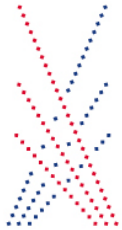

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Contextualising entrepreneurship capital provisions for graduate start-ups: The university and the regional context

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1. Introduction

Entrepreneurship is considered as a major stimulant of economic growth and social transformation. The literature points out that the contextual provisions play a relevant role in promoting entrepreneurship by providing opportunities and a supporting economic environment for nascent entrepreneurs (Audretsch and Keilbach, 2008). There has been a call to better "contextualise" entrepreneurship within institutional and spatial contexts (e.g. Welter, 2011; Walter and Dohse, 2012; Autio et al., 2014; Maresch et al., 2016). In response to this, our study shows the interplay between spatial and organisational contexts and their concurrent influence on entrepreneurial activities. More specifically, this paper contributes to the understanding of institutional and geographical contexts of entrepreneurship by examining the influences of universities and their broader geographical contexts in promoting graduates' entrepreneurial activities. We argue that graduate entrepreneurial endeavours are contingent upon the particular conditions of the university environment while being conditioned by wider spatial and institutional contexts (Wright *et al.*, 2017).

The roles higher education institutions (HEIs) play in developing entrepreneurial and innovative environments have been attracting policy and scholarly attention. Over the last decade, studies on the role of universities have expanded from a narrow focus on academic entrepreneurship from commercialisation of research (such as faculty spin-offs and licensing) to a broader range of activities including student and graduate start-ups (Astebro et al., 2012; Siegel and Wright, 2015; Wright et al, 2017; Morris et al., 2017). In recent years, a growing body of work suggests that the relevance of graduate start-ups is substantial when compared to other entrepreneurial endeavours generated by faculty (Lindholm Dahlstrand and Berggren, 2010; Astebro and Bazzazian, 2011; Astebro et al., 2012; Roberts and Eesley, 2011; Colombo et al., 2015; OECD, 2015; Hayter et al., 2017), demonstrating the scale and economic impact

of graduate entrepreneurship in relation to value creation, labour market conditions and local economies (e.g. Bergmann et al., 2016; Larsson et al., 2017).

This study aims to better understand how both HEIs and regional[1] economies support graduate entrepreneurship outcomes by disentangling contextual characteristics that help sustain graduates' start-up creation and growth. Using the knowledge