Academic spinoffs: the role of entrepreneurship education

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Abstract New ventures depend on the capability of entrepreneurs to transform an idea or a technology into a successful company. The literature on entrepreneurship has recognized that Entrepreneurship Education (EE) plays a key role in this process, but the literature on academic spinoffs has focused on other determinants (e.g., Technology Transfer Offices - TTO, and university research expenditures). This research investigates the role of EE in the creation of academic spinoffs by using a new dataset built around 1,262 entrepreneurship courses offered between 2011 and 2014 by 80 US universities included in the Licensing Survey by the Association of University Technology Managers - AUTM). Adopting a Poisson panel regression model, we show that, in addition to TTO size and university research expenditures, EE favours the creation of academic spinoffs. Moreover, we find that practical – rather than theoretical - entrepreneurship courses favour the creation of academic spinoffs. We conclude discussing the theoretical and practical implications for universities, students and scholars interested in entrepreneurship.

Keywords Entrepreneurship Education; Academic spinoff; Academic entrepreneurship; University entrepreneurship

Introduction

Academic spinoffs are important regional economic growth actors (Bramwell and Wolfe 2008; Breznitz et al. 2008; Guerrero et al. 2015, 2016; Hayter 2016; Mariani et al. 2018) thanks their role in the entrepreneurial ecosystem (Stam 2015; Cavallo et al. 2018a; Cavallo et al., 2018b) by introducing innovations, increasing the productivity of regions and creating new jobs (Doutriaux 1987; Shane 2004; Van Praag and Versloot 2007; O'Shea et al. 2008; Vincett 2010; Hahn et al. 2018). In the last twenty years, the attention of universities toward the creation of academic spinoffs, academic and student entrepreneurship has increased, as part of their 'Third-Mission', aimed at contributing to local economic development (Philpott et al. 2011). The relevance of academic spinoffs has led scholars to analyse the reasons for their emergence. Among the factors that have influenced the creation of academic spinoffs, literature has distinguished five key aspects: personal factors, such as faculty motivations (e.g., Hayter 2011); financial factors, such as the amount of money that universities invest in research activities (e.g., O'Shea et al. 2005); organizational factors, such as size and other characteristics of TTOs (Technology Transfer Office) supporting spinoff creation (e.g., Di Gregorio and Shane 2003); cultural factors, such as the internal culture of universities (e.g., Feldman and Desrochers 2004); and policy and ecosystem factors (e.g. Fini et al. 2011). However, despite a large number of different determinants that have been identified, to the best of our knowledge, no attention has been paid to the role that Entrepreneurship Education (EE) plays on the creation of academic spinoffs (Lamine et al. 2018). The aim of this paper is to fill this gap by studying whether and how EE has an impact on the creation of academic spinoffs. In this vein,

we root our paper in the literature studying the impact of university characteristics on academic spinoffs creation (Di Gregorio and Shane 2003; Fini et al. 2011).

There are several theoretical reasons that support the hypothesis that EE can contribute to spinoff creation. At a general level, entrepreneurship courses raise the entrepreneurial attitudes and intentions of students (e.g., Peterman and Kennedy 2003; Souitaris et al. 2007; Sánchez 2011; Walter et al. 2013; Zhang et al. 2014; Gielnik et al. 2015; Muscio and Ramaciotti 2019), create an entrepreneurial culture which pervades the whole university (Bramwell and Wolfe 2008; Prodan and Drnovsek 2010; Guerrero and Urbano 2012; Fryges and Wright 2014; Marzocchi et al. 2018), and favour the development of entrepreneurial competences (Lee et al. 2005; Phan and Siegel 2006; Sánchez 2011; Morris et al. 2013; Sánchez 2013; Hayter 2016; Gümüsay and Bohné 2018) which – in turn - may favour the creation of academic spinoffs. In fact, a positive entrepreneurial culture is a social state of mind where previous efforts made by pioneering professors, students, and university administrators led other professors and students to believe that entrepreneurship is a possible, acceptable and desirable activity within the university ecosystem (Bramwell and Wolfe, 2008; Gilsing et al., 2010). These efforts include the development of university policy and the creation of infrastructures (e.g. TTO, co-working space, facilities for "makers", etc.), programmes (e.g. incubator, accelerator, EE, hackathon, business competition, mentorship) and organizations (e.g. student-led entrepreneurial club) facilitating the development of Technology Transfer activities, such as the commercialization of technology and university knowledge and the creation of companies. These efforts also improve relationships between the academic and business community. Moreover, universities may leverage their entrepreneurial courses to directly support the creation of academic spinoffs based on research activities (Müller 2010) as promotion of innovation and human capital training for entrepreneurship. For instance, universities may set these courses as mandatory for those students and faculty members who are willing to establish an academic spinoff (Etzkowitz 2004; Bramwell and Wolfe 2008). Although the relationship between EE and academic spinoff creation can seem straightforward, studying it is complicated by two main factors: (i) the unobservable direct impact of EE on the creation of new spinoffs; (ii) the heterogeneous nature of EE, which may take multiple and different forms under which it is taught within and between universities (Martin et al. 2013; Bae et al. 2014; Rideout and Gray 2013; Hahn et al. 2017; Nabi et al. 2017). In order to overcome these issues, in this study we take two further steps to investigate the relationship that exists between EE and the creation of academic spinoffs. First, we analyse whether EE enhances the entrepreneurial culture at the university level not at the level of specific courses, controlling for organizational factors (e.g. the size of the TTO in the university) and financial factors (e.g. the amount of money spent on research by the university). Second, we observe the nature of the entrepreneurial courses offered by universities, adopting the taxonomy introduced by Béchard and Grégoire (2005). This latter step helps us identify whether more theoretical or more practical entrepreneurship courses have different impacts on the creation of academic spinoffs.

Our research is based on a new dataset built around a sample of 80 US universities included in the Licensing Survey by the Association of University Technology Managers (AUTM). We complemented the Licensing Survey by the AUTM dataset with information about all the entrepreneurship courses offered by these 80 universities in years ranging from 2011 to 2014. We have categorized the entrepreneurship courses adopting Béchard and Grégoire's taxonomy. In total, we have identified and examined 1,262 entrepreneurship courses in our sample over a time span of 4 years. We have analysed their impact on academic spinoff creation – at the university level – adopting Poisson panel regression models. We have found that – in addition to TTO size and research expenditures - EE favours the creation of academic spinoffs. In other words, the greater is the number of entrepreneurship courses offered by a university, the greater is the number of academic spinoffs created by a university. In addition, our analyses have shown practical - rather than theoretical - models of teaching entrepreneurship favour the creation of more academic spinoffs. Our results mainly contribute to two streams of literature. First, we contribute to the academic and student entrepreneurship literature by identifying EE as another important factor in the creation of spinoffs.

By doing this, this study answers a call from Lamine et al. (2018) to provide evidence on the role of EE to promote the creation of academic spinoffs. Second, we contribute to the EE literature, by testing and providing empirical evidence about the different impact that different teaching models may have in the field of entrepreneurship, thus responding to open points in the scientific literature (e.g. Nabi et al. 2017).

In the following section, we present the relevant literature on the determinants of academic spinoffs and the importance of EE for the creation of academic spinoffs. At the end of this section, we present our two hypotheses. In the third section, we present our research design, our data selection process, the sample, the variables, and the methodology. In the fourth section, we present our results. In the results, we show first descriptive analyses to understand and illustrate our sample and then we present our regression analyses to test our hypotheses. Finally, we conclude our paper by discussing our findings and implications for researchers, deans, teachers, and university policy makers. In the conclusion, we also discuss the limitations of our work and we suggest avenues for future researches.

Literature review and hypotheses development

The determinants of academic spinoffs

As specified by Di Gregorio and Shane (2003) an academic spinoff is defined as "[a] start-up created when the licensee of a university-assigned invention creates a new company to exploit it". (Di Gregorio and Shane 2003, p. 2010). Therefore, academic spinoffs have a key role on delivering value to the Society from the research and the knowledge of the academic world (Bramwell and Wolfe 2008; Vincett 2010; Hayter 2016) as required by the so called 'Third-Mission' (Philpott et al. 2011). For instance, Bramwell and Wolfe (2008) highlighted how the academic spinoffs of the University of Waterloo, Canada, had a relevant role in the development of the local and regional economy.

