



The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship

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ABSTRACT

Although sources and determinants of academic entrepreneurship have begun to command the attention of policy-makers and researchers, there remain many unanswered questions about how individual and social factors shape the decisions of academics to engage in entrepreneurial activities. Using a large-scale panel of academics from a variety of UK universities from 2001 to 2009, this paper examines how an academics' level of entrepreneurial capacity in terms of opportunity recognition capacity, and their prior entrepreneurial experience shape the likelihood of them being involved in starting up a new venture. In addition, we explore what role university Technology Transfer Offices (TTOs) play in stimulating venture creation. The results show that individual-level attributes and experience are the most important predictors of academic entrepreneurship. We also find that the social environment surrounding the academic also plays an influential role, but its role is much less pronounced than individual-level factors. Finally, we show that the activities of the TTO play only a marginal, indirect role, in driving academics to start new ventures. We explore the implications of this analysis for policy and organizational design for academic entrepreneurship.

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1. Introduction

The rise in the number of spin-offs from universities in Europe, which has taken place since the 1990s, is often linked to the professionalization of Technology Transfer Offices (TTOs) at these universities. With the support of public funds, TTOs have stimulated a range of entrepreneurial activities by academics, spanning invention disclosures to patent applications, the generation of licensing income, and the involvement of academics in the founding of spin-offs (Clarysse et al., 2007; Siegel, 2006; Wright et al., 2007).

The US Bayh–Dole Act of 1980, and its European counterparts, by encouraging universities to patent inventions funded by government agencies, marked the beginning of notably greater professionalization of the TTOs at the different universities (OECD, 2003; Rothaermel et al., 2007; Siegel et al., 2003). Meyer (2003) suggests that the professionalization of the TTO increases the degree to which academics are involved in entrepreneurial activities. Although earlier academic work suggested a strong link between the efficiency of the TTO and the entrepreneurial activity of the aca-

demics at the different universities, more recent empirical work does not find a clear impact of the TTO office. For example, Stuart and Ding (2006) highlight the social structural antecedents, i.e. the specific normative beliefs, which prevail at the department and university about entrepreneurial activity, as strong determinants of academic entrepreneurship. In this study, whether or not a university had a specific TTO did not have a consistent and significant impact on the likelihood of academics to engage in commercial activities. Bercovitz and Feldman (2008) build upon these results and conclude that the social environment mediates the individual attributes of academics, such as exposure to entrepreneurial activities in previous universities, which might explain why certain academics are more likely to engage in entrepreneurial activities.

Yet, surprisingly, the literature on academic entrepreneurship makes very little reference (one exception is Mosey and Wright (2007)) to the individual attributes which the wider entrepreneurship literature have repeatedly put forward as the central determinants of entrepreneurial activity and success. There is, for instance, a vast literature on habitual or serial entrepreneurs, which claims that entrepreneurial experience is a very good predictor of future start-up activity (Hsu, 2007; Ucbasaran et al., 2006). This literature on habitual entrepreneurs is in line with the equally large literature on entrepreneurial intent, which puts entrepreneurial self-efficacy (the belief one has in his/her own competencies to start a company) as a consistent predictor of the intent which people have to become entrepreneurs or undertake

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entrepreneurial activities (Fini et al., 2011; Souitaris et al., 2007). Both streams suggest that confidence, either through experience or through personality, is a strong determinant of the probability that one will undertake entrepreneurial activities. A third stream of literature in the field of entrepreneurship refers to "opportunity recognition" defined as the identification of a chance to combine resources in a way that might generate a profit. This too appears to be a strong predictor of subsequent entrepreneurial activity (Shane, 2003). For instance, Baron and Ensley (2006) show that skills in opportunity identification increase the probability that an individual will become an entrepreneur. This is because people need the capacity to identify opportunities prior to engaging in entrepreneurial efforts. Moreover, Nicolaou et al. (2009) in their study of twins show that these opportunity recognition skills can, in part, be explained by genetic differences. This indicates that this ability is partly innate, and therefore somewhat impervious to social pressures and environmental context.

In short, various streams in the literature on entrepreneurship tend to emphasize individual-level attributes such as experience and opportunity recognition skills as critical explanations of entrepreneurial activity. In contrast, the extant literature on academic entrepreneurship has pre-dominantly focused on social environmental factors to explain entrepreneurial behavior, while not addressing these individual attributes. This is reflected in the recent empirical literature focus on the importance of local (departmental) and university-level social contexts to explain entrepreneurial behavior of individual academics (Bercovitz and Feldman, 2008; Stuart and Ding, 2006), while the pre-2005 literature highlighted the crucial role of TTOs in stimulating entrepreneurial behavior (Clarysse et al., 2005; Colyvas et al., 2002). Since the European versions of the Bayh–Dole Act have been put in place, TTOs have increased in size and have continued to professionalize their activities. As a result, their role has been focused both on assisting academic spin-offs and improving the social desirability of engaging in commercial activities within university departments.

In this paper, we argue that academic entrepreneurship literature has underestimated the importance of individual differences between academics, while at the same time it has overestimated the role that TTOs have played in stimulating entrepreneurial behavior. To examine this question, we draw from a rich dataset, which includes 1761 academics from 90 UK universities across a wide range of disciplines and departments. Our results suggest that the "opportunity recognition capacity" of the academics, which we call entrepreneurial capacity, is the single most important variable explaining their engagement in entrepreneurial ventures. The social environment of the university and the professionalization of the TTO amplify the impact of entrepreneurial capacity, but have no, or only marginal, direct effects after controlling for the entrepreneurial capacity of the individual academic.

In doing so, our study makes three contributions to a richer understanding of the nature of academic entrepreneurship. First, unlike prior studies, our research design allows us to assess individual-level and organizational-level factors – individual and jointly – that shape academic entrepreneurship. Second, the study offers the rare opportunity to gauge the role of TTOs as a facilitator (or blocker) of individual-level predispositions towards new venture creation. Third, since we use data from a wide range of disciplines, universities and departments, we are able to investigate the general properties of academic entrepreneurship, rising above the tendency in the current literature to focus on particular disciplines or institutions. Because we are able to both measure individual and organizational-level issues, we can compare the impact of the policy measures that were implemented following the increased alertness among policy-makers in Europe about the commercial potential of universities, inspired by the Bayh–Dole Act.

