers leading to the creation of academic spin-offs. A second stream of research has concentrated on the outcome of university entrepreneurship processes, evaluating the performance of academic spin-offs from different perspectives (Zhang, 2009). In evaluating the performance of academic spin-offs, growth is a key issue as academic spin-offs often remain small, are exposed to market selection and face very low survival rates. These two streams of research have been seldom connected with the investigation of internal processes universities employ with academic spin-offs. As universities may exhibit marked differences in their attitudes towards spin-offs (Benassi, 2014), university internal processes can play a pivotal role for spinoffs growth.

In our work, we focus on a specific nuance of internal processes which relate to the management practices that universities can put in place to help the growth of academic spinoffs. We build upon the recent literature on the economics of management practices (Bloom et al., 2012, 2014, 2017) which has consistently shown how a defined set of

[1] We adopt this last definition in accordance with the report of Netval, the Italian association for the valorisation of results from public research (Ramacciotti and Daniele, 2015).

management practices (i.e. monitoring performance, target setting, incentive setting and people management) contributes to explaining a large proportion of the variability in the performance of organisations (both private and public) (Bloom et al., 2010; 2014). Building upon this literature, management practices can be conceived as routines, rules and processes, which relate to the deep-seated structure of organisations (Bloom et al., 2014). Our goal is twofold. First, we want to assess whether management practices in a university affect the growth of academic spin-offs. Existing research on management practices posits that they matter also in universities (McCormack, Propper, and Smith, 2014). However, this is not necessarily the case of academic spin-offs, as they originate from organisations with primary goals that are far from profit-oriented (Merton, 1973; Dasgupta and David, 1994). Second, we want to assess which management practices are related to academic spin-offs' growth, and how.

In order to investigate the two research questions outlined above, we rely on a longitudinal dataset comprising 790 Italian university spin-off companies observed over the period of 2006 to 2014.

The remainder of this article is organised as follows. Section 2 offers a review of the most recent research on academic spin-offs and management practices and sets forward our key research questions. Section 3 presents data and methodology, Section 4 outlines and discusses the results, and Section 5 concludes.

2. Literature Review and Research Questions

2.1 Academic entrepreneurship, management practices and universities' internal processes

Academic spin-offs are a possible vehicle to extract value from the innovative knowledge universities produce (Di Gregorio and Shane, 2003), nevertheless the adoption of an

entrepreneurial model and the creation of academic spin-offs can be a quantum leap for universities. Institutional rules and cultural barriers can make entrepreneurship inside universities a nearly impossible mission (Markman *et al.*, 2004; Bercovitz and Feldman, 2008; Sauermann and Stephan, 2012). Furthermore, norms and beliefs shared among faculties might significantly limit entrepreneurial behaviour (Louis *et al*., 1989). Therefore, academic spin-offs can be comparatively more exposed to the "liability of newness" problem (Stinchcombe, 1965). These limits make some scholars sceptical of universities' contribution to fostering entrepreneurship (Cohen et al., 1998; Florida and Cohen, 1999; Miranda et al., 2018).

We share the view that the tasks involved in the creation and support of spinoffs represent new challenges for universities, as they are quite different from the ones that these organisations have been exposed to for centuries. One way of dealing with these challenges is to adopt specific management practices in the process of creating and assisting academic spin-offs, providing support and selectivity policies and programs that reduce administrative burdens or provide tax incentives and access to financing, business networks, and training (Patzelt and Shepherd, 2009).

Management practices[2] are a key concept in organisational theory since the 1960s (Likert, 1961). The central tenet is that organisations learn which management practices to pursue and discriminate among different alternatives while, at the same time, they redefine them by learning as they evolve (March, 1999). By placing good and effective practices in place, managers can improve the performance of their organisation. Management practices are not

[2] According to this definition, management practices should not be confused with managerial capital, which refers mainly to the talent and skills of individuals (such as a manager) and comes as the aggregation of individual contributions but lacks an organisational dimension (Bertrand and Schoar, 2003).

an attribute of single managers: they reflect the collective accumulation of knowledge and can change over time.

Literature on management practices has gained momentum in recent years (Bloom et al., 2012, 2014, 2017). This stream of research investigates and explains differences in management practices across organisations and countries in different sectors (Bloom et al., 2016). The authors show how practices put in place by managers contribute to explaining a large proportion of the variability in the performance of organisations. The former literature has grouped management practices into three broad areas: monitoring (how well organisations monitor what goes on inside and apply to continuous improvement), targets (whether organisations set the right targets, track the right outcomes, and take appropriate action if the two are inconsistent), and incentives (how well organisations promote and reward employees based on performance, and try to hire and keep their best employees) (Bloom and van Reenen, 2006).

Management practices have been found to explain variation among organisations' performance. Bloom and Van Reenen (2010) found that management practices are associated with firm performance in terms of productivity, sales and growth rate. Similarly, Bloom (2010) concluded that firms with better management practices tend to have better performance on a wide array of dimensions. A well-managed organisation is defined as one that continuously monitors and attempts to improve its processes, sets comprehensive and stretching targets, and promotes high-performing employees.

Management practices are also useful for explaining variations among different kinds of organisations, whether private or public such as hospitals and schools (Bloom et al., 2010; 2014). They have also been found to influence universities' performance. For example, McCormack et al. (2014) explored management practices in British universities and found

that better management practices are associated with better performance in both research and teaching assessments. Notably, the authors find that the provision of incentives for faculty recruitment, in the form of promotion and retention of talent, is positively associated to research and teaching performance of British universities.

2.2 *Management practices oriented towards academic spin-offs*

Building upon the former literature, we explore the management practices implemented by universities to support academic entrepreneurship.