As a consequence, the determinants of the creation of academic spinoffs have been largely discussed in the literature (e.g., O'Shea et al. 2007; O'Shea et al. 2008) in order to understand how to increase their number and impact. At a macro level, five key factors have been identified as determinants of the creation of academic spinoffs: personal factors (i.e. related to the founder's characteristics), financial factors (i.e. related to both the funding necessary for the creation of the technology at the basis of the spinoff, and to the spinoff's funding), organizational factors (i.e. related to the parent university of the spinoff), cultural factors (i.e. the type of entrepreneurial culture in the spinoff's parent university) and ecosystem and policy factors (i.e. related to the ecosystem in which the academic spinoff is incorporated and to the policies that support its creation).

Table 1 summarizes these five key aspects and details each factor by presenting their second-order constructs and their main references in the literature. We, therefore, discuss such factors in the light of EE to frame the complexity of the creation of academic spinoffs. Then, we introduce EE as a sixth factor that can contribute to the creation of academic spinoffs.

Table 1 – First and second-order determinants of the creation of academic spinoffs

First-order factors	Second-order factors	Main References
Personal	Faculty motivations	Prodan and Drnovesk 2010
		Hayter 2011
	Social capital	Shane and Stuart 2002
		Walter et al. 2006
		Diánez-González and Camelo-Ordaz 2017
		Huynh et al. 2017
	Experience	Landry et al. 2006
		D'Este et al. 2012

		Visintin and Pittino 2014
		Huynh et al. 2017
Financial	Research expenditure	Di Gregorio and Shane 2003
		Lockett and Wright 2005
		Powers and McDougall 2005
	Government and private financial support	Di Gregorio and Shane 2003
		O'Shea et al. 2005
		Landry et al. 2006
	Venture capital funding	Di Gregorio and Shane 2003
		Wright et al. 2006
	Proof-of-concept	Munari et al. 2016
Organizational	TTO	Di Gregorio and Shane 2003
		Friedman and Silberman 2003
		Lockett and Wright 2005
		Markman et al. 2005
		O'Shea et al. 2005
		Powers and McDougall 2005
		Clarysse et al. 2011
		Algieri et al. 2013
	Research park	Link and Scott 2005
	Incubator	O'Shea et al. 2005
		Soetanto and Jack 2016
Cultural	University's culture	Siegel et al. 2003
		Feldman and Desrochers 2004
		Philpott et al. 2011
		Berbegal-Mirabent et al. 2015
		Gümüsay and Bohné 2018
Ecosystem and policy	Policy principles	Goldfarb and Henrekson 2003
		Gilsing et al. 2010
		Meoli et al. 2017
	Local and regional ecosystem	Fini et al. 2011
		Casper 2013
		Sternberg 2014

Personal factors. As far as start-ups are concerned, the founder's characteristics and social networks are crucial in determining their creation (Smeltzer et al. 1991; Bonaccorsi et al. 2014), and the same holds true for academic spinoffs (Prodan and Drnovesk 2010). Prodan and Drnovesk (2010), for instance, suggest applying the theories that are used to understand the intentions of creating start-ups – such as the Theory of Planned Behaviour (Ajzen 1991) – to study the entrepreneurial intentions of academics. In order to explain why some faculty members and students create academic spinoffs, Hayter (2011) shows that their primary motivation is technology diffusion since faculty members generally wish to spread their theoretical knowledge to the community, thus creating value for the society (Hayter 2011). In this vein, by promoting entrepreneurial courses for students and faculty members university could engage students and faculty member in the creation of academic spinoffs. In fact, EE promotes entrepreneurial self-efficacy which – in turn – boosts the entrepreneurial intentions of both students and academics (Prodan and Drnovesk 2010). In addition to their motivation, another key feature is represented by social capital (Walter et al. 2006). Hayter (2011) pointed out that "motivating peers" as a social norm is an important lever to favour the creation of academic spinoffs. These "motivating peers" are often represented by people – who are closer to the business context than academics - who operate as gatekeepers between university and industry. However, Hayter (2011) also suggested that – apart from "motivating peers" - there are also "de-

motivating peers", who may create a negative environment for academic and student entrepreneurship inside a university, thus suggesting that peers, and social capital in general, have an impact on entrepreneurship intention. In fact, social norm is a fundamental construct of the Theory of Planned Behaviour (Ajzen 1991) and networking is important for developing entrepreneurship intention (Krueger Jr et al. 2000). In more detail, network ties increase the willingness to create academic spinoffs, since having direct and indirect relationships with external investors enhance the probability of faculty members creating an academic spinoff and of surviving (Shane and Stuart 2002). Moreover, Diánez-González and Camelo-Ordaz (2017) have recently shown that university support networks have a positive influence on the enhancement of the entrepreneurial orientation of academic spinoffs. In addition, Huynh et al. (2017) recently found that the networks of a founding team of an academic spinoff have an indirect impact on their performance through the enhancement of a team's entrepreneurial capabilities. In line with this, Gümüsay and Bohné (2018) have recently shown that entrepreneurial competences are important for the creation of academic spinoffs. In this vein, both team's capabilities and its experience represent other relevant personal factors that can influence the willingness of students and academics to create an academic spinoff (Clarysse and Moray 2004; Nikiforou et al. 2018). Regarding their experiences, Landry et al. (2006) found that faculty members involved in consulting have a higher likelihood of creating academic spinoffs than others. These results were confirmed by D'Este et al. (2012). However, Gras et al. (2008) do not find a statistically significant correlation between the academic staff involved in industry research and the spinoffs activity in European universities. In addition, Gras et al. (2008) find a strong statistically significant correlation between the number of professors and the number of university publications on spinoffs activity in European universities. Moreover, D'Este et al. (2012) also found that prior invention experience has a positive and significant impact on the creation of academic spinoffs. Lastly, Visintin and Pittino (2014) suggested that not only personal experience, but also team heterogeneity of experience pays off in enhancing the probability of creating academic spinoffs. In fact, Visintin and Pittino showed that the integration of academic and non-academic profiles in an academic spinoff team has a positive impact on their early performance. In the same line, Ferretti et al. (2018) find that academic spinoffs in the post-creation stage perform better if the board of the academic spinoffs is composed by academic individuals and representatives of non-academic organizations. In short, the motivation, the social capital and the previous experience of the faculty members and students are three key personal characteristics of academics that may influence their willingness to create spinoffs (Rasmussen et al. 2011).

Financial factors. The existing literature recognizes the importance of personal factors for the creation of academic spinoffs and discusses how to incentivize and support them. Wright et al. (2006) showed a key element in enabling the creation and development of academic spinoffs is represented by their financial support (see Civera et al. 2017 for an extensive review). The benefits related to providing financial incentives and support to researchers have been pointed out clearly by Lockett and Wright (2005), who found a positive relationship between a university's research expenditures and the creation of academic spinoffs in the UK context. Similarly, Gras et al. (2008) find a statistically significant and positive correlation between the availability of financial support and spinoff activity in European universities. This suggests that providing financial resources for research enhances the likelihood of developing a technology with a higher potential impact on the market. In fact, since the technology exploited by academic spinoffs is usually discovered thanks to research subsidies, the number of research inputs and the number of created academic spinoffs are likely to be correlated (Di Gregorio and Shane 2003). For this reason, significant indications may be obtained by analysing the sources of financial resources, in order to understand which source is more relevant for the creation of academic spinoffs. However, literature arrived at different conclusions about it. For instance, Di Gregorio and Shane (2003) found that a university's total sponsored research funding has a positive and statistically significant impact on the creation of spinoffs. However, Di Gregorio and Shane analysed the financial support to researchers from the US government, without finding any

significant impact on the creation of spinoffs. Nevertheless, O'Shea et al. (2005) found that both, government and private research funding have a positive impact on the creation of spinoffs. On the contrary, Landry et al. (2006) found that financial resources from private companies have a negative impact on the creation of academic spinoffs, and they proposed that financial support from private firms can stimulate academics to transfer their knowledge to the private sector rather than to create academic spinoffs. However, Landry and colleagues found that research grants from the federal funding agency have a positive impact on the creation of academic spinoffs. Finally, Powers and McDougall (2005) found a positive impact of university research expenditure on the creation of academic spinoffs. In conclusion, financial supports are important for the creation of academic spinoffs, but the sources of these financial supports can have different impacts on the creation of academic spinoffs.