The paper unfolds along the following lines. We begin with a literature review and we draw upon results from our interviews with technology transfer managers and faculty involved in starting new ventures to develop a conceptual framework about the individual faculty member's decision to engage in entrepreneurial ventures. The second section of the paper introduces the data and the methodology. The third part of the paper presents a discussion of the empirical results. We finish with a discussion section and reflect upon the conclusions from this study.

2. Literature review and hypotheses

The literature on academic entrepreneurship has mainly focused on how Technology Transfer Offices can create a structural environment which facilitates the creation of academic spin-offs (Clarysse et al., 2005; Wright et al., 2007) and/or improves the entrepreneurial culture within the department. Clarysse et al. (2005) have shown how various levels of support at the level of the TTO determine both the amount of, and the kind of, companies which are started by academics in the universities in which they are active. Stuart and Ding (2006) and Bercovitz and Feldman (2008) have analyzed the role of organizational stimuli in an indirect way by looking at the importance of the social environment in explaining the degree to which scientists in biotech and medical departments are likely to engage in entrepreneurial activities. However, none of these studies takes the individual attitudes of academics into account. They assume that creating a supportive environment can result in higher levels of academic entrepreneurial activity in a relatively straightforward way. Although Bercovitz and Feldman (2008) find that an entrepreneurial social environment will increase the likelihood that a particular scientist in that domain will also engage in entrepreneurial activities, it is difficult to know whether this finding is the product of a selection effect, whereby academic entrepreneurs are attracted to departments where this activity is supported. In this respect, as they admit, their study is inconclusive about whether the social environment will have the same effect for academics with low degrees of entrepreneurial capacity or whether only scientists with a relatively high degree of entrepreneurial capacity will tend to join such a department in the first place. In a different context, Kraatz and Moore (2002) suggest that it is a combination of the two.

Within the wider entrepreneurship literature, scholars consider individual differences to be the critical factor explaining who becomes an entrepreneur (Shane and Venkataraman, 2000). Nicolaou et al. (2008) show that individual differences matter, regardless of whether entrepreneurship is measured as self-employment, starting companies, owning one's own business, or being involved in the firm start-up process. They show that the individual differences account for close to 60% of the variation even after taking into consideration environmental effects such as income, education, marital status and race. Two main factors seem to explain differences between individuals: genetic differences and experience (Shane, 2010). Nicolaou et al. (2009) show that genetic differences may account for over 60% of the differences in the individual tendency to become an entrepreneur. Most of this can be related to the differences in "opportunity recognition capacity", the ability to spot, recognize and absorb opportunities among individuals. Nicolaou et al. (2009) show that the same genes are responsible for explaining entrepreneurial capacity (measured as opportunity recognition skills) in individuals as those that account for entrepreneurial activity itself. However, Shane (2010) shows that the genetic factor is more significant in explaining entrepreneurship among women than men. He argues that direct experience in entrepreneurial activities is a good substitute within male popula-

tions in explaining entrepreneurial activity. Shane's findings are in line with the literature on habitual and serial entrepreneurs (Ucbasaran et al., 2008), which highlights that the likelihood of starting of new firm increases significantly if an individual has already been involved in the founding of a previous one, regardless of the outcome of that previous company. Also the psychological view in entrepreneurship attributes some importance to experience, which they consider to be a good indicator of self-efficacy (Ajzen, 1991).

We can summarize the above findings as follows. First, mainstream entrepreneurship literature attributes a central role to individual differences followed by the social context in explaining the tendency to become an entrepreneur, regardless of whether the entrepreneurial activity is seen as starting a business on your own, being involved in a start-up or becoming self-employed as a career choice. The literature on academic entrepreneurship in contrast has highlighted the efficiency and professionalization of the TTO to explain changes in entrepreneurial activity at different universities. Studies before 2005 almost exclusively looked at the direct impact of TTO activities on spin-out activity at universities. The more recent studies have also focused on indirect influences such as the local social context at departmental level as explanations of entrepreneurial activity among scientists. Despite the abundant entrepreneurship literature, little reference has been made to individual characteristics as possible indicators of entrepreneurial activity. A second, though less important shortcoming is that the more recent studies on academic entrepreneurship have focused on entrepreneurial activity in one particular domain, namely life sciences and biotechnology. The choice for a single domain is inspired by the fact that these studies want to focus on the role of the local social environment and thus want to minimize the heterogeneity at the more general environmental level. However, at the same time, it introduces a bias towards a very specific scientific domain, usually in a selected number of leading universities.

Entrepreneurial capacity, which we define as the skill which individuals have to spot, recognize and absorb opportunities, has been put forward in the entrepreneurship literature as a necessary individual characteristic to become an entrepreneur (Nicolaou et al., 2008; Shane and Venkataraman, 2000). Entrepreneurially oriented individuals identify opportunities that might lead to new venture ideas that can be commercialized and show a general interest in pursuing these opportunities and/or ideas. Moreover, Nicolaou et al. (2009) have shown that more than half of the variation in entrepreneurial capacity can be traced back to genetic differences between individuals, which is, in turn, unrelated to the environment in which these individuals have grown up or to the environment in which they currently operate. Therefore, we can infer that academics who have a high degree of entrepreneurial capacity will be more actively involved in entrepreneurial initiatives that spin-out from the university.

Hypothesis 1. Academics with a high degree of entrepreneurial capacity (capacity to recognize opportunities) will be more likely to be involved in entrepreneurial initiatives created by others or in founding entrepreneurial ventures themselves.