In the existing studies on academic spin-offs, the role and impact of management practices is normally left in the background. Evidence on the role of management practices is indirect, scant and mostly oriented to the establishment of academic spin-offs, such as setting a specific entrepreneurial programme (Reitan, 1997), expanding business development capabilities of TTO's (Lockett et al., 2005), and defining appropriate general rules and regulations (Muscio, Quaglione e Ramacciotti, 2016). Even when differences in management practices are considered, they are usually referred to as conditions favouring or discouraging spin-off creation rather than their performance (see Lockett, Wright, and Franklin, 2003, on university spin-offs in the UK; and O'Shea et al., 2005 for the US). For example, O'Shea et al. (2005) argued that knowledge accumulation inherent in the process of generating university spin-offs influences a university's future ability to produce university spin-off companies. In a similar way, Pazos and colleagues (2012) show that the tradition of the university's spin-off activity and the existence of incubation services positively influence spin-offs. Vinig and Van Rijsbergen (2012) found that the stock of technology, in terms of scholarly publications, and the presence of an incubator have a positive impact on the number of spin-offs. This literature is extremely variegated, and the results seem to depend upon contextual factors, which are largely specific to the domain under investigation.

Empirical literature has mainly addressed the issue of academic spin-off growth at individual (e.g. inventor involvement), firm (i.e. business model) and institutional level (e.g. university relationship). Few studies investigated how universities internal processes (e.g. internal processes, support programmes, management practices) might facilitate spin-off growth (Mathisen and Rasmussen, 2019). Degroof and Roberts (2004) explored spin-off policies in the largest Belgium universities to assess how selectivity in spin-off policies and support affect the growth of new ventures. Using a sample of academic spin-offs from the Netherlands, Norway and the United Kingdom, Soetanto and Jack (2016) analysed the potential moderating effect of incubation support on the performance of academic spin-offs.

In our work we take into consideration the classification of management practices proposed by Bloom and Van Reenen (2016) and investigate whether and how specific instances of management practices (i.e. management of operations, monitoring processes, setting targets, providing incentive schemes and managing people) influences academic spinoff growth. Borrowing from existing literature on the empirical economics of management practices, and recalling universities need to adopt specific rules to deal with a new mission, we do in general expect management practices to be positively associated to academic spin-off growth. However, significance and sign of each management practice set cannot be taken for granted. For instance, one may expect that support operation practices help selecting more robust projects. However, encouraging by far and large an entrepreneurial attitude might be self-defeating without a rigorous selection process. For example, universities might launch support initiatives like entrepreneurial and start-up courses, but lack the internal knowledge to discriminate promising projects from good ideas impossible to implement. Monitoring and targeting practices can be effective, as they promote control of performances and set goals. However, they can be out of focus as universities might pursue conflicting objectives. For instance, universities might be interested in promoting successful spin-off, but also in

attaining scientific excellence, thus making financial and economic performances secondary. Professional oriented practices should positively contribute to stimulate spin-off growth. For instance, reward and incentive practices, when aligned with academic spin-off growth targets, could produce visible effects. Similarly, recruitment of professionals with previous experience in business could might contribute to strengthen academic spin-offs. On the other hand, reward and incentive practices might turn out to be ineffective if perceived as unfair (e.g. incentives and rewards way lower the market average). Likewise, complying with the organizational procedures of universities by professionals with previous business experience might become impossible, making their recruitment ineffective.

By building upon the contribution of the literature on the empirical economics of management (systematisation of management practices in higher order constructs, widely tested survey methodology and robust measures of management practices), we surmise that the analysis of management practices oriented towards academic spin-offs is a meaningful way also to better systematise the results from the academic entrepreneurship literature in relation to the growth of academic spinoffs.

3. Data and Methods

3.1 Data sources

The empirical analysis is based on a longitudinal dataset comprising 790 Italian university spin-off companies observed over the period 2006-2014. It combines data from three main sources.

Our starting point is the list of Italian university spin-offs provided by *Spinoff Italia* (http://www.spinoffricerca.it/) as of June 2015,.[3] *Spinoff Italia* reports the following information for these companies: spin-off name, university of affiliation; foundation year; year of exit.[4]

We match this information with balance sheet data from the Bureau van Dijk AIDA database over the period 2006-2014. Notably, we collect information on turnover, capital stock (tangible and intangible), industrial sector (2-digit NACE rev.2 industrial classification) and geographical location of companies (NUTS 2 level of geographical aggregation).

Lastly, we collect information about university management practices relating to spin-offs by administering a structured questionnaire to the key individuals in the academic spin-off's process inside Italian universities, mostly the head of the TTO and/or their designates.[5] The TTO is the place where the distinct logics of scientific production and innovation get reconciled and where a number of important operational decisions are taken (Sauermann and Stephan, 2012). As the recent literature on management practices refers to very operational constructs, we do believe that the TTO' are an appropriate source of information for our study.

To collect information about the management practices enforced by each university, we interviewed TTO's responsible as they have a clear view of what occurs both at central (e.g. Board, Committees) and peripheral (e.g. spin-offs) levels. In fact, different actors can design,

[3] Building upon the definition provided by NETVAL (Muscio et al., 2016) and adopted by the Italian National Agency for the Evaluation of the University (ANVUR), *Spinoff Italia* defines a company an academic spin-off if it satisfies one of the following conditions: (i) Italian university holds a share of the company; (ii) at least one member of the founding team is a tenured member of staff of a university.

[4] Unfortunately, the data does not allow to distinguish exit by acquisition from exit by end of operations (i.e. bankruptcy) thus making the option of measuring performance by firm death unfeasible in the present case.