Organizational factors. The link between the organizational structure of universities and the academic spinoffs they created has been largely recognized in the literature. These organizational factors, in fact, play a key role in supporting the creation of new spinoffs, mainly through their unit that is dedicated to technology transfer: the TTO (e.g., Friedman and Silberman 2003; Markman et al. 2005). The development of TTOs has been shown to be beneficial for the creation of academic spinoffs, since the latter may benefit from the experience, network and business skills of the TTO staff, all of which are transferred to spinoffs under the form of business development consulting (Lockett and Wright 2005). Clarysse et al. (2011) suggested two important caveats: first, that the more a university invests in developing the TTO (that implies increasing its resources), the more it will benefit in terms of created academic spinoffs; second, that such a mechanism is not straightforward, but is subject to learning economies, thus implying that it may take some time to achieve results. Powers and McDougall (2005) pointed out that more developed and older TTOs seem to have better established competences to facilitate technology transfer activities. In line with this, analysing 870 academic spinoffs in UK, Prokop et al. (2019) found that the TTO is a core network actor for the academic spinoff survival. Moreover, Lockett and Wright (2005) showed that business development capabilities of TTOs have a positive impact on the creation of spinoffs, thus suggesting that universities need to improve their business skills, if they aim to increase the creation of valuable spinoffs. In addition, another key factor that seems to play a crucial role in explaining the positive correlation between the creation of academic spinoffs and TTOs is the size of such an office. Di Gregorio and Shane (2003), O'Shea et al. (2005) and Algieri et al. (2013) found that the greater the size of the TTO offices, the higher the number of academic spinoffs. Similarly, Gras et al. (2008) find a statistically significant and positive correlation between TTO staff dedicated to spinoffs support and the spinoffs activity in European universities. While this evidence might be driven by an endogenous factor (larger universities tend to have larger TTOs but also have a higher probability of creating more spinoffs), it also seems to confirm that the more the capabilities included in TTOs, the higher the support they can offer to researchers, thus enhancing their probability of creating a new spinoff. Moreover, Ferretti et al. (2019) showed that the presence of the parent university on the board of the academic spinoffs – as well in its ownership structure – has an impact on academic spinoffs' revenues. Finally, TTOs may facilitate the access to funding methods, such as proof-of-concept (Kochenkova et al. 2016; Munari et al. 2016), thus allowing the founders of spinoffs to enhance the Technology Readiness Level of their technology and enhance the probability of creating an academic spinoff. The organizational structures that support the creation of academic spinoffs are not limited to those structures that are internal to universities. Although TTOs may not be strictly internal to universities (Battaglia et al. 2017; Brescia et al. 2016), external organizations that support entrepreneurial actions may also play a relevant role (Markman et al. 2008). Link and Scott (2005), for instance, suggested that the existence of a link between scientific parks and universities can be considered a significant predictor of the number of academic spinoffs created by universities. Similarly, Soetanto and Jack (2016) highlighted that incubators, thanks to their network, managerial education and their managerial support, enhance the probability of creating academic spinoffs. In more detail, Soetanto

and Jack (2016) suggested that the incubators' supports overcomes the shortcomings that arise due to the lack of resources, entrepreneurial capabilities and experience needed to manage the tension that escalates when a researcher transfers his/her research from a technology to a market domain. However, O'Shea et al. (2005) did not find any impact of the presence of a university incubator on the creation of academic spinoffs. These results suggest that the presence alone of an external organization is not enough. Universities and these external organizations need to have a close connection and they need to interact in order to exploit their network capacity and social capital and to have a positive impact on the creation of academic spinoffs and thus to foster a local entrepreneurial ecosystem.

Cultural factors. Although a "magic recipe" for the creation of academic spinoffs does not exist (Berbegal-Mirabent et al. 2015), an important activity for universities is to create not only the conditions for the market development of the technologies discovered by researchers (i.e. to financially promote their development or to establish supporting organizations for business development, such as TTOs), but also to operate at a more general level by applying strategies that foster a university's entrepreneurial culture and increase knowledge transfer (Berbegal-Mirabent et al. 2015; Gümüsay and Bohné 2018; Civera et al. 2019). For instance, the lack of entrepreneurial culture in universities could limit and cancel out all the efforts were undertaken to promote academic and student entrepreneurship and may also reduce any positive effects of investments and programmes on the creation of academic spinoffs (Berbegal-Mirabent et al. 2015; Gümüsay and Bohné 2018). For instance, Huyghe et al. (2016) found that just a minority of students and faculty members are aware of the existence of a TTO in their university. Therefore, universities need to improve this awareness by developing entrepreneurial culture (Prodan and Drnovsek 2010). In addition, to foster academic and student entrepreneurship, universities need to improve their communication and educational programme regarding entrepreneurship (Philpott et al. 2011) in order to break down cultural barriers which are the main inhibitors to the development of academic and students entrepreneurship (Hayter 2011) and technology transfer (Siegel et al. 2003). A possible approach regards the growth of the commercial orientation of universities aimed at narrowing the existing gap between universities and firms (Feldman and Desrochers 2004).

Policy and ecosystem factors. Finally, in order to foster the creation of academic spinoffs, universities develop and apply several policies (Meoli et al. 2017). Such policies may be an important instrument to favour the development of an entrepreneurial culture in universities (Gilsing et al. 2010), but they are also limited in fostering the academic and students entrepreneurial outcome, since they cannot deal with all the internal specificities characterizing each university (Philpott et al. 2011). However, several studies suggest that a support to the creation of spinoffs should come from universities according to a bottom-up approach rather than a top-down one (e.g. Goldfarb and Henrekson 2003). Meoli et al. (2017) found that the university's board of directors has an important role in the creation and the type (technology or non-technology) of academic spinoffs. However, Gras et al. (2008) do not find a statistically significant correlation between tech transfer policy and spinoffs activities in European universities. In addition, policies need to consider the complexity of academic spinoff creation and the involvement of external factors, such as investors and local social-economic contexts (Lockett and Wright 2005; Fini et al. 2011; Sternberg 2014). In fact, previous research also acknowledged the important role of the ecosystem in which the universities are embedded, as well as the need for policies to sustain the development of academic spinoffs (Wright et al. 2006). For this reason, Fini et al. (2011) suggested considering the idiosyncrasies of the regional setting to develop effective policies in order to foster the creation of academic spinoffs, especially because the regional environment is often even more important than the government support for the creation of academic spinoffs (Sternberg 2014). Casper (2013) showed how the San Francisco entrepreneurial regional ecosystem, through the structure of its social networks, facilitates the creation of academic spinoffs for their universities.

In short, the literature on academic spinoff creation has suggested several factors (e.g., TTO size and university research expenditures) that can shape the creation of academic spinoffs. However, it has not been fully able to capture why there is such a huge heterogeneity in the number of academic spinoffs created by universities (O'Shea et al. 2007; Rothaermel et al. 2007; Djokovic and Souitaris 2008; Perkmann et al. 2013; Gümüsay and Bohné 2018), even in contexts characterized by the same institutional factors (e.g. universities in the same regions) or by a similar level of resource endowment (e.g. the same university over different years)[1]. We assume that EE is a factor that can explain such a heterogeneity. In the next paragraph, we explore and present the reasons that support our hypotheses.

Hypotheses development

EE may be considered as a sixth relevant determinant of the creation of academic spinoffs for several reasons. In the next sections, we will present our two hypotheses related to how EE and the entrepreneurship teaching models are related with spinoff creation.

Entrepreneurship Education

EE may have a positive impact on the creation of academic spinoffs for the following three theoretical reasons: (i) entrepreneurship courses can provide direct support to entrepreneurs; (ii) entrepreneurship courses can raise the entrepreneurial attitudes and intentions of students; (iii) the presence of entrepreneurship courses may improve entrepreneurial culture and networking opportunity in universities.