The second individual characteristic that we explore is entrepreneurial experience. In the entrepreneurship literature, 'experience' is generally associated with a belief in entrepreneurial skills. In other words, entrepreneurs who have been involved in start-ups before – labeled as habitual or serial entrepreneurs (Westhead and Wright, 1998) – are considered to have a greater belief in their own entrepreneurial potential, regardless of the outcome of their entrepreneurial efforts (Shepherd, 2003; Sitkin, 1992). Increasingly, the learning literature points to negative experiences as very intensive learning events, which might be of equal value as positive ones. McGrath and MacMillan (2000) provoc-

tively asserted that serial or habitual entrepreneurs might have a '*entrepreneurial mindset*' that prompts them to search continuously for new opportunities. Various sources show that the prevalence of serial entrepreneurs ranges from 40% in Sweden (Wiklund and Shepherd, 2008) to levels as high as 61% in the states (Schollhammer, 1991) with 51% in Great Britain (Ucbasaran et al., 2006). This means that once an individual is involved in a start-up activity, the chances that he/she will be involved in a subsequent one are quite high, irrespective of the outcome of the previous one. The mechanism used to explain this is, what the psychology literature refers to as, self-efficacy. Once you have set up a business or once you have been directly involved in such a founding process, you know what to expect and you can better evaluate your own skills. Shane (2010) shows that a lack of experience among females explains why the genetic differences in females prevail as explanations of their tendency to become an entrepreneur in comparison to the male population. In short, the experiences which individuals have, either directly as founders or indirectly through being involved in start-up activities by students or colleagues, is expected to have an impact on their own tendency to become entrepreneurs. Thus:

Hypothesis 2. Academics who have entrepreneurial experience will be more involved in entrepreneurial initiatives created by others and/or in founding entrepreneurial ventures themselves.

Whereas we introduced the individual characteristics of academics as explanations of entrepreneurial activity, a number of studies such as Kenney and Goe (2004), Bercovitz and Feldman (2008) and Stuart and Ding (2006) have highlighted the role of the local social environment in stimulating entrepreneurial behavior among academics. Both studies illustrate empirically that the local social context explains why academics make the transition from pure science to commercial activities related to their research. Stuart and Ding (2006) focus on the direct contacts between academics and coauthors who have an entrepreneurial record as a stimulus for engaging in entrepreneurial activities. Bercovitz and Feldman (2008) focus more on the entrepreneurial attitude of colleagues and the head of the department. Both studies focus solely on academic entrepreneurship in the medical and biotech domains. This choice allows them to use very detailed proxies of the local social context variables, but also implies that the findings might not easily be generalized to other fields such as engineering and physical sciences. Since local social context is an important explanatory element of entrepreneurial intent, we expect that the influence of that environment can, however, be generalized across fields. Therefore, we argue:

Hypothesis 3. Academics who operate in a context where academic entrepreneurship is stimulated will have greater likelihood of being involved in entrepreneurial initiatives created by others or in founding entrepreneurial ventures themselves.

Hypotheses 1 and 2 emphasize individual characteristics of academics. Since entrepreneurial capacity has a strong genetic basis, it is likely that TTOs have very little impact on this. Even entrepreneurial experience can only be rarely stimulated by TTOs, although they might assist in setting up various programs which increase the entrepreneurial enthusiasm of academics and hence stimulate them to be involved in start-ups of others and cumulate entrepreneurial experience over time (Souitaris et al., 2007). They might also indirectly play a role in providing role models and therefore increase the social acceptance of being involved in commercial activities. However, the question remains whether TTOs, which have emerged following various Bayh–Dole legislative initiatives in various European countries since the mid 1990s also have a direct impact on academic entrepreneurship, after controlling for individual-level variables and the social context. In Europe and the

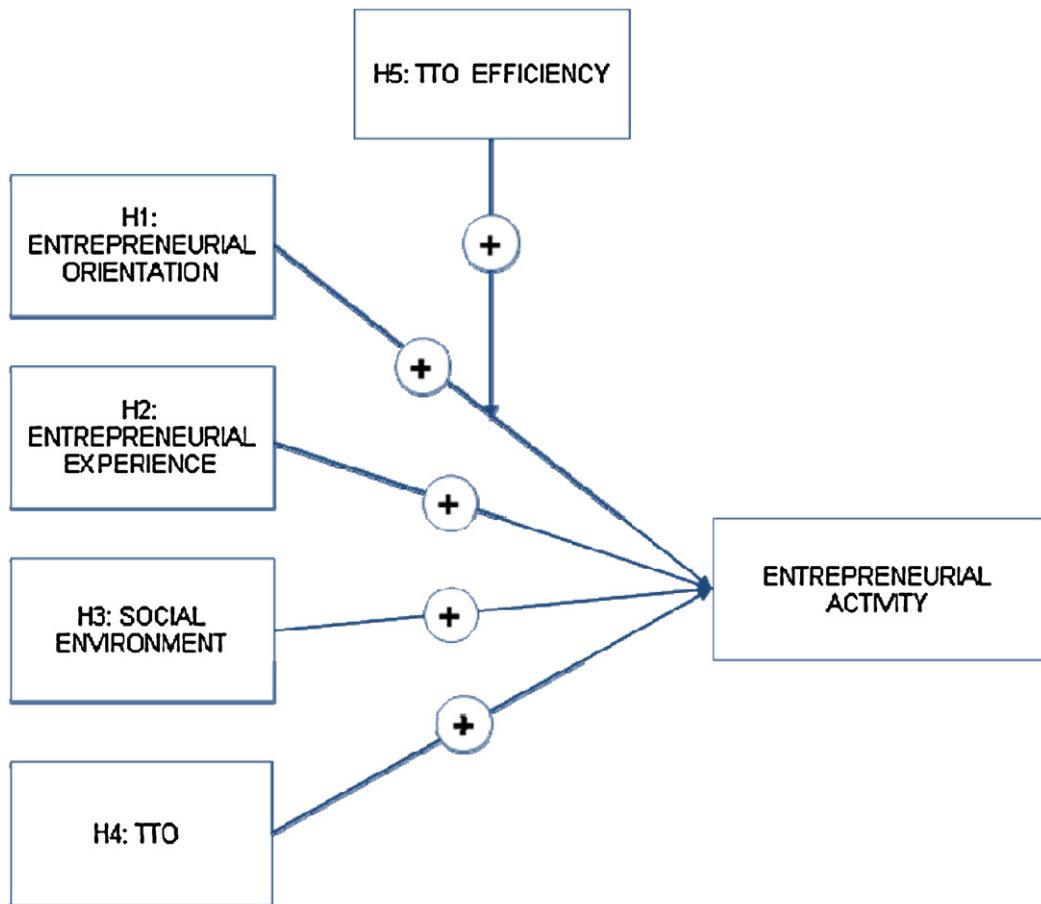


Fig. 1. Hypothetical framework.