[5] It is critical to point out that faculty reporting on third stream activities is mandatory in the Italian higher education system. Notably, all contractual arrangements should be directly reported to the university central services and TTOs. Failing to report on contracting arrangements on the side of the faculty would be considered as illegal in the Italian higher education system. Therefore, the data collected is liable to be a very accurate and comprehensive.

promote and put in place academic spin-offs-oriented management practices. Table 1 gives an overview of the main actors involved for each category of management practices, as resulting from preliminary face-to-face interviews conducted with six key informants (mainly head of TTOs but also head of university incubators and responsible of university technology transfer temporary committees).

[Table 1 about here]

The population of reference consists of 64 public universities who were invited to participate to a telephone interview. The survey was conducted between July 2015 and March 2016 and interviewees reported responses covering the period 2010-2014. We obtained 42 valid responses, totalling a 65.6% response rate. These responses were representative of the population of Italian public universities in relation to size (t=1.19, p-value=0.24), patenting activity (t=1.203, p-value=0.23), research funding (t=1.35, p-value=0.18) and contract research (t=1.114, p-value=0.268).[6]

Our final sample comprises information for the variables of interest for 790 companies. Our resulting dataset is thus an unbalanced panel of 790 academic spin-offs affiliated with 42 different Italian universities and observed over the period 2006-2014.[7] Unfortunately, we do not have information on each company over the full period (e.g. half of the companies are observed over a 5-year period), which reduced our estimating sample to 3,695 firm-year observations.

[6] Data on the number of patents, the amount of research funding and contract research comes from the Italian National Research Assessment (VQR 2004-2010) and refers to the period 2004-2010. Information on the size of universities comes from the Ministry of Education, Universities and Research (MIUR) and refers to period 2006-2014.

[7] Our starting point was the 1226 academic spin-offs contained in *Spinoff Italia*. The final number of unique companies was reduced to 790 for two reasons: 1) we were not able to match information from AIDA for 181 companies and 2) we did not obtain responses to our survey from 22 universities which generated 255 spin-offs over the period under consideration.

We are aware of the issue arising from our research design due to a possible problem of reverse causality: our survey on university management practices is not antecedent to our firm-level measures. We believe this is not affecting our results because management practices tend to be persistent and to take much effort and time to change. The persistency of management practices for academic spin-offs was confirmed by introductory semi-structured interviews we had with six key informants (head of TTO or university incubator, head of school and the like) before initiating the large-scale survey. Several interviewees stressed how the Italian university system has been historically characterised by long and painful adaptations to university systems of other European countries and that the support and practices for academic spin-offs do not represent an exception to this general trend. The point above supports the idea that university management practices in 2010-2014 have been there for a long time and that they can be treated as time invariant constructs for the sake of our analysis.

3.2 Estimation method and dependent variable

As discussed in the theoretical section, we are interested in examining the relationship between university-level management practices aimed at academic spin-offs and firm growth. We measure company growth using data on the turnover retrieved from the Bureau van Dijk AIDA database. Specifically, our dependent variable is the turnover growth rate and has been calculated as the difference between the logarithm of real turnover in year *t* and the logarithm of real turnover in year *t-1*.[8] We are aware that firm growth can be investigated using a wide variety of measures (Delmar, Davidsson, and Gartner, 2003). Unfortunately, information

[8] To obtain real turnover, gross turnover has been deflated by adopting the ratio of current prices to chained-linked prices (reference year 2010) at the higher level of disaggregation, as provided by the Italian National Institute of Statistics (ISTAT) at the NACE rev. 2 2-digit industrial level.

about the number of employees is under-reported in our data, so we prefer to use turnover growth, which has the advantage of maximising the number of non-missing information.

Building upon the approach adopted in several empirical works, which focused on the determinants of firm growth, we employ a quantile regression approach (Coad and Rao, 2008; Goedhuys and Sleuwaegen, 2010; Kesidou and Demirel, 2012). When investigating firms' growth quantile analysis is preferred over standard least squares for a number of reasons (Buchinsky, 1998). First, the quantile approach provides a more robust and efficient alternative to OLS when the error term is non-normal, as well as in the presence of outliers. Second, the distribution of growth rates is recognised to be highly non-linear and considerably heavy-tailed (Bottazzi and Secchi, 2003). The quantile approach allows for richer characterisation of the data, as it estimates the effects of the different explanatory variables at the different quantiles of the growth distribution rather than at the conditional mean only. Since different types of management practices might have different effects on companies located at different points of conditional growth distributions (e.g. high-growth firms vs low-growth firms), the quantile approach can serve the purpose to uncover these effects.

As our data have a hierarchical structure – our key explanatory variables are measured at the university level while the dependent variable is measured at the firm level – standard errors are likely to be clustered and this would lead to a loss of efficiency in the estimates. In an attempt to control for the presence of intra-cluster correlation in quantile regressions, we compute robust clustered standard errors at the university level following a recent development in the applied econometrics literature (Parente and Santos Silva, 2016).[9]

[9] As further robustness check, we have also run the analysis by bootstrapping standard errors with 1000 replications. Results do not differ from those presented in the main text and are available from the authors upon request.

3.3 Explanatory variables

As for our key explanatory variables, we are interested in testing the relationship between management practices, which support academic entrepreneurship, and the growth of academic spin-offs. We capture the quality of management practices drawing upon an existing methodology that has been used in manufacturing (Bloom and Van Reenen, 2007; Bloom et al., 2012), health care (Bloom et al., 2015a), schools (Bloom et al., 2015b), and higher education (McCormack et al., 2014). Notably, we adapted the survey developed by McCormack et al. (2014) in their analysis of the effect of management practices on teaching and publication performance of UK universities. The focus is on management practices which belong to five main categories.