First, in the last twenty years, both entrepreneurship courses and academic spinoffs in universities increased (Di Gregorio and Shane 2003; Siegel et al. 2007; Clarysse et al. 2011; Martin et al. 2013; Rauch and Hulsink 2015; Siegel and Wright 2015; Lamine et al. 2018). Müller (2010) - using a sample of 20,000 German start-ups and academic spinoffs - put forward evidence that more than 6% of the sample had received direct support, prior to firm formation, from entrepreneurship courses offered by universities, thus implying that a possible correlation between spinoff creation and entrepreneurship courses may exist, as future entrepreneurs may receive support in the form of specific training. Moreover, EE has a fundamental role in the human capital training for entrepreneurship (e.g. Gümüsay and Bohné 2018). For instance, Criaco et al. (2014) found that academic spinoffs whose management teams had an entrepreneurial education, improved the survival rates. Moreover, entrepreneurship programmes can foster venture formation by students and faculty members thanks to their mentoring and financial support (O'Shea et al. 2007). Furthermore, in Sweden, several academic spinoffs originated from entrepreneurship teaching programmes which were linked to students and faculty members (Etzkowitz 2004; Bramwell and Wolfe 2008). Bramwell and Wolfe (2008) found that EE improves the university entrepreneurial culture, and this can have a positive effect on the creation of spinoffs (Gilsing et al. 2010).

Second, EE may make universities more successful in creating academic spinoffs thanks to a more active role of students exposed to EE in the creation and management of such ventures (Bramwell and Wolfe 2008; Rasmussen and Wright 2015; Muscio and Ramaciotti 2019). Similarly, O'Gorman et al. (2008) showed that academic spinoffs generally involved PhD students in their initial phases. Hayter et al. (2017), employing a case study based on MIT academic spinoffs, found that students played comparable roles to those of faculty entrepreneurs in academic spinoffs. Bramwell and Wolfe (2008) indicate the importance of students in the commercialization process of technology transfer. Muscio and Ramaciotti (2019) have recently determined that availability of entrepreneurship classes as part of PhD career increases the likelihood of PhD creating a new venture. In addition, Åstebro et al. (2012) showed that students have a greater probability than faculty members of creating

[1] For instance, despite their limited geographical distance and their belonging to a similar institutional environment, in the US context, the University of South Florida created approximately 38% fewer academic spinoffs than the University of Florida between 2011 and 2014 (data source: Licensing Survey by the AUTM).

academic spinoffs, probably because students are younger, they have more time and they are more likely to take risks. Moreover, the founders of successful academic spinoffs usually work together with students (Rasmussen et al. 2014). This is because, especially in technical or medical schools, graduate students are frequently engaged in research activities, and they usually maintain their efforts within the academic spinoffs they founded with the research team they collaborated with (Hayter 2016). Furthermore, Boh et al. (2016), by analysing eight US universities, recently showed that among 47 of the academic spinoffs included in their sample, PhD students and postdocs were involved in 36 of them (77%), with at least 11 (23%) academic spinoffs having been established with no faculty involvement. Given the key role students can play in academic spinoffs, and due to the positive impact of EE on students' entrepreneurial attitudes (Souitaris et al. 2007; Piperopoulos and Dimov 2015), competences (Lee et al. 2005; Phan and Siegel 2006; Sánchez 2011; Morris et al. 2013; Sánchez 2013; Gümüsay and Bohné 2018) and intention (Lee et al. 2005; Peterman and Kennedy 2003; Souitaris et al. 2007; Sánchez 2011; Sánchez 2013; Vanevenhoven and Liguori 2013; Walter et al. 2013; Zhang et al. 2014; Gielnik et al. 2015; Karimi et al. 2016; Maresch et al. 2016; Gielnik et al. 2017), we hypothesize that EE may have an important role in the creation of academic spinoffs. For instance, O'Shea et al. (2007) suggested that entrepreneurship programmes have a positive influence on the entrepreneurial intentions of students and faculty members, and this can have an impact on the entrepreneurial culture of a university.

Third, if a university offers several entrepreneurship courses, it may indicate that that the university has a high knowledge in that field, based on the expertise of Professors and mentors in entrepreneurship. This may help the university to generate more spinoffs by leveraging on their know-how, experience, and networks. Furthermore, if a university develops a rich curriculum characterized by several entrepreneurship courses, it indirectly contributes to the creation of an entrepreneurial environment and culture connecting the students, the faculty and the local entrepreneurial ecosystem, which, in turn, will have a positive effect on the generation of academic spinoffs. This view is in line with what was suggested by Van Burg et al. (2008), who concluded their case study by pointing out that, to create more academic spinoffs, universities need to inspire the growth of entrepreneurial ideas with EE programmes targeted at students and academic faculty. EE, in fact, contributes to creating a vibrant entrepreneurial climate which enables the development of social capital and – in turn - favours the development of new academic spinoffs (Guerrero and Urbano 2012; Marzocchi et al. 2018). This phenomenon, which Borges and Filion (2013) called "preparation", represents a phase in which the future entrepreneur develops social and business skills that are determinant in enhancing the intention to develop a business. In addition, the influence of education activities, such as entrepreneurship courses, is not limited to those who participate in the classes. In fact, entrepreneurship courses contribute to creating an entrepreneurial culture (Bramwell and Wolfe 2008; Prodan and Drnovsek 2010; Fryges and Wright 2014; Bergmann et al. 2016), which may also be contagious to those who do not participate in such activities. In other words, the elements that affect the creation of academic spinoffs - which are in place when EE is considered - are analogous to those of boundary spanners that provide specific knowledge about the development of a business, but also enable the development of social capital, which could help the entrepreneur (Hayter 2016). In particular, the presence of entrepreneurship courses within a university facilitates the contamination of students and faculty members coming from different knowledge domains (e.g. engineering, business, law, etc.), educational level (bachelor, master, PhD, professors) and culture (national and international) enhances the possibility of getting in touch with people with substantial expertise (Fiore et al. 2019). Thanks to this contamination, it is possible to increase the likelihood of scholars and students of better understanding the market implications of the technology they developed and of getting feedback need to understand the entrepreneurial risk associated with the creation of an academic spinoff.

In sum, the literature suggested that several factors such as TTO size and university research expenditures have a positive impact on the creation of academic spinoffs. However, despite many different determinants that have been identified, no attention has been paid to the impact of EE on the creation of academic spinoffs. In fact, even if the importance of EE for the development of

entrepreneurial culture, competences and academic spinoffs has already been suggested (e.g., O'Shea et al. 2007; Hayter 2016), this connection has mainly been explored through qualitative assessments. From a more theoretical viewpoint, EE is one of the main enablers for the development of entrepreneurial competences (Sánchez 2011; Morris et al. 2013; Sánchez 2013; Gümüsay and Bohné 2018) and entrepreneurial competences are important for the creation of academic spinoffs (Gümüsay and Bohné 2018). In addition, authors have also underlined the importance of tacit knowledge in the activities of technology transfer (Lowe 2006; Karnani 2013) and of the limited role played by patents. Moreover, based on the Knowledge Spillover Theory of Entrepreneurship (Acs et al. 2009; Acs et al. 2013), universities are a knowledge-intensive context where it is possible to generate more entrepreneurial activities (Audretsch et al. 2005; Civera et al 2019), since they contribute to the promotion of innovation, human capital training and knowledge generation (Audretsch et al. 2016). According to this theory and based on the previous discussion of literature, we believe that EE can contribute to the development of innovation and human capital for entrepreneurship, thus increasing the ability to generate academic spinoffs. Based on these considerations and the theoretical reasons described above based on previous studies, we advance that:

H1. In addition to TTO size and university research expenditures, EE favours the creation of academic spinoffs.

Entrepreneurship teaching models

Given the importance of EE, it is useful to identify the optimal way of teaching this subject (Fiet 2001; Honig 2004; Kuratko 2005; Béchard and Grégoire 2005; Fayolle and Liñán 2014; Fayolle et al. 2016; Nabi et al. 2017; Lamine et al. 2018). In fact, the offered entrepreneurship courses vary greatly from one university to another, and even inside the same university, in terms of content, target groups and teaching models. Therefore, entrepreneurship courses are seldom uniform (Solomon 2007; Rauch and Hulsink 2015) and are difficult to categorize. For this reason, Béchard and Grégoire (2005) identified three entrepreneurship teaching models to summarize and cluster all the differences that may arise between different ways of teaching entrepreneurship. [2] In more detail, Béchard and Grégoire identified Supply, Demand and Competence models. Table 2 presents a summary of these models.