UK more specifically, the change in laws and regulations about who owns the intellectual property of research results, which are based on public funding, was accompanied by significant investments in creating TTO in the different universities. Most countries have set up specific public schemes where universities can apply for money to co-finance or seed finance the set up of such a TTO office. For instance, in the UK, universities have received around £700 million in constant value since 2000 for such efforts, which is equivalent to around £5000 per academic. The initial distribution of that public money correlated closely with the size and quality of the university applying for it.

The TTOs that were created were expected to increase the commercial returns to be earned from university research. To do so, they developed activities to stimulate invention disclosures among the researchers, to protect inventions from copying and to assist researchers in the contractual and marketing part of their research. The general output measures that are used to benchmark the efficiency of a TTO against their colleague TTOs are the “number of patent applications” filed by the university (Thursby and Thursby, 2002); the level of income through contract research and the number of research-based spin-offs, which are created at the university (Wright et al., 2007). Thursby and Thursby (2002) have empirically shown that patent applications increased in US universities after the creation of central TTOs in these universities. Moray et al. (2009) have empirically shown that the number of contracts, the size of these contracts and the money generated through industry contracts has increased significantly at Belgian universities after the creation of central TTOs at these universities in the 1990s. Wright et al. (2007) suggested that the number of research-based spin-offs has also increased since central TTOs were created, but empirical

evidence on this remains inconclusive as data on research-based spin-offs and their performance has greatly improved since the creation of these TTOs. As a result, one is not sure whether the number of spin-offs has increased in reality or whether the increased number on the list only reflects the fact that statistics have improved since the creation of these TTOs.

Meyer (2003) has shown that although the initiatives that were taken by central TTOs may not have led to the creation of more high growth oriented spin-offs, they have increased the entrepreneurial intent of academics. Similarly, Bercovitz and Feldman (2008) found that academics who were familiar with TTO activities in their PhD or post-doctoral period were more likely to get involved in entrepreneurial activities later on in their career because they had become familiar with the business norms and skills that are needed to be successful in commercializing research. The main conclusion from this research is that TTOs, regardless of whether they have been able to create more successful companies, have supported the creation of an environment in which academics feel more comfortable in undertaking entrepreneurial activities. This is likely to be especially true for academics that were trained in the period that TTOs have become active. It is also in this period that expectations for venture creation among academics become a wider public policy goal, with explicitly targeted funding. Therefore, we hypothesize:

Hypothesis 4. Academics who started their career *after* the creation of a central TTO at the university are more likely to get involved in entrepreneurial initiatives created by others or in founding entrepreneurial ventures themselves.

In **Hypothesis 4**, we suggest a direct impact of the emergence of central TTO offices on the entrepreneurial activity of academics that are working in the shadow of the TTO. However, we might also expect an interaction effect between the academic's entrepreneurial capacity and the efficiency and/or professionalization of the TTO. If a TTO is efficient in its operations, then one would expect it to facilitate the creation of a venture, which then amplifies the impact of the efficiency of the TTO, and, in turn, the degree to which academics at the university get involved in starting a venture. There is increasing empirical evidence that the commercial results, which can be realized through spin-offs, are a multifold from the ones that are derived from selling licenses (Wright et al., 2007). Therefore, TTOs have extensively invested in supporting the setting up of entrepreneurial ventures. For instance, TTOs usually organize pre-seed capital to be invested in potential spin-offs (Clarysse and Bruneel, 2007). Academics, who want to start a new business, therefore have access to capital. In addition, they offer incubation services, which make it possible for academics to stay within the familiar setting of the campus while setting up the new business. They also offer a variety of advice and coaching activities towards the academics and help in finding experienced managers from industry to help support the new firm. So, one could expect that for academics with a high degree of entrepreneurial capacity, the barriers to effectively start-up their own business or get involved in a start-up would be significantly lower.

A central TTO office is thus expected to not only to stimulate entrepreneurial activity directly, but also to amplify the direct relation which we hypothesized between the entrepreneurial capacity of an academic and his/her involvement in starting new businesses that emerge from universities. Thus,

Hypothesis 5. The efficiency of the TTO will amplify the likelihood of an entrepreneurial oriented academic to become involved in entrepreneurial initiatives created by others or in founding entrepreneurial ventures themselves.

Fig. 1 summarizes our overall conceptual framework, indicating the expected relationships between individual, social and TTO efforts on the decision of an academic to be engaged in a new venture.

3. Data collection and methods

3.1. Sample frame and sampling process

To test our conceptual framework presented in **Fig. 1**, we draw upon a range of integrated and rich datasets. The most important of these is a questionnaire survey of 6200 academic researchers in the United Kingdom. This sample frame of academics includes the principal investigators and co-investigators who received grants from the UK Engineering and Physical Sciences Research Council (EPSRC) in the period 1992–2006. The EPSRC is the largest funding body for research in the UK (it distributed £740 million of research funding in 2008) and funds research in all fields of engineering, mathematics, chemistry, and physics. The EPSRC encourages partnerships between researchers and third parties, such as private firms, government agencies, local authorities, non-profit organizations, etc. Therefore, in the grant portfolio we can observe a mixture of collaborative (involving industrial or non-industrial partners) and response mode grants. The selection process for these grants is based on peer review. The questionnaire was administered electronically between April and September 2009: a letter of endorsement sent by the Chief Executive of the EPSRC was included in the invitation to participate in the survey. An email containing a personalized link to access the survey was sent a few days later, followed by two emails and a telephone reminder to non-respondents.

This yielded a total of 2194 completed questionnaires – a response rate of 36%.