Our first category relates to operations aimed at supporting the creation and development of spin-offs. The respondents to our questionnaire were asked to rate the importance of different practices supporting the creation and development of academic spin-offs in the period 2010-2014. The respondents were asked to rank the importance of the items on a five-point Likert scale, ranging from 'not important' to 'highly important'. The different practices were: (1) coaching; (2) mentoring; (3) awards and internal competition; (4) training support; (5) support in the development of a proof-of-concept; (5) support for patenting activity and (6) help with fund raising activity. We run factor analysis on the six different items to synthesize the information in common factors underlying 'lean' management practices. The three resulting predicted factors are used as our first set of explanatory variables in the econometric model. Previous literature assists in the interpretation of these three constructs (Bloom et al., 2014). The first factor contains a range of items that involve support operations relating to training, such as counselling activity for the academic spin-off founding team, but also

specific on-the-job training activities. Accordingly, this factor is labelled *Support Operations Training*. The second group, *Support Operations Patent*, includes two items that relate to the patenting activities which are conducive to the creation and development of the spin-offs: support in the proof of concept and assistance in the process of filing. The third group comprises a single item which refers to fund raising activity. The corresponding variable is labelled *Support Operations Funding*.

Our second category of management practices captures the relevance of different targets/objectives for the spin-off firms. We use information about the management of targets/objectives as defined by the university TTO's. We built this set of variables from responses to the following question contained in the survey: "How would you rate the level of importance for the following goals for the spin-offs your organisation has contributed to create?". Respondents were asked to provide a score between one and five, with a higher score indicating a better performance. Four items were present: (i) growth; (ii) scientific excellence; (iii) employment creation, and (iv) technological excellence. Similarly to our first set of explanatory variables, we run factor analysis to reduce the information in common factors underlying target management practices. The two resulting predicted factors are again used as explanatory variables in the econometric model. Quite straightforwardly, we obtain two factors. The first one is mainly related to growth targets – item (i) and (iii) above – and is labelled *Target Growth.* The second group includes items (ii) and (iv) above and relates to scientific/technological objectives (*Target Scientific Excellence*).[10]

[10] We run a number of robustness checks to evaluate the robustness of results from factor analyses for the first two sets of explanatory variables (*support operations* and *target management*). First, we adopted different methods of factor extraction – principal components, iterated principal factors and maximum likelihood – which yield consistent results. We further test the robustness of the factor analyses by running them with a polychoric correlation matrix, which has been shown to be more appropriate with ordinal variables (Flora and Curran, 2004). Finally, we included in the regressions the average value of the items entering each factor instead of the predicted factor. The results are robust to all these specifications and are available from the authors upon request.

Our third key variable relates to the monitoring activities in place to track the performance of the academic spin-offs. Respondents were asked whether the performance of the spin-offs was regularly tracked and whether this was done using specific measures (e.g. balance sheet information, reports from the spin-off management team, etc.). *Monitoring Management* is a dummy variable which takes value one if the respondents answered positively to both questions and zero otherwise.

Fourth, we capture the existence of incentives management drawing on responses to the following question contained in the survey: "Do you have a reward system (e.g. rewarding or promoting high performers) for your employees linked to the achievement of targets/objectives set out for the spin-offs?". *Incentives Management* takes the value one if the organisation has a reward system for personnel, and zero otherwise.

Finally, we measure people management with the ability of the TTO to attract human capital from the private sector (Bloom et al., 2015b). As supporting the creation and development of academic spin-offs can potentially benefit from the combination of skills and competences from different organisational dimensions (e.g. private and public organisations), we expect the ability of the TTO to attract employees with private sector experience to be a good proxy for the ability of universities to hire talent with private sector experience. *Professional Management* is thus computed as the share of TTO employees with at least two years of experience in the private sector.

3.4 Controls

To account for other firm- and university-level attributes that might be associated with the growth of academic spin-offs, we considered some additional control variables.[11]

First, we control for a set of variables that are often included in growth rate regression models: the stock of investment in tangible (*Tangible Capital Stock*) and intangible (*Intangible Capital Stock*) assets. Investments and access to capital are recognised as important explanatory factors when explaining firms' growth (Hall, 1986).[12] *Tangible Capital Stock* (*Intangible Capital Stock*) is calculated as the yearly net acquisition of tangible (intangible) assets plus the amortisation (Grazzi et al., 2015)[13]. Moreover, based on Gibrat's law and other works on firms' growth (e.g., Audretsch et al., 2012), we control for initial firm size measured as the turnover of the firm (*Turnover*). All these variables have been lagged by one year to minimise problems of reverse causality and log transformed (plus one).

Second, we included structural characteristics for the firms in our sample, such as firm age (*Age*), *Herfindahl-Hirschman index* as a popular measure of industry concentration which has been found to play a relevant role with respect to firms' performance (Kaniovski and Peneder 2008) and *University Size* (the number of tenured professors per university)[14]. This information was obtained from the data provided by Bureau van Dijk AIDA and the Italian

[11] We are unable to include fixed effects in our regressions as our core explanatory variables (management practices) are time invariant, nevertheless we believe that the rich set of variables described in this section would contribute to control for the influence of intra-firm strategies and capabilities.

[12] We do not have information on the amount of venture capital obtained by the firm. Although venture capital has been shown to explain spin-offs' growth in a large number of contexts, this does not necessarily apply to the Italian case where venture capitalists play a minor role. For example, Bolzani et al., (2014) show that VC-backed academic spin-offs in Italy have been around the 1% of the total over the period 2003-2013. Even more interestingly, the average nominal equity invested by VCs has been less than 1 million euros over the period 2010-2013.

[13] Investments are measured in millions of euros and deflated by adopting the ratio of current prices to chained-linked prices (reference year 2010) at the NACE rev. 2 2-digit industry level, as provided by the Italian National Institute of Statistics (ISTAT) The investments have later been transformed into stocks. We adopt the standard approach found in the relevant literature and calculate it using the following formula: $K_t = K_{t-1}(1 - \delta) + P_t$ where K_{t-1} is the stock of capital at year $t-1$, δ is the depreciation rate assumed at 5%, and P_t is the investment in year t.