Table 2 - Three entrepreneurship teaching models according to Béchard and Grégoire (2005)

	Supply model	**Demand model**	**Competence model**
Teacher	Teacher as presenter	Teacher as tutor and facilitator	Teacher as coach or developer
Student	Student as passive learner	Student as active participant, interactivity with teacher	Student as active participant, central role instead of teacher during lessons
Content	Content derived from scholarly research in the relevant discipline(s)	Content derived from student's needs	Content derived from student's projects, which rely on problems to be solved by competent players in real-life scenarios
Knowledge	Knowledge is theoretical	Knowledge is based on student's demand of topics	Knowledge is acquired in practical ways, student is the central driver of lessons
Evaluation	Summative	Formative and summative	Performance in authentic situations
Goal	Remember and apply: retrieve from memory and solve simple problems	Understand and analyse: give meaning to acquired information and organize it	Evaluate and create: reaching conclusions and critical thinking on tasks

[2] Nabi et al. (2017) have recently also used the framework presented by Béchard and Grégoire (2005).

The models advanced by Bechard and Gregoire (2005) suggest that there are one theoretically-oriented entrepreneurship teaching model (Supply model) and two practically-oriented entrepreneurship teaching models (Demand and Competence models). In the Supply model, students are usually passive learners. On the other hand, in the Demand and Competence models, students are active participants. However, the role played by the teacher is still important for EE (Rasmussen and Sorheim 2006). For instance, in the Demand and Competence models, the teacher acts as a mentor by guiding students along their learning path through a more nuanced process of interiorization of the presented concepts. In this vein, such teachers very often suggest possible entrepreneurship paths to their students and guide them in the development of an entrepreneurial idea. Conversely, teachers of the Supply model are more involved in transferring theoretical concepts to students, and thus of acting less as mentors.

The literature on EE has suggested to use practical – rather than theoretical - entrepreneurship teaching models to teach entrepreneurship (e.g., Honig 2004; Rasmussen and Sørheim 2006; Pittaway and Cope 2007; Kassean et al. 2015; Campos et al. 2017; Fiore et al. 2019). For instance, since entrepreneurs work in a complex environment, Honig (2004) suggested to use practical entrepreneurship teaching models in order to allow students to work in complex situations. Moreover, teachers in practically-oriented entrepreneurship act as a mentor and several studies (e.g., Sullivan 2000; St-Jean and Audet 2012; Fiore et al. 2019) explained that mentors help students and entrepreneurs to increase their entrepreneurial skills. Furthermore, Rasmussen and Sørheim (2006) described that practically-oriented entrepreneurship teaching models offer students the opportunity to achieve a true entrepreneurship experience turning out more competent entrepreneurs with the ability of developing and running new ventures. In addition, Kassean et al. (2015) observed that students who participate in more practical entrepreneurship classes have higher entrepreneurial intentions. These findings can derive from the fact that founding and developing a new venture requires entrepreneurial skills which are easier to be acquired through more practically-oriented training (Fiore et al. 2019). Moreover, testing and experimentation are crucial for the creation of new ventures (Ries 2011), and those aspects are mostly stressed within practically-oriented rather than on theoretically-oriented courses (Camuffo et al. 2019).

In sum, undertaking more practical courses offer future entrepreneurs a set of instruments which can be easily applied in real-world situations emerging while they manage their enterprise. For this reason, it is straightforward to expect that entrepreneur's confidence and intention could be higher if they have participated in a practical – rather than theoretical- entrepreneurship course as it lowers the perceived risk of founding a new venture (Kassean et al. 2015). Thus, based on these considerations and the theoretical reasons described above, we advance that:

H2. The presence in a university of more practical – rather than theoretical – entrepreneurship courses favour the creation of academic spinoffs.

Research design

Research setting

Consistently with previous research (e.g., O'Shea et al. 2005), we focused on academic spinoffs in line with the definition of Di Gregorio and Shane (2003). In addition, as in similar studies (e.g., Di Gregorio and Shane 2003; O'Shea et al. 2005), we focused our attention on one specific context, that is the US, to reduce the impact of other context variables (e.g. different legislations). In other words, we limited our empirical analyses to universities and academic spinoffs operating in the US. The US is a reliable setting for our study since it is characterized by a strong education system, and it has one of the most effective entrepreneurial ecosystems in the world (Graham 2014). According to Kauffman

Foundation's data (Fairlie et al. 2019) the US is one of the most vibrant territory for pursuing entrepreneurship opportunities as the 0.33% of the population starts a new entrepreneurial business each year, giving, in the first year of activities, employment to almost six persons. More in detail, AUTM[3] reports that since 1995 more than 11.000 spinoffs have been created by universities, largely contributing to the 591 billion of dollars of contribution of technology transfer activities to US GDP. Moreover, entrepreneurship courses are widespread among US universities (Fiet 2001; Katz 2003; Kuratko 2005; Solomon 2007; Katz 2008; Siegel and Wright 2015).

Empirical strategy

In order to uncover the relationship between EE and the creation of academic spinoffs, we adopted the following empirical strategy. As a first step, we tested, at the university level, whether the number of entrepreneurship courses has a direct relationship with the number of created academic spinoffs. In our first hypothesis, we expect to find a positive relationship between the number of entrepreneurship courses in a given university and the number of academic spinoffs. As a second step, we explored the mechanism through which an entrepreneurship teaching model favours a higher creation of academic spinoffs in order to answer to our second hypothesis. In particular, being informed by literature (e.g. Bramwell and Wolfe 2008; Siegel and Wright 2015; Nabi et al. 2017), we uncovered the impact that EE has on the creation of academic spinoffs by investigating the specific contents of the entrepreneurship courses to highlight whether the direct relationship could be explained by the teaching entrepreneurship models adopted in the courses (Béchard and Grégoire 2005). This analysis resorted to the idea that each way of teaching entrepreneurship is not equivalent to other ways (Honig 2004; Solomon 2007; Rauch and Hulsink 2015; Fayolle et al. 2016; Nabi et al. 2017; Lamine et al. 2018) and that some approaches may increase the likelihood of creating new ventures (Barr et al. 2009; Piperopoulos and Dimov 2015; Nabi et al. 2017). In more detail, we expect that practical – rather than theoretical - entrepreneurship courses favour the creation of a greater number of academic spinoffs

Sample and data collection

The sample we have used in this study comes from the integration of the Licensing Survey by the AUTM dataset with a proprietary dataset on EE and focuses on the time span between 2011 and 2014. This dataset is one of the most famous, complete and reliable regarding academic entrepreneurship (Rothaermel et al. 2007) and has been extensively used by previous studies investigating academic entrepreneurship (e.g. Di Gregorio and Shane 2003; O'Shea et al. 2005; Di Gregorio and Shane, 2003; Markman et al. 2005). AUTM develops a Licensing Survey each year, and more than 180 research institution are used to answer to it. The Licencing Survey focuses on universities and other research institutions as research centres, technology investment firms, and US hospitals. As we are interested only in academic spinoff creation from universities, we discarded the other research institutions from the sample, thus reducing the numerosity of entries in our sample to approximately 150 each year. From this dataset, we collected data regarding the number of created academic spinoffs, the TTO size and the budget allocated to research by universities are among the key data collected in this survey. Survey data are usually released by the Association with a two-year lag. For our study, we, therefore, related to the newest data available when this research began (i.e. 2014).

We then proceeded to collect the information about the entrepreneurship courses offered by each university among the approximately 150 aforementioned universities. We explored the online course catalogue of each university in each year. This process has been conducted backward beginning from 2014. Thus, for each university and for each year, we analysed the online course catalogue and the timetable containing all the offered courses to search for the entrepreneurship courses and for the specific contents of such courses. The entrepreneurship courses in these catalogues

[3] https://autm.net/

were selected through a key-word search of each course title and description. We used the following keywords to identify entrepreneurship courses: entrepreneurship[4]; start-up, startup or start up; new venture; venture creation; venture development; new business; business development and business plan. The courses returned by the key-word search were then checked by two researchers who, reading the full syllabus of each course, categorized it independently as an entrepreneurship course or not. These researchers then cross-validated the categorization and, when inconsistencies arose, the course was submitted to a third researcher for a final review. The same process was applied to categorize the teaching model of each course (according to Béchard and Grégoire's taxonomy) in order to test our second hypothesis. In this latter case, we encompassed the fact that a course may use more than one teaching model, thus offering the possibility of categorizing some courses as if they used several teaching models (however, never more than two out of three models). The research of online course catalogues returned results for 80 universities among the approximately 150 [5] universities. We limited the collection of information to 2011 as the online catalogues available for 2010 were very few at the moment of the research.