The survey was designed to capture university researchers' attitudes to collaboration with industry and their entrepreneurial activities. A draft version of the questionnaire was tested during a pilot study conducted with 30 academics at Imperial College London. We merged the information obtained through the survey with additional secondary data. First, we matched our sample with the population of academics included in the Research Assessment Exercise (RAE) conducted in 2008 (HEFCE, SFC, HEFCW, and DELNI, 2008). The RAE assessed the quality of research in universities and colleges in the UK: 2344 submissions were made by 159 Higher Education Institutions (covering the period 2001–2007). The RAE was conducted jointly by the Higher Education Funding Council for England, the Scottish Funding Council, the Higher Education Funding Council for Wales and the Department for Employment and Learning of Northern Ireland and the quality profiles obtained are used to determine the amount of research-related grants given to UK higher education institutions. We assigned individuals in our sample to the unit of assessment they belonged to in the RAE, obtaining additional information about the size of the unit of assessment, the amount and nature of funding received in the last 7 years, the quality of the research performed in the department.

Second, we matched the universities included in our sample with the data collected by the Higher Education Funding Council for England (HEFCE) through the Higher education–business and community interaction survey (HE-BCI) conducted in 2008 (covering the years 2005–2007). The annual HE-BCI survey examines the exchange of knowledge between universities and society in a wider sense: it collects financial and output data per academic year at university-level on a range of activities, from the commercialization of new knowledge, through the delivery of professional training, consultancy and services, to activities intended to have direct social benefits. From this source, we collected information about the different streams of funding universities receive, and the magnitude of their commercialization efforts (such as number of patent applications, revenues from intellectual property and number of spin-offs created).

3.2. Estimation method

To empirically investigate the determinants for academics to be involved in entrepreneurial activities, we use an event (survival) analysis techniques: more specifically, we use the semi-parametric specification called the Cox model (Cox, 1972). Event models are used to analyze the relationship between the time that passes before an event occurs and one or more covariates. The Cox model is a general semi-parametric model in which no assumption about the distribution of survival times is made: estimates are obtained through partial likelihood methods based on the ordering of events. As we are dealing with tied data (multiple observations register the event of interest at some point in time, t_j), we approximate the partial likelihood function with the Breslow method (Breslow, 1974).

We can outline our model as:

$$h(t) = h_0(t) \exp(X_i\beta)$$

where $h_0(t)$ is the baseline hazard (this corresponds to the case in which all the covariates equal zero) which is shifted by an order of proportionality with changes in X (representing the vector of covariates).

The event in our model is the creation of a company by an academic (self-reported in the questionnaire). The analysis period starts at $t_0 = 2000$ and we observe all the individuals in our sample (1761) until $t = 2009$. Academics may present three different

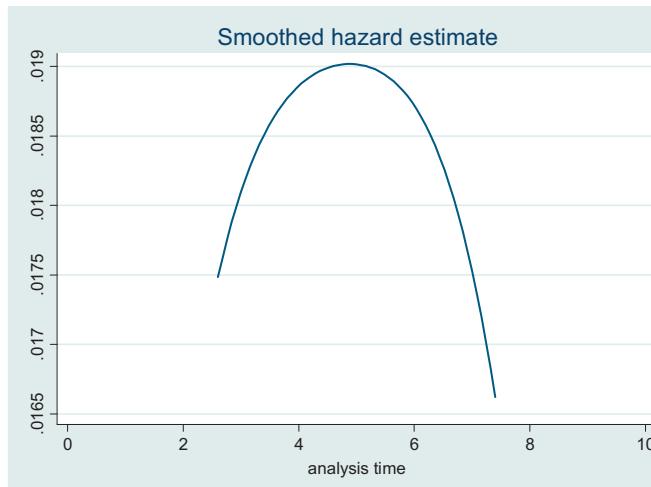


Fig. 2. Smoothed baseline hazard function (gauss).

categories of entrepreneurial activity: they may have not created any company in the period 2000–2009, they may have created one company in the period 2000–2009, or they may have created multiple companies in period 2000–2009. Different to most survival models, individuals in our study do not exit the sample after the event has occurred as they may be involved in several commercial ventures.

Without introducing any covariates, we can estimate the baseline hazard function based on the data displayed in Fig. 2. We can derive from this baseline hazard function that an academic in our sample typically gets involved in the creation of a company between 4 and 6 years after entering the observation sample. Before that, it is very unlikely that he/she gets involved in entrepreneurial activities and after 4–6 years the chances that he/she is involved in a start-up significantly decrease again.

4. Variables

4.1. Dependent variable

As explained above, the dependent variable is the baseline hazard rate for each individual in each year of observation. The hazard rate represents the researcher's decision to either get involved in a newly founded venture as a director or as a co-founder. In the overall sample, 16% of the academics are involved in start-ups in the period of our study. This figure is marginally higher than found in other studies, in part reflecting the seniority of our sample of academics.

4.2. Entrepreneurial capacity

To test Hypothesis 1, we introduce a first independent variable in our analysis, which is the researcher's *entrepreneurial capacity*. The construct entrepreneurial capacity is based upon Nicolaou et al. (2008, 2009). It consists of three items: (1) 'I frequently identify opportunities to start-up new businesses (even though I may not pursue them)'; (2) 'I frequently identify ideas that can be converted into new product or services (even though I may not pursue them)'; (3) 'I am generally not interested in ideas that may materialize into profitable enterprises (reverse-coded)'. The respondents were asked to rate these items on a 5-point Likert scale going from "strongly disagree" to "strongly agree". The final measure is an average of the three scores given: the Cronbach alpha for the construct obtained is 0.8, with well above standard thresholds for new

Table 1
Descriptive statistics.

Variable	Mean	S.D.	Min	Max
[1] Gender	0.13	0.33	0	1
[2] Department quality	62.29	15.47	10	95
[3] Top university	0.19	0.40	0	1
[4] Entrepreneurial capacity	2.93	1.00	1	5
[5] University spin-offs	3.24	4.03	0	25
[6] Entrepreneurial experience	0.15	0.51	0	5
[7] TTO	0.18	0.39	0	1
[8] University patent applications	41.60	44.71	0	185
[9] Professor	0.54	0.50	0	1

and short scales. Overall, the average self-reported entrepreneurial capacity of an academic is 2.8 (see Table 1).