[14] *HH index* is the sum of the square of the turnover shares of firms operating in (NACE Rev.2) industries. University size is measured by the number of tenured professors per university because, owing to the data sources used, only they held relevance for spin-off establishment in our study (please refer to the definition of academic spin-off reported in footnote 2).

Ministry of Education, Universities and Research (MIUR). In order to control for the scientific and technological sectorial base, we include controls for 37 industries (NACE rev.2 2 digit level). Finally, we include two different sets of dummy variables to control for geographical (NUTS 2 level) and time effects (period 2006-2014).[15]

Table 2 presents the descriptive statistics for the variables used in this study; Table 3 reports the correlation matrix of our variables. In general, correlation among the independent variables is low, and variance inflation factor range between 1.2 and 7.2 (well below the threshold value of 10) suggesting the absence of multi-collinearity problems.

[Table 2 and Table 3 ABOUT HERE]

4. Results and Discussion

4.1 Core findings

The main results are reported in Table 4. Model 1 presents the OLS estimates while Models 2 to 6 show results for different percentiles of the conditional growth rate distribution (10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles).

Concerning "lean" operations management which support the creation and development of spin-offs, we observe a positive and significant effect of *Support Operations Training* ($\beta = 0.094$, $p < 0.1$) and *Support Operations Patent* ($\beta = 0.142$, $p < 0.01$) on spin-off's growth.

[15] We have also tried to include a number of controls at the TTO level (e.g. TTO's age and size) but they do not contribute to explain academic spin-offs' growth. Consequently, we do not include these variables in our estimates on the ground of parsimony.

Interestingly, when we take into consideration the effects at different points of the conditional growth rate distribution by adopting our quantile regression approach (Columns 2 to 6 of **Error! Reference source not found.**), we still observe a positive and significant effect of *Support Operations Training* ($\beta = 0.153$, $p < 0.01$; $\beta = 0.023$, $p < 0.1$) and *Support Operations Patent* ($\beta = 0.116$, $p < 0.01$; $\beta = 0.074$, $p < 0.01$), but only for low-growth companies which belong to the 10^{th} and 25^{th} percentiles.

Regarding the role of target management, Table 4 reports negative and significant coefficients of *Target Growth* for OLS estimates as well as all the percentiles in the conditional growth rate distribution. Our results seem to point to a controversial outcome: setting a growth goal for academic spin-offs leads to a negative effect on the actual ability of these companies to realise turnover growth.

As for incentives management, Table 4 provides good evidence of a positive relationship between reward systems for the achievement of specific objectives of the spin-offs and turnover growth across all the percentiles. Model 6 indicates that the highest effect of *Incentives Management* is to be found for high-growth companies ($\beta = 0.665$, $p < 0.1$).

Finally, as long as professional management is concerned, we find evidence of a negative relationship between the share of TTO's employees with at least two years of business experience and the conditional growth rate distribution. Models 1 to 6 always report a negative and significant coefficient of *professional Management*.

[Table 4 ABOUT HERE]

4.2 Robustness checks

We check the stability of our results to two problems. First, there might be problems related to the misalignment of the time-frame for firm- and university-level information. While information referring to university management practices, which come from our survey, refers to the period 2010-2014, we are able to control for firm-level characteristics (included turnover growth) for a longer period (2006-2014). Although management practices tend to be persistent and to take much effort and time to change, we checked the robustness of our results to this problem by estimating our models for the reduced time period 2010-2014 which represents a perfect overlap between firm- and university-level information.[16] We also consider the likelihood that our results are driven by a low number of high or low performing spin-offs in some universities: universities with a reduced number of spin-offs are characterised by an extremely high (or low) average turnover growth over the period 2006-2010. In order to control for this, we consider the sample of universities which have ten spin-offs or more. This amounts to drop twelve universities and 68 spin-offs from our initial sample. Table 5 and Table 6 provide evidence of the robustness of our main results with minor variations from our core findings.

[Table 5 and Table 6 ABOUT HERE]

4.3 Discussion

[16] The persistency of management practices for academic spin-offs has also been confirmed by introductory semi-structured interviews we had with 6 heads of TTOs before starting with the large scale survey. Several interviewees stressed how the Italian university system has been historically characterised by long and painful adaptations to university systems of other European countries and that the support and practices for academic spin-offs do not represent an exception to this general trend.

Our results bear a number of implications in regard to the role of university management practices that may influence academic spin-offs. First and foremost, in line with the recent developments in the literature on the empirical economics of management (Bloom et al., 2014), we obtain evidence that university management practices contribute to explaining the variation in the growth of academic spin-offs. At the same time, our results suggest that the overall picture is far from unambiguous. While some types of management practices (*support operations* and *incentives*) show a positive correlation with the growth of academic spin-offs, other management practices (*target* and *professional management*) are negatively correlated. In subsequent paragraphs, we argue that the specific organisational context, namely, a public university system, can help to shed light on these contrasting results.

Out of the five possible different typologies of management practices, we find that the most relevant ones are *support operations* and *incentives management*. For the former, we show that the extent of the adoption of management practices to support *patent* and *training* is positively correlated to the growth of the spin-offs, although this positive correlation is significant for low-growth spin-offs only. This result resonates well with the historical reason that brought public universities to establish TTOs in the first place. TTO offices were designed to economise on a number of functional services within universities, particularly by pooling innovations and services across research units subject to economies of scale and learning, such as patenting (Macho-Stadler et al., 2007). This approach has been a key support for spin-offs, which bet their destiny on a patent and invest in patenting as their main strategic avenue (i.e., possibly to realise a profitable exit through acquisition).