Then, the process of enrichment of such a dataset involved the collection of information about the 80 universities surveyed by AUTM in the 2011-2014 time frame. To do so, we collected university information from the Times Higher Education ranking (THE), which is a recognized reliable ranking of universities (e.g., Brescia et al. 2016). From this ranking, we have been able to collect data about university characteristics (e.g., the number of students) and to understand the overall value of the university in a global environment (university ranking). At the end of this match, a sample was obtained pertaining to eighty US universities with data from 2011 to 2014.

Statistical approach

In order to test our first hypothesis, we used the following model:

$$(1)\ Academic\ Spinoff_{i,t} = f(\#entre.courses_{i,t-1}, X1_{i,t}, X2_{i,t}, \dots, Xn_{i,t}, \gamma, \beta)$$

where:

- $Academic\ Spinoff_{i,t}$ represents university *i*'s number of academic spinoffs created at time *t;*
- $\#entre.courses_{i,t-1}$ is the (1 year lagged) number of entrepreneurship courses offered at university level *i*;
- $X1_{i,t}, X2_{i,t}, \dots, Xn_{i,t}$ is a vector of control variables that could influence the creation of academic spinoffs in university *i* at time *t*;
- γ and β are vectors of parameters that have to be estimated.

The vector of the control variables includes several relevant variables that were usually included in previous literature. We included the logarithm of research expenditures (*Research expenditures*) undertaken by university *i*, since higher academic spinoff creation is likely to be linked to the amount of money invested in research by the university (Lockett and Wright 2005; O'Shea et al. 2005; Powers and McDougall 2005). Then, we control for the *TTO size* that it is the number of FTE[6]s employed in

[4] We used the word "*entre*" as a keyword in order to display results containing such terms as *entrepreneurship, entrepreneur* and *entrepreneurial*.

[5] Several universities did not report at all the course catalogue, or they did not report enough information to categorize them in the three teaching models we use. For instance, some universities just reported the course ID code and/or the name of the course, making not reliable a categorization about the kind of teaching model the course have adopted. To avoid bias in categorizing courses we chose to discard such universities.

[6] Full-time equivalent (FTE) is the hours worked by one employee on a full-time basis.

the TTO of university *i*. We controlled for this variable since the development of more academic spinoffs might be influenced by a higher support from the TTO staff (Di Gregorio and Shane 2003; O'Shea et al. 2005; Algieri et al. 2013). We also included controls for the age of the TTO (*TTO age*) to control for the positive effect that a TTO's experience might have on favouring the creation of academic spinoffs (Lockett and Wright 2005; Powers and McDougall 2005; Clarysse et al. 2011). We also controlled for the level at which entrepreneurship courses are offered at the university *i* level (*Undergraduate, Graduate, PhD entre. courses)* and the different ecosystems in which universities are embedded (which might be munificent in favouring the creation of academic spinoffs), proxying them with the real Gross Domestic Production (GDP) per capita of the US State where university *i* is located (*GDP per capita*). We then included controls for the presence of a medical school (*Medical school)* inside university *i* (Lockett and Wright 2005; O'Shea et al. 2005; Meoli et al. 2017) and for the value and reputation of university *i* (*University ranking*) as was done in similar works (O'Shea et al. 2005; Powers and McDougall 2005; Civera and Meoli 2018). In addition, we controlled for the total number of students at university *i* (*University size*) as was done in similar works (e.g., Meoli et al. 2017). Finally, we included a year dummy vector to control for the macroeconomic effect, as we expected the creation of academic spinoffs to vary over time (e.g., Di Gregorio and Shane 2003).

Next, in order to test our second hypothesis, we used a model that links the creation of academic spinoffs to the entrepreneurship teaching models. We adopted the following model:

$$(2)\ Academic\ Spinoff_{i,t} = f(\#entre.courses_{i,t-1}, Supply\ model_{i,t-1}, Demand\ model_{i,t-1}, Competence\ model_{i,t-1}, X1_{i,t}, X2_{i,t}, \dots, Xn_{i,t}, \gamma, \beta)$$

In this specification, we created three variables ($Supply\ model_{i,t-1}, Demand\ model_{i,t-1}, Competence\ model_{i,t-1}$) that measure the percentage of courses offered in university *i* at *t-1*, according to a specific entrepreneurship teaching model. The three variables may take on a value of between zero and one. In other words, each variable is equal to zero if university *i* does not adopt the specific entrepreneurship teaching model for any of the entrepreneurship courses offered in year *t*, while it takes on the value of one if university *i* only uses that model for all its entrepreneurship courses offered in year *t*. In order to test our second hypothesis, we consider the Supply model as a theoretically-oriented entrepreneurship teaching model and the Demand and Competence models as two practically-oriented entrepreneurship teaching models. The control variables are the same as those of the previous regression model.

The description of all the variables included in our analyses, the way they have been computed, and their sources are reported in Table 3.

Table 3 - Definition of the variables

Name	Definition	Data source
Academic spinoff	Counts the number of academic spinoffs generated by university *i* at time *t*.	Licensing Survey by the AUTM
#entre. courses	One-year lagged variable. Number of entrepreneurship courses offered by university *i* at time *t-1*.	Universities' online course catalogue
Supply model	One-year lagged variable. Value that varies between 0 and 1, which indicates the percentage of how many entrepreneurship courses offered by university *i* at *t-1* use the Supply entrepreneurship teaching model.	Universities' online course catalogue
Demand model	One-year lagged variable. Value that varies between 0 and 1, which indicates the percentage	Universities' online course catalogue

	of how many entrepreneurship courses offered by university *i* at *t-1* use the Demand entrepreneurship teaching model.	
Competence model	One-year lagged variable. Value that varies between 0 and 1, which indicates the percentage of how many entrepreneurship courses offered by university *i* at *t-1* time use the Competence entrepreneurship teaching model.	Universities' online course catalogue
Research expenditures	The logarithm of the total research expenditure for university *i* at time *t*.	Licensing Survey by the AUTM
TTO size	Number of professional technology transfer staff for university *i* at time *t*.	Licensing Survey by the AUTM
TTO age	The age of TTO for university *i* at time *t*.	Licensing Survey by the AUTM
Undergraduate entre. courses	Value that varies between 0 and 1, which indicates how many entrepreneurship courses offered by university *i* at time *t* are for undergraduate students.	Universities' online course catalogue
Graduate entre. courses	Value that varies between 0 and 1, which indicates how many entrepreneurship courses offered by university *i* at time *t* are for graduate students.	Universities' online course catalogue
PhD entre. courses	Value that varies between 0 and 1, which indicates how many entrepreneurship courses offered by university *i* at time *t* are for PhD students.	Universities' online course catalogue
GDP per capita	The real GDP per capita of the US State where university *i* is located at time *t*.	BEA[7]
Medical school	Presence of a medical school (1 = yes) in university *i* at time *t*.	Licensing Survey by the AUTM
University ranking	The ranking of university *i* at time *t*.	THE university ranking
University size	Number of students of university *i* at time *t*.	THE university ranking

The nature of the dependent variable (*Academic spinoff*) used in both models made it relevant to adopt a specific econometric technique for the count data. According to Hausman et al. (1984) and Cameron and Trivedi (2013), there are two ways of dealing with the discrete nature of count data: the Poisson regression model or the negative binomial model. We analysed the 4-year panel of this study using Poisson models with random effects, since the use of a negative binomial model would have involved a high frequency of zeros in the data regarding the dependent variable (Cameron and Trivedi 2005, 2013) and this assumption is violated in our case.[8] In addition, we preferred random to fixed effects since, as also shown by Di Gregorio and Shane (2003) and O'Shea et al. (2005), the unobserved heterogeneity is randomly distributed in such samples as the one we adopted.

[7] https://www.bea.gov/index.htm

[8] The frequency of zeros for our dependent variable is reported in Annex A.