4.3. Social environment

Several studies have shown that social influences increase the likelihood that an academic will become an entrepreneur (Kenney and Goe, 2004; Krabel and Mueller, 2009), typically refer to the availability of showcases and best practices in the direct environment of the academic as main motivators. For instance, Stuart and Ding (2006) show that proximity to other academics who have started new spin-offs significantly increases the likelihood that a focal scientist will engage in entrepreneurship. In other words, having academics who have successfully started spin-offs does have a positive impact on others. Kim and Miner (2007) further show, in a review of the literature on vicarious learning, that having both positive and negative showcases in the close proximity is a good indicator of vicarious learning. Regardless of whether there is a direct contact between the academics who are involved in the spin-offs or not, the existence of these spin-out companies in the local setting is a source of learning and norm creation.

In line with this, to measure the social environment, which prevails at the university where the academic is employed, we measure the number of *spin-offs* created by this university in the same year. This data has been included in the model as panel data: every individual is observed in nine periods (2001–2002–2003–2004–2005–2006–2007–2008–2009) and the number of spin-offs changes according to the period. Therefore, each entry in the model corresponds to a combination researcher-period. The data on spin-offs from universities is derived from the HE-BCI survey: data are available from academic year 2002/2003 to academic year 2007/2008. As our analysis spans other years, we have used the data of the closest year to fill in the missing values in the data.

We assume that if a university generates a large number of spin-offs in a given year, this reflects a strong social appreciation of this kind of commercial activity at the university in this period. As shown in Table 1, an average UK university generates on average between three or four spin-offs per year. However, the standard deviation is quite high and the maximum number of spin-offs was 25.

4.4. Entrepreneurial experience

The variable *past ventures* measures how many commercial companies the researchers were involved (as entrepreneurs) before 2000. 28% of the academics we observe between 2000 and 2009 had a venture before that period (see Table 1). This is significantly less than the 51%, which is shown to be the empirical average for the UK (Ucbasaran et al., 2006). This means that academics on average do not often start-up a business nor do they get involved in some form in businesses started up by others.

4.5. TTO presence

As mentioned above, all UK universities have started to create central TTO offices from the middle of 1990s. By the end of the 1990s, almost all UK universities had created these offices, partly financed by government funding, and started to develop best practices. So, academics who started their academic careers at a post-doctoral level after this period of TTO emergence and expansion are likely to have familiarized themselves with the activities of a TTO. To capture this transformation in the climate for academic entrepreneurship in the UK in the late 1990s, we have introduced in the model an additional variable at the individual level. The dummy variable *TTO* takes a value of 1 for researchers who have been awarded a PhD after 1998 and a value of 0 for researchers who have been awarded a PhD before 1998. As shown in Table 1, 18% of the academics in our survey have received their PhD after 1998, indicating that most of the samples were trained before the emergence and expansion of UK TTOs.

4.6. TTO efficiency

To measure the efficiency with which a TTO operates, we include the number of *patent applications* of that university as a proxy, related to the number of employees at the TTO office. Thursby and Thursby (2002) have shown that the efficiency of the TTO directly results in an increase in patent applications at the level of the university. Other output measures such as income from licenses or contract research depend much more on the quality of the underlying research base at these universities, the socio-economic environment in which the universities are located and the overall prestige of the university. In line with the proxy for entrepreneurial efficacy, this variable changes over time for each of the universities in the sample. An average UK university applies for 42 patents a year and has a TTO office with 38 employees. Again, the standard deviation is quite large and the maximum patent applications, which we noted in a given year was 185, while the largest TTO office employed 240 people (see Table 1).

4.7. Control variables

We include several control variables in the estimation. First, Stuart and Ding (2006) have shown that whether an academic works at a top 10 university in the US or not, explains the degree of entrepreneurial activity of that academic. In the UK, there are clearly four universities, which have consistently outperform the rest in terms of science and technology, so we include a dummy variable capturing these universities, namely University of Cambridge, University of Oxford, Imperial College London and University College London. We also control for the department's *research quality*, which has been indicated by Bercovitz and Feldman (2008) as an explanation of entrepreneurial activity of academics. This variable is measured as the percentage of staff rated 'internationally leading' and 'international excellent', which is a signature measure of research quality used for allocating funding in the RAE. In the entrepreneurship literature, it is often found that women have less probability of starting a business than men. Given this, we include a gender dummy to capture whether the academic is male or female. Overall, only 13% of our respondents are female.

5. Results

Table 2 presents the correlations between the variables employed in the model, showing no problem of multicollinearity. Table 3 provides the results of our model. Model (1) is the baseline model. The gender control variable is statistically significant and negative (the coefficient is lower than 1). This means

Table 2
Correlation matrix.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
[1]	1.00								
[2]	0.00	1.00							
[3]	0.06	0.42	1.00						
[4]	-0.07	0.01	0.00	1.00					
[5]	-0.01	0.20	0.21	0.02	1.00				
[6]	-0.07	0.04	0.07	0.23	0.04	1.00			
[7]	0.14	0.05	0.01	0.03	-0.02	-0.09	1.00		
[8]	0.03	0.43	0.70	0.00	0.18	0.02	0.00	1.00	
[9]	-0.12	0.00	0.01	0.03	0.01	0.12	-0.40	0.00	1.00

female academics have 40–50% less chance of being engaged in an entrepreneurial venture than their male equivalents. Also the quality of the research department plays a role. Academics who work at research departments with a high research status have a slightly higher chance of being involved in entrepreneurial venture. This result confirms that academic excellence and commercial outputs are often complementary to one another (Bercovitz and Feldman, 2008; Stuart and Ding, 2006). Yet, being employed at a top university does not make a significant difference in chance of being involved in an entrepreneurial venture.