As for incentive management, a positive and significant correlation is shown with growth, particularly for high-growth spin-offs. This result relates to the findings of the recent literature on management practices, which show that incentives are an effective way, even for

public organisations (e.g., hospitals, schools, and universities), to react to external competition or institutional pressure (Bloom et al., 2015a, 2015b; McCormack et al., 2014). Similarly, incentives have been shown to be an important determinant of technology transfer in technology transfer literature (Friedman and Silberman, 2003). We contribute to this literature by showing that incentive management contributes to explaining the performance of academic spin-offs, as well.

Our result that professional management has a negative correlation with growth, with no remarkable differences being observed across the conditional growth distribution, points to a double-faceted selection process. On one hand, we interpret this result as evidence on the existence of an adverse selection process where universities are often unable to attract external talent. Notably, the presence of a standardised contract, the lack of flexibility in offering adequate benefits or a compensation package comparable to the private sector, as well as the hiring procedure can limit the attractiveness of public job posts for candidates from the private sector (Karl and Sutton, 1998; Buelens and Van den Broeck, 2007). On the other hand, even when universities manage to attract excellent employees from the private sector, problems can still arise. Notably, there could be a misalignment between the previous experience of the employee hired from the private sector and the real knowledge required to efficiently perform the job. Similarly, universities may be unable to create the conditions whereby the newly hired employee is able to perform due to the limited degrees of freedom or a lack of adequate flexibility.

Finally, the negative association between target setting and the performance of academic spin-offs resonates well with recent findings in management practices literature when applied to public administrations (Benassi and Rentocchini, 2017). A number of reasons explain the above result. First, the selection at entrance for academic spin-offs has been historically weak

with the absence of appropriate support after the start-up phase (Siegel Wright, and Lockett, 2007). Second, and more importantly, there is often a lack of credibility coming from setting growth objectives in universities, as TTOs are often unable to enforce the achievement of these goals with credible actions (e.g., credible threats or rewards). Furthermore, growth targets usually refer to the short-term, but setting stringent goals in the short-term can actually be detrimental to medium- or long-term growth, which is likely the main interest of academic spin-offs. This is particularly relevant in the valorisation of patents when they form a central intellectual asset for the spin-off (Djokovic and Souitaris, 2008). These last two points suggest that the existence of growth targets by universities can be mere 'ceremonial' commitments. Therefore, academic spin-offs are likely to systematically miss these short-term targets and instead aim for medium- or long-term growth targets.

5. Conclusions

Academic spin-offs are a possible backbone of universities' third mission and can play a key role in transferring knowledge to local contexts (Mathisen and Rasmussen, 2019; Benassi and Rentocchini, 2017). Recent works in the field of academic entrepreneurship have focused mainly on the antecedents of spin-off creation by universities and spin-off performance

Our study can be instrumental in bridging these two areas of research. The analysis of internal processes might help explain under which conditions spin-offs originate and how they evolve over time. From this perspective, our study contributes to the research stream of academic entrepreneurship by using the management practices framework. We interpret management practices as an outcome of universities' decisions. We assume that, despite the fact that rules and regulations do constrain their autonomy, universities have degrees of freedom in structuring internal processes regarding spin-offs. We observed significant

differences in how universities structure their processes: management practices are not all alike and their adoption is uneven.

We also find that not all management practices have the same effect. Some management practices show a counterintuitive relationship with spin-off growth: it is the case of the negative coefficient of growth target setting. This finding highlights the difficulty of importing practices that are 'developed' in other institutional settings. It is reasonable to assume that there is a fit issue, as universities are organisations facing new challenges. We believe that future research on different management practices and their impact on spin-off performance should help in designing more appropriate governance structures and coordination mechanisms for universities.

Our study has several limitations. First and foremost, it refers to Italy, whose institutional context is for several reasons distinct from those of other countries. We focused on public universities, by far the large majority of the Italian population. Private universities might leverage management practices for academic spin-offs more freely.

Second, our study covers a significant time interval as far as spin-off performance is concerned but does not offer comparable data and information on the adoption of management practices. We did not observe management practices from a longitudinal viewpoint, so we cannot completely rule out the possibility of reversed causality between observed results and specific management practices.

Third, management practices are not algorithms. They require interpretation and adaptation by competent decision-makers. In other words, more investigation is required to assess the interdependence between management practices and competence of decision-makers.

Finally, as hierarchy is not the usual coordination mode universities use, the enforcement of management practices might differ widely. Some universities might simply suggest which practices spin-offs should adopt; others might have a say and directly influence spin-offs. More evidence on the real adoption of management practices from a spin-offs point of view is required.

Despite these limitations, we are confident that our study has relevant policy implications for universities and policy makers. First, universities should be more aware of the management practices they adopt and how these practices fit into their internal organisation. Second, universities should focus on practices they can directly enforce. For example, training support depends on regulations set in place at the university level, whereas target setting is likely to be better enforced by the spin-off founding team. Third, launching spin-offs requires time and is not a one-shot activity. Universities can be equipped for providing services and assistance in the first stages, but too constrained in the following stages. Therefore, management practices supported in theory have low chances to be adopted in practice.

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Table 1: Management practices supporting the creation and development of academic spin-offs: main actors involved

Variables	Description	Main actors*
	1) Support operations	
Support operations – training	counselling activity for the academic spin-off founding team; on-the-job training activities	1, 2, 3, 4, 5
Support operations – Patent	support in the proof of concept; assistance in the process of filing	1, 2
Support Operations - Funding	fund raising activity	2, 3, 5
	2) Target setting	
Target growth	relative importance of academic spin-offs growth and employment creation	1, 3
Target Scientific Excellence	relative importance of academic spin-offs scientific and technological excellence	1, 3
	3) Monitoring	
Monitoring Management	monitoring activities to track the performance of the academic spin-offs; measures like balance sheet information, reports from the spin-off management team	1, 2, 3
	4) Incentives	
Incentives Management	reward system for personnel linked to the achievement of targets/objectives set out for the academic spin-offs	1, 2, 5
	5) Professional	
Professional management	TTO employees with experience in the private sector	1

Source: own elaboration on introductory semi-structured interviews and survey data

According to the introductory semi-structured interviews made, the main actors involved in the academic spin-offs process are the following: 1) TTOs, 2) University board of directors, 3) Ad-hoc committees, 4) faculty programme directors, 5) head of schools.