Results

Descriptive analyses

Table 4 reports the descriptive statistics for the variables included in our study.

Table 4 - Summary statistics of 80 US universities for the 2011-2014 period

Variable	Mean	Median	S.D.	Minimum	Maximum
Academic spinoff	7.20	5	8.40	0	75
#entre. courses	12.64	10	8.73	0	60
Supply model	0.46	0.47	0.20	0	1
Demand model	0.10	0.08	0.10	0	0.5
Competence model	0.37	0.36	0.17	0	1
Research expenditures (US million dollars)	570.34	390.50	692.29	21.52	5,695
TTO size	8.96	6	9.42	1	69
TTO age	29.21	26	14.74	6	89
Undergraduate entre. courses	0.64	0.67	0.25	0	1
Graduate entre. courses	0.50	0.50	0.25	0	1
PhD entre. courses	0.01	0	0.04	0	0.25
GDP per capita	50,584.91	49,050.50	14,456.30	35,359	166,908
Medical school	0.74	1	0.44	0	1
University size	25,557.68	24,079	14,864.04	2,243	83,236
University ranking	145.98	114.50	117.30	1	475.5

Table 4 shows a high heterogeneity for the 80 US universities included in our sample. For instance, the variable TTO size has a standard deviation of more than 9 FTEs employees and the TTO age varies from 1 to 89 years. However, the variables University ranking and University size can capture the heterogeneity of the sample. In addition, although the number of academic spinoffs varies from 0 to 75 per university, we have noted an increase in the number of academic spinoffs created by the universities between 2011 and 2014 (from 486 in 2011 to 657 in 2014). Furthermore, the mean of the number of academic spinoffs in the US increased from 2 at the end of the 90' (Di Gregorio and Shane 2003; O'Shea et al. 2005) to more than 7 in the time window we investigated. Annex A presents more information regarding the number of academic spinoffs in our sample. Reflecting evidence present in the scientific literature (e.g., Siegel and Wright 2015), the number of entrepreneurship courses offered by the 80 universities in the sample increased from 755 to 1,209 between 2011 and 2014. In addition, it is interesting to note that the most frequently used entrepreneurship teaching model is the Supply model. This result is in line with the literature on EE (e.g., Solomon 2007), where it is shown that most entrepreneurship courses are still theoretical since theoretical entrepreneurship courses are easier to teach. In this vein, since the Supply model is a theoretically-oriented entrepreneurship teaching model, it does not require a hard-entrepreneurial experience by the teachers and can be taught carrying over competences gained in previous business courses as -for instance- strategy. However, this trend seems to have changed between 2011 and 2014 in our sample. For instance, in our sample, the use of the Supply model slightly decreased from 2011 onwards, while the use of the Demand model remained almost the same and the use of the Competence model slightly increased over our time span.

Regression analyses

The results of the random-effect negative binomial estimations for university spinoff creation are presented in Table 5. In this study, we used a hierarchical regression that resulted in three models: (a)

a baseline model with only control variables; (b) a second model that includes the number of entrepreneurship courses as an independent variable; (c) a third model that considers the number of entrepreneurship courses and the entrepreneurship teaching models as independent variables.

Table 5: Random effects Poisson regression estimate of academic spinoff production

	(1) Model 1		(2) Model 2		(3) Model 3	
#entre. courses $_{(t-1)}$			0.014*	(0.008)	0.013*	(0.008)
Supply model $_{(t-1)}$					-0.064	(0.444)
Demand model $_{(t-1)}$					1.226*	(0.627)
Competence model $_{(t-1)}$					0.777*	(0.457)
Research expenditures	0.323***	(0.102)	0.257**	(0.104)	0.272***	(0.101)
TTO size	0.021***	(0.007)	0.019**	(0.008)	0.015**	(0.007)
TTO age	0.001	(0.005)	0.002	(0.005)	-0.001	(0.004)
Undergraduate entre. courses	-0.263	(0.213)	0.014	(0.269)	0.138	(0.256)
Graduate entre. Courses	-0.124	(0.227)	-0.020	(0.269)	0.052	(0.252)
PhD entre. Courses	0.102	(1.165)	0.370	(1.266)	0.960	(1.160)
Medical school	-0.039	(0.142)	0.032	(0.151)	-0.038	(0.142)
University size	0.008*	(0.004)	0.007	(0.005)	0.005	(0.004)
University ranking	-0.002***	(0.001)	-0.002***	(0.001)	-0.001*	(0.001)
GDP per capita	-0.000	(0.000)	-0.001	(0.000)	-0.001	(0.000)
Constant	-4.405**	(2.040)	-3.443	(2.099)	-4.103**	(2.047)
Observations	296		223		223	
Log likelihood	-695.08162		-531.39882		-525.94367	

Standard errors in parentheses. Dummy year variables are included in all the regressions.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In more detail, we used all our control variables as a baseline in Model 1. We estimated the impact of a university's financial conditions (*Research expenditures*), organizational conditions (*TTO size* and *TTO age*), cultural conditions (*Undergraduate entre. courses*, *Graduate entre. courses*, *PhD entre. courses*) and other information (*Medical school*, *University* size, *University ranking*, *GDP per capita*) on the creation of academic spinoffs. Then, in Model 2, we added the *#entre. courses* variable to support our first hypothesis. Finally, we also included the three different entrepreneurship teaching models (*Supply model*, *Demand model* and *Competence model*) in Model 3 to support our second hypothesis.

Model 1 shows that, in agreement with previous literature, university research expenditures and the TTO size are positively correlated with the number of spinoffs created by a university, thus confirming that both the amount of money invested in research and having support in realizing spinoffs enhance the number of academic spinoffs, based on research results. Interestingly, we have also found that a size effect is in place (positive and significant university size effect) and that the quality effect of the university is negatively correlated with the number of created spinoffs[9].

Model 2 highlights the first key finding of our paper, namely that EE favours the creation of academic spinoffs. This result points out the key role of EE in favouring the development of academic spinoffs and, interestingly, also absorbs the size effect of universities. This implies that the fact that, in Model 1, university size is positive and significant, is probably related to the fact that larger universities have a greater probability of offering entrepreneurship courses which, in turn, enhances the number of spinoffs created by universities. Moreover, as suggested by the literature, TTO size and university research expenditures have a positive impact on the creation of academic spinoffs. Therefore, our first hypothesis is accepted.

Model 3 shows a more nuanced picture of how EE has an impact on the creation of academic

[9] The negative coefficients can be explained by the fact that better universities show a lower ranking, and this means that the lower the ranking of a university is, the better its quality and the more the spinoffs created.

spinoffs. First, the number of entrepreneurship courses presents again a statistically significant and positive effect on the number of academic spinoffs created. Therefore, our first hypothesis is accepted again. Moreover, as can be seen, in Model 3 the *Supply model* does not present a statistically significant effect on the creation of academic spinoffs. On the other hand, the *Demand model* and *Competence model* present a statistically significant and positive impact on the creation of academic spinoffs. These results indicate that the entrepreneurship teaching models adopted by a university matter, and that the adoption of more practical courses (*Demand model* and *Competence model*) favours the development of more academic spinoffs more than the adoption of more theoretical courses (*Supply model*). Therefore, our second hypothesis is accepted.

Moreover, regarding the control variable year, in all the regression model only the control variable of the year 2014 has a statistically ($p < 0.05$) and positive coefficient (beta=0.21). In addition, as a robustness check, we ran Model 2 and Model 3 regression analyses with a different time lag (t and t-2) for the *#entre.courses*, *Supply model*, *Demand model* and *Competence model* predictive variables, provided similar results.

Discussion and Conclusion

In this paper, we have explored the impact of EE on the creation of academic spinoffs, a topic that was overlooked in previous literature analysing the effect of university characteristics on spinoffs creation (Di Gregorio and Shane 2003; Lamine et al. 2018), but which is of relevance given that EE can stimulate and sustain the creation of new ventures (e.g., Sánchez 2013). We tested this relationship on a panel sample of 80 universities in the US from 2011 to 2014, and found that: (i) EE is positively related to the number of new academic spinoffs; (ii) offering more practical courses – rather than more theoretical ones – favours the development of more academic spinoffs by a university.