Model 2 adds the two individual-level variables and the nested social environment variable. These variables correspond with Hypotheses 1, 2 and 3: (1) entrepreneurial capacity; (2) entrepreneurial experience and (3) social environment. Hypothesis 1, which links the entrepreneurial capacity of an individual academic to his/her entrepreneurial activity, is confirmed in this model. Each change on the entrepreneurial capacity scale of one unit increases the chance that the academic will eventually get involved in an entrepreneurial venture by a staggering 157%. In line with Hypothesis 2, we analyzed the entrepreneurial experience of an academic by using his/her involvement in previous entrepreneurial initiatives as a proxy. Again, we find that this variable is positive and significant, indicating the impact of having been involved in entrepreneurial initiatives before increase the probability of being involved in these initiatives in the future, thus confirming Hypothesis 2. In particular, being a serial or habitual entrepreneur increases the likelihood of getting involved in a next entrepreneurial venture by close to 30%. To test Hypothesis 3, we used the spin-offs that were generated in a given year in the academic's home university as a proxy to reflect the social environment, which prevailed at that university in that year. In line with other studies on social environment, we find a positive and significant impact of the social environment on the probability that an academic will create his/her own business. However, the impact of this environment is much weaker than the impact of the entrepreneurial capacity of the academic.

Model 3 adds the TTO level variables. First, we hypothesized that academics that had been familiar with TTO activities at the beginning of their career would have a higher propensity to engage in entrepreneurial activities during their academic career. This hypothesis is in line with the social learning hypothesis, which was put forward by Bercovitz and Feldman (2008). However, we find little empirical support for this hypothesis. On the contrary, academics that have received their PhD *after* 1998 have a much lower probability of being involved in a venture than those that have received a PhD *before* 1998.

Model 4 also includes a robustness check to analyze the counter-intuitive result of the test of Hypothesis 4 in Model 3. In that model, we find that academics that received their degree after 1998 have a lower chance of being engaged in entrepreneurial activities than those who received their PhD *before*. An alternative explanation for the negative sign might be that academics that answered our survey stay connected with the university in a particular role, even after founding a company or stay full time academics while

Table 3
Estimation model.

Variables	(1)	(2)	(3)	(4)
Gender	0.465** (0.125)	0.641 (0.174)	0.679 (0.185)	0.714 (0.194)
Department quality	1.016** (0.005)	1.015** (0.005)	1.014** (0.005)	1.013* (0.005)
Top university	0.900 (0.161)	0.766 (0.142)	0.662* (0.161)	0.669* (0.162)
Entrepreneurial capacity		2.568*** (0.206)	2.243*** (0.246)	2.188*** (0.240)
University spin-offs		1.026* (0.015)	1.022 (0.015)	1.023 (0.015)
Entrepreneurial experience		1.313*** (0.091)	1.269*** (0.089)	1.203* (0.087)
TTO			0.545** (0.111)	0.795 (0.176)
University patent applications			0.987* (0.007)	0.987* (0.007)
Entrepreneurial capacity × patent applications			1.004* (0.002)	1.004* (0.002)
Professor				2.033*** (0.323)
Scientific discipline	Yes	Yes	Yes	Yes
Observations	13,892	13,892	13,892	13,892

Hazard ratios reported instead of coefficients. Standard errors in parentheses.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

+ $p < 0.1$.

being involved in the board of these companies. Therefore, we may miss those researchers who leave the academic community to be more directly involved in their new ventures. We might expect that tenured academics have more possibilities to engage themselves in commercial activities while staying at university than their non-tenured colleagues, who still have to publish actively to build their tenure profile. In order to capture this question, we include a dummy variable to measure whether the academic in a given year had already achieved the status of professor or not. We find that professors are twice as likely to engage in entrepreneurial activities than their non-tenured colleagues. After controlling for professorship, we also find that the TTO variable, which distinguishes between those who have received their PhD after and before 1998, is no longer significant. However, the sign remains negative. So, the result does not change our initial findings with respect to *Hypothesis 4*.

Finally, we hypothesized that the interaction between the efficiency of the TTO at a given university (proxied by the number of patent applications in a given year in relation to the number of employees at the TTO in that year) and the entrepreneurial capacity of the academics would increase the likelihood that academics would get involved in entrepreneurial activities. In other words, we expected that the TTO would facilitate the process of entrepreneurial activity for those academics that are already likely to get involved in entrepreneurial activities. We indeed find a positive relation between the interaction term of the TTO's efficiency and the entrepreneurial capacity of an academic. However, this relation is only marginally significant, so *Hypothesis 5* only receives weak support.

Overall, we can conclude that the hypotheses which link the different predictors of entrepreneurial intent to entrepreneurial activity of individual academics receive strong support, while the hypotheses which relate the role of the TTO to the entrepreneurial activity of an academic receive little or no support.

6. Discussion and conclusions

Explaining why academics become involved in entrepreneurial ventures is a domain that has received increasing levels of inter-

est from academics and practitioners. Most papers of the first generation of studies, i.e. published before 2005, have tried to use university-level factors, such as development of the TTO, to explain the rise in the number of entrepreneurial ventures that spin-out of these universities. In general, these studies are empirically driven exercises and remain poorly linked to the wider entrepreneurship literature. Indeed, these university-level studies have often ignored the role of the individual academic in the process of spin-off creation, while more recent studies have tried to explain social mechanisms that lead individual academics to engage in entrepreneurial activities. Two of these studies ([Bercovitz and Feldman, 2008](#); [Stuart and Ding, 2006](#)) have more specifically shown that the (local) social environment in which an individual operates plays an important role in explaining his/her entrepreneurial activity.

This paper extends the literature in two important ways. First, we offer a link between the individual-level explanations of entrepreneurial activity that are found in the entrepreneurship literature and the emerging literature on academic entrepreneurship. Our analysis looks at the social environment surrounding the academic in line with the academic entrepreneurship literature, but also at individual-level characteristics such as entrepreneurial capacity and experience. Although entrepreneurial capacity, defined as the capacity to identify, recognize and absorb opportunities, and entrepreneurial experience, in terms of previous involvement in entrepreneurial activities, have been identified as determinants of the tendency to become an entrepreneur in the mainstream entrepreneurship literature, they have been ignored by the literature on academic entrepreneurship. By including these variables in a model of academic entrepreneurship, we helped to realign the literature on academic entrepreneurship with the wider literature on entrepreneurship. Second, by exploring the role of the TTO as an additional explanation in this model, by both showing the potential direct impact of the TTO and its indirect interaction with the individual-level variables, we are able to integrate the TTO level and individual levels. This combination allows us to gain insights into whether and how TTO efforts shape individual-level entrepreneurial behavior.