Table 2: Descriptive statistics (n=3695)

Variable	Mean	Std. Dev.	Min	Max
Turnover Growth	0.08	2.57	-13.81	13.81
Turnover	0.31	2.13	0	97.53
Support operations – training	2.13	0.82	0	3.75
Support operations – patent	2.19	0.75	0.5	3.5
Support operations – funding	1.72	0.97	0	4
Monitoring management	0.70	0.46	0	1
Target – growth	2.31	1.06	0	3.5
Target – scientific excellence	2.13	1.01	0	3.5
Incentives management	0.08	0.27	0	1
Professional management	31.34	33.12	0	100
Tangible capital stock	0.08	0.36	0	6.21
Intangible capital stock	0.12	0.45	0	7.44
Industrial concentration index	0.05	0.06	0.001	0.95
Age	5.28	2.73	2	14
University size	1165.77	783.52	58	4161

Descriptive statistics for tangible capital stock, intangible capital stock and turnover refer to the variables before natural log-transformation and are measured in million euros.

Table 3: Correlation Table

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
[1]	Turnover	1											
[2]	Support operations – training	0.047	1										
[3]	Support operations – patent	-0.026	0.085	1									
[4]	Support operations – funding	0.017	0.171	0.296	1								
[5]	Monitoring management	0.031	-0.204	-0.004	0.005	1							
[6]	Target – growth	-0.021	0.144	0.173	-0.090	-0.101	1						
[7]	Target – scientific excellence	0.033	0.161	-0.258	-0.035	0.007	0.169	1					
[8]	Incentives management	-0.018	0.130	-0.073	-0.215	-0.121	-0.015	0.176	1				
[9]	Professional management	-0.001	-0.161	-0.167	0.106	-0.265	-0.364	0.250	0.201	1			
[10]	Tangible capital stock	0.541	0.091	0.026	0.029	-0.062	-0.001	0.036	-0.040	-0.011	1		
[11]	Intangible capital stock	0.062	0.041	0.099	0.058	-0.015	0.073	-0.006	-0.047	-0.064	0.454	1	
[12]	Industrial concentration index	-0.014	-0.048	0.037	0.042	0.013	0.028	0.016	-0.011	0.002	-0.014	0.004	1
[13]	Age	0.056	0.034	0.018	0.003	-0.047	0.079	-0.006	0.063	-0.112	0.155	0.148	-0.014

Table 4: The relationship between management practices and the growth of academic spin-offs

	(1) OLS	(2) 10th Percentile	(3) 25th Percentile	(4) 50th Percentile	(5) 75th Percentile	(6) 90th Percentile
Support operations - training	0.094*	0.153***	0.023*	-0.007	-0.013	0.036
	[0.052]	[0.049]	[0.014]	[0.013]	[0.032]	[0.067]
Support operations - patent	0.142***	0.116***	0.074***	0.013	0.033	0.074*
	[0.048]	[0.039]	[0.017]	[0.018]	[0.022]	[0.042]
Support operations - funding	-0.014	0.019	0.031	0.019*	0.031	0.006
	[0.037]	[0.031]	[0.023]	[0.011]	[0.026]	[0.039]
Monitoring management	-0.046	0.048	-0.047	-0.029	-0.035	-0.030
	[0.159]	[0.148]	[0.072]	[0.034]	[0.070]	[0.159]
Target – scientific excellence	0.064	0.072	0.016	0.006	0.023	0.044
	[0.043]	[0.049]	[0.017]	[0.012]	[0.026]	[0.034]
Target - growth	-0.095**	-0.126***	-0.074***	-0.035**	-0.045*	-0.105**
	[0.042]	[0.039]	[0.018]	[0.014]	[0.025]	[0.051]
Incentives management	0.291	0.528*	0.271**	0.133*	0.371***	0.665*
	[0.353]	[0.320]	[0.105]	[0.080]	[0.137]	[0.383]
Professional management	-0.004***	-0.005***	-0.003***	-0.002***	-0.003***	-0.005**
	[0.001]	[0.002]	[0.001]	[0.000]	[0.001]	[0.002]
Log tangible capital stock -1	1.389***	0.678***	0.269**	0.078	1.310***	2.241***
	[0.372]	[0.159]	[0.113]	[0.074]	[0.352]	[0.363]
Log intangible capital stock -1	-0.269	-0.151	-0.089	-0.057*	0.210	0.366*
	[0.316]	[0.168]	[0.142]	[0.032]	[0.169]	[0.193]
Ind concentration index -1	0.642	-0.172	0.159	0.220	0.178	0.490*
	[0.556]	[0.777]	[0.216]	[0.137]	[0.232]	[0.281]
Log age -1	-0.182***	-0.039	-0.087***	-0.132***	-0.087**	0.037
	[0.059]	[0.069]	[0.026]	[0.018]	[0.043]	[0.079]
Log Univ size	0.033	-0.034	0.034	0.012	0.096***	0.141**
	[0.089]	[0.072]	[0.023]	[0.021]	[0.036]	[0.068]
Turnover -1	-0.294***	-0.067***	-0.032***	-0.013***	-0.417***	-0.735***
	[0.024]	[0.011]	[0.005]	[0.004]	[0.065]	[0.016]
Industry controls	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.
Year controls	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.
Geographical controls	Inc.	Inc.	Inc.	Inc.	Inc.	Inc.
N	3695.000	3695.000	3695.000	3695.000	3695.000	3695.000