Our results are relevant to both literature and practice. First, the fact that EE is positively related to the creation of academic spinoffs confirms the usefulness of EE in providing entrepreneurial competences (Gümüsay and Bohné 2018), thus suggesting that entrepreneurial competences can be learned through EE (Sánchez 2011; Hahn et al. 2019). Therefore, this study answers a call from Lamine et al. (2018) to provide evidence on the role of EE to promote the creation of academic spinoffs. A second contribution of our study is related to the understanding of the impact of different entrepreneurship teaching models (Béchard and Grégoire 2005) on the creation of academic spinoffs. Our study, in fact, answers a call from Nabi et al. (2017) to provide evidence on the impact of different entrepreneurship teaching models. Our results show the importance of the development of action-based entrepreneurship training, rather than theoretical training (e.g., Gielnik et al. 2015; Hahn et al. 2017). These results are derived from the fact that EE has a positive impact on the entrepreneurship intention of students (e.g., Maresch et al. 2016), and that students are an important asset for the creation of academic spinoffs (Pirnay and Surlemont 2003; Van Burg et al. 2008; Rasmussen and Borch 2010; Åstebro et al. 2012; Boh et al. 2016; Hayter 2016; Hayter et al. 2017). An important result is related to the fact that the theoretically-oriented entrepreneurship teaching model (Supply model), although is the most widespread teaching model among universities, has no impact on the creation of academic spinoff. This suggests that pure theoretical courses do not contribute to increase the attitude competences and intention of students as much as more practical courses. This is in line with previous literature suggesting that more practical teaching methodologies are more suited for entrepreneurship courses, in particular in shaping students' intentions and attitudes (e.g., Honig 2004; Rasmussen and Sørheim 2006; Pittaway and Cope 2007; Kassean et al. 2015; Campos et al. 2017; Fiore et al. 2019). In more detail, our analyses accepted our first hypothesis that in addition to TTO size and university research expenditures, EE favours the creation of academic spinoffs. Moreover, our analyses accepted our second hypothesis that the presence in a university of more practical –

rather than theoretical – entrepreneurship courses favour the creation of a greater number of academic spinoffs.

Our results have implications for university policy makers (such as deans), entrepreneurship teachers and students. First, the relationship between EE and academic spinoffs suggests that universities need to provide more EE under the form of new courses to overcome informational and cultural barriers, which may limit the development of entrepreneurial actions by both academic faculties and students (Siegel et al. 2003; Hahn et al. 2018). Second, teaching entrepreneurship, by means of more practically-oriented teaching models, allows universities to create more academic spinoffs and to better valorise the results obtained from research. In fact, although we are unable to clearly identify the mechanism through which this process occurs, it is possible to speculate that the provision of entrepreneurship courses stimulates the creation of academic spinoffs through a greater involvement of both students and researchers in entrepreneurship activities. In this vein, Boh et al. (2016) pointed out that students generally lack business knowledge and experience and it is possible to hypothesise that, thanks to a more practical EE – which encompasses cooperation between scholars who are willing to develop an academic spinoff from a research result and students who are enrolled in an entrepreneurship course – students and scholars may gain the competences, knowledge and networks required to accelerate academic spinoff development (Hayter 2016). For doing this, deans and other key decision makers in universities should stimulate entrepreneurship professors to invest in practical entrepreneurial skills, introducing also incentives aimed at an active participation directly in university spinoffs and/or collaborate with the local entrepreneurship ecosystem (e.g. incubators/accelerators, science parks and student-led entrepreneurial organizations). In this vein, our work supports the suggestion of Gilsing et al. (2010), namely, that stimulating universities to build more entrepreneurial-oriented PhD programmes as well as building a socially supportive entrepreneurial climate would lead to an increase in the number of academic spinoffs. In line with this, offering more entrepreneurship course – especially practically-oriented – can help students, researchers and professors to work together on their research and technology and to receive feedbacks which may favour the creation of an academic spinoff (Hahn et al. 2017). Entrepreneurship courses offered to different field of studies, educational levels and cultures can be able to combine different knowledge and experiences in order to stimulate the university entrepreneurial culture. Finally, offering many entrepreneurial courses may require the collaboration with several mentors and entrepreneurs which may enhance the local entrepreneurial ecosystem.

This study is not free of limitations. One shortcoming of this work concerns the fact that we have not been able to analyse the direct impact of EE on the creation of academic spinoffs, since we did not have access to any information about who created the academic spinoffs. Although this limit has made our analysis more stylized, our results should still be considered valuable since they show the existence of a relationship at the university level, thus suggesting that EE may be responsible for a change not only in the specific competences of the people employed in the spinoffs, but also in the overall culture of the university, of academic faculty and of students. The second limitation of our study is related to the fact that although we have been able to determine whether EE favours the creation of more spinoffs, we have been limited in controlling for their value (Powers and McDougall 2005; Gras et al. 2008; Van Looy et al. 2011; Cho and Sohn 2017). The fact that more academic spinoffs are created, does not imply that their quality is higher. This, in fact, is a relevant feature that deserves to be studied in the future. Future research could also analyse the impact of the characteristics of entrepreneurship teachers on the creation of academic spinoffs and the entrepreneurship teaching model applied to their entrepreneurship courses. It would be possible for an entrepreneurship professor to apply an entrepreneurship teaching model based on their experiences. Therefore, we suggest analysing if and how different experiences of an entrepreneurship professor can impact the entrepreneurship teaching model used in his/her entrepreneurship course. We hypothesize that a professor with a practical experience will be more likely to apply a practically-oriented entrepreneurship teaching model compared to a professor without a practical experience. A practical experience of a professor can be analysed on the basis of his/her entrepreneurial experience

(e.g. the professor has created and/or has worked in a startup or academic spinoffs) or a work experience (e.g. the professor has worked in the board of directors of a corporation) by using a survey and/or a database such as LinkedIn. In fact, Bercovitz and Feldman (2008) suggested the existence of a training effect. Therefore, the different characteristics of teachers may play different roles in the creation of academic spinoffs. Additionally, since new ventures created by students are increasing (e.g., Barr et al. 2009; Rasmussen and Borch 2010; Åstebro et al. 2012; Bergmann et al. 2016; Boh et al. 2016), we suggest the need to analyse their role and how universities can support them. For instance, future studies can analyse the difference between academic spinoffs created by students and academic spinoffs not created by students. Moreover, since the studies on social entrepreneurship are increasing (e.g., Leborgne-Bonassié et al. 2019; Rawhouser et al. 2019; Saebi et al. 2019), it would be interesting to analyses social academic spinoffs. These social academic spinoffs are academic spinoffs aim at solving social and/or environmental issues such as the seventeen Social Development Goals created by the United Nations in 2015. In addition, since entrepreneurial intentions and dispositions as well as the impact of entrepreneurial activities on the economy of nations may differ by country (Giacomin et al. 2011; Díaz-Casero et al. 2012; García-Rodríguez et al. 2015), future researches could also analyse the impact of EE on academic spinoffs in different nations. Finally, we recognize that other sources of heterogeneity in the impact of EE on academic spinoff creation may arise due to the incorporation of universities in different States. For this reason, we encourage further research to investigate this issue.

Appendix

Annex A

Table 6 - Descriptive statistics on the number of academic spinoffs per university over the period of study (2011-2014)

year	#academic spinoff	% of university
2011	0	3,75%
	1-10	77,50%
	11-20	8,75%
	21-30	2,50%
	31-40	0,00%
	41-50	0,00%
	51-60	1,25%
	61-70	0,00%
	71-80	0,00%
	N.A.	6,25%
2012	0	10,00%
	1-10	71,25%
	11-20	11,25%
	21-30	1,25%
	31-40	0,00%
	41-50	0,00%
	51-60	1,25%
	61-70	0,00%

	71-80	0,00%
	N.A.	5,00%
2013	0	3,75%
	1-10	70,00%
	11-20	20,00%
	21-30	2,50%
	31-40	0,00%
	41-50	0,00%
	51-60	0,00%
	61-70	1,25%
	71-80	0,00%
	N.A.	2,50%
2014	0	3,75%
	1-10	67,50%
	11-20	22,50%
	21-30	3,75%
	31-40	0,00%
	41-50	0,00%
	51-60	0,00%
	61-70	0,00%
	71-80	1,25%
	N.A.	1,25%

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