The results of the analysis have important implications. First, they suggest that among the individual-level variables, the opportunity recognition capacity of an academic is by far the most important variable to predict whether an academic will get involved in entrepreneurial activities or not. Although most emphasis has been put in the literature on explaining how the social norms in a particular department contribute to the eventual engagement of a particular academic in an entrepreneurial venture, these social norms have much less predictive power than the individual entrepreneurial capacity of the academic, which appears to be to a large extent genetically imprinted. In addition, by showing that an academic who has already been involved in entrepreneurial activities is more likely to be involved in subsequent entrepreneurial activity, the results suggest that individual attributes might play a much larger role than initially thought in drivers of academic entrepreneurship. Second, our results suggest that the role of the TTO in increasing the entrepreneurial activities of academics appears to be rather limited, or even non-existent. The efficiency of a TTO or even the mere presence of a TTO has often been used to explain why particular universities were able to produce so many research-based spin-offs. This might be a plausible finding, if we only take spin-offs into account which are based on a formal transfer of technology and, in which the TTO has a major stake. However, if we take a wider range of the start-ups into account, regardless of whether they are officially listed as spin-offs or not and regardless of whether there is a formal IP relation between the spin-off and the university, we find that the presence of a TTO plays little role in shaping academic venture creation, and that the efficiency of the TTO is only of marginal value.

This finding raises questions about the overall efficiency of TTOs in commercializing results through entrepreneurial ventures. Many of these TTOs adopt best practices, which focus on assisting the transfer of technology to industry, including new companies under the assumption that academics have an entrepreneurial capacity. TTOs spend most of their time protecting technology and formalizing the contractual relations around this technology. Much less effort is put into the development of a social environment, which stimulates entrepreneurial activities among academics such as entrepreneurship training, entrepreneurship seminars, etc. and little or no effort at all is put into attracting individuals with a high level of entrepreneurial capacity at the universities. This is an important issue in the light of the central topic of how the Bayh–Dole Act has affected technology transfer activities. In Europe, the Bayh–Dole Act was not only a regulatory framework, which had changed. It also formed the basis of a number of initiatives that were taken by various governments to support the development and professionalization of TTOs. In the case of the UK, various schemes for supporting university technology transfer were extended and enhanced in 1999 to provide direct support for university's 'third stream' activities (Mustar and Wright, 2010). The first of these programs, Higher Education Reach Out to Business and the Community Initiative (HEROBAC), was launched in 1999 and was later succeeded in 2002 by the Higher Education Innovation Fund (HEIF), which included four subsequent rounds of funding. These programs began by allocating funding to universities on the basis of competitive tender, but in 2003 they moved to block funding based on performance measures. Overall, the UK government has provided almost £700 million pounds (in constant 2003 prices) in direct support to English universities for third stream activities from 2000 to 2008, with another £340 million pounds committed for the 2009–2011 period (PACEC, 2009). Funding within HEROBAC and HEIF has included support for a range of commercial activities, including commercial venturing by academics, personal exchanges between university and industry and university patenting. However, the majority of these funds have

been used to build up and extend the efforts of the universities' TTOs.

Our findings of the salience of individual characteristics are consistent with Lockett and Wright (2005), who question the role of TTOs if the universities do not undergo a structural change. It is clear that universities have created TTO offices of considerable size and scope, and have very high expectations about the commercial results that these TTO offices might generate through entrepreneurial ventures. However, the universities, which have invested so much in the TTOs, made little or no attempt to attract entrepreneurially oriented academics as tenured professors or to recruit entrepreneurially oriented individuals in an academic career. Nor was entrepreneurship a core subject in the doctoral education of PhD students, especially of those aiming for an academic career. Yet, it is exactly the entrepreneurial capacity of the academic, which seems to be the most predictive factor of his/her entrepreneurial behavior.

7. Policy recommendations

There are a number of policy recommendations, which can be derived from this study. First, it is very clear that the individual attributes of the academics employed at a particular university are very important in explaining institutional levels of entrepreneurship. The university's potential for commercializing its research results through entrepreneurial ventures is liable to depend on its ability to attract and retain academics with high levels of entrepreneurial capacity. Given the importance of this individual level, the creation and efforts of TTOs is of modest or little use in itself unless such a creation is backed up by changes in the hiring and promotion practices of the university itself. This suggests that one of the implications of the Bayh–Dole and its European counterparts may be to make the university itself a more attractive place for individuals with a high entrepreneurial capacity to work. In this sense, the effect of these policies may be to deter self-selection of individuals with high levels of entrepreneurial capacity away from academic careers. Of course, this outcome is somewhat distant from the original intentions of these laws to change the culture of academics towards industrial engagement and commercialization.

Second, it is clear that the analysis that once an academic is tenured, he/she is more likely to engage in entrepreneurial activities. This may be so because early career researchers may wish to focus on meeting their universities tenure requirements in terms of publication in the formative part of their career. A significant involvement in a commercial venture may distract them from these efforts. Second, given the slow pace of tenure processes in many European universities, it may be that early career researchers exit academic life altogether in order to express their entrepreneurial intent. One implication of these findings is that if a university wants to stimulate involvement in entrepreneurial activities, they should ensure that promotion and tenure decisions reward such efforts. They should also seek to make decisions about promotion within a reasonable time span. Since, in many European universities, the process to obtain a full professorship can last over decade for even the most talented researcher, this is an important issue. With such a long gestation period to a professorship, it may be that many entrepreneurial academics turn away from academic careers as their efforts are unrewarded or unappreciated by their universities.

Third, we found that academic excellence, reputation and entrepreneurial activity go hand-in-hand. This means that attracting entrepreneurial academics does not mean that these academics will need to sacrifice their scholarship. The underlying quality of the research at the department remains highly important to explain the potential of starting new businesses based upon that research. So, changing career and recruitment practices does not imply that aca-

demic norms should be devalued. Only, these environments might be made more attractive to potential academics with a high degree of entrepreneurial capacity.

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