Table 5: The relationship between management practices and the growth of academic spin-offs - period 2010-2014

	(1) 10th Percentile	(2) 25th Percentile	(3) 50th Percentile	(4) 75th Percentile	(5) 90th Percentile
Support operations - training	0.048	0.013	-0.015	-0.024	0.084
	[0.062]	[0.013]	[0.012]	[0.034]	[0.054]
Support operations - patent	0.061	0.051***	0.005	0.031	0.073
	[0.062]	[0.017]	[0.016]	[0.029]	[0.055]
Support operations - funding	0.022	0.004	0.003	0.014	-0.026
	[0.037]	[0.014]	[0.012]	[0.026]	[0.041]
Monitoring management	-0.068	-0.047	-0.036	-0.108	-0.058
	[0.182]	[0.051]	[0.031]	[0.080]	[0.122]
Target – scientific excellence	-0.018	-0.003	0.017	0.029	0.027
	[0.048]	[0.014]	[0.013]	[0.025]	[0.043]
Target - growth	-0.065*	-0.046**	-0.029**	-0.056**	-0.138**
	[0.039]	[0.019]	[0.013]	[0.029]	[0.057]
Incentives management	0.198	0.198	0.082	0.407**	0.725***
	[0.483]	[0.124]	[0.078]	[0.199]	[0.237]
Professional management	-0.005**	-0.002***	-0.001***	-0.004***	-0.005***
	[0.002]	[0.001]	[0.000]	[0.001]	[0.002]
Log tangible capital stock -1	0.644***	0.306***	0.060	1.304***	2.236***
	[0.155]	[0.100]	[0.059]	[0.389]	[0.274]
Log intangible capital stock -1	0.122	-0.050	-0.016	0.259*	0.439**
	[0.304]	[0.102]	[0.037]	[0.155]	[0.196]
Ind concentration index -1	-0.074	-0.007	0.247*	0.271	0.537*
	[1.097]	[0.314]	[0.127]	[0.260]	[0.279]
Log age -1	-0.029	-0.078***	-0.105***	-0.056	0.062
	[0.071]	[0.029]	[0.017]	[0.041]	[0.088]
Log Univ size	0.048	0.021	0.002	0.084*	0.119**
	[0.086]	[0.036]	[0.020]	[0.048]	[0.057]
Turnover -1	-0.061***	-0.033***	-0.011***	-0.425***	-0.731***
	[0.011]	[0.004]	[0.004]	[0.063]	[0.024]
Industry controls	Inc.	Inc.	Inc.	Inc.	Inc.
Year controls	Inc.	Inc.	Inc.	Inc.	Inc.
Geographical controls	Inc.	Inc.	Inc.	Inc.	Inc.
N	2855.000	2855.000	2855.000	2855.000	2855.000

Robust standard errors clustered at university level are reported in parenthesis. * p<0.10, ** p<0.05, *** p<0.01

Table 6: The effect of management practices on the growth of academic spin-offs - universities with 10 spin-offs or more

	(1)	(2)	(3)	(4)	(5)
	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Support operations - training	0.068	0.024*	0.003	0.002	0.055
	[0.070]	[0.013]	[0.013]	[0.032]	[0.069]
Support operations - patent	0.151***	0.052***	0.002	0.037	0.073
	[0.047]	[0.017]	[0.019]	[0.024]	[0.046]
Support operations - funding	0.062	0.036*	0.020	0.028	0.010
	[0.069]	[0.019]	[0.013]	[0.038]	[0.040]
Monitoring management	-0.741**	-0.107**	-0.018	0.010	0.079
	[0.325]	[0.054]	[0.058]	[0.120]	[0.245]
Target – scientific excellence	0.142***	0.025	0.035*	0.051*	0.038
	[0.035]	[0.016]	[0.018]	[0.029]	[0.032]
Target - growth	-0.284***	-0.072***	-0.028	-0.038	-0.108*
	[0.048]	[0.018]	[0.020]	[0.030]	[0.055]
Incentives management	-1.115	0.154	0.197*	0.511**	0.922*
	[0.732]	[0.104]	[0.105]	[0.211]	[0.553]
Professional management	-0.010***	-0.003***	-0.002**	-0.003**	-0.005**
	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]
Log tangible capital stock -1	0.638***	0.234**	0.065	1.248***	2.236***
	[0.129]	[0.103]	[0.066]	[0.439]	[0.301]
Log intangible capital stock -1	-0.128	-0.041	-0.043	0.211	0.348*
	[0.193]	[0.135]	[0.037]	[0.164]	[0.190]
Ind concentration index -1	-0.002	-0.150	0.078	-0.272	0.136
	[0.956]	[0.512]	[0.209]	[0.537]	[0.915]
Log age -1	0.019	-0.093***	-0.135***	-0.096**	0.040
	[0.100]	[0.024]	[0.019]	[0.044]	[0.091]
Log Univ size	-0.417**	0.018	0.028	0.118*	0.185*
	[0.167]	[0.030]	[0.028]	[0.071]	[0.096]
Turnover -1	-0.064***	-0.029***	-0.014***	-0.403***	-0.733***
	[0.013]	[0.005]	[0.005]	[0.071]	[0.019]
Industry controls	Inc.	Inc.	Inc.	Inc.	Inc.
Year controls	Inc.	Inc.	Inc.	Inc.	Inc.
Geographical controls	Inc.	Inc.	Inc.	Inc.	Inc.
N	3394.000	3394.000	3394.000	3394.000	3394.000

Robust standard errors clustered at university level are reported in parenthesis. * p<0.10, ** p<0.05, *** p<0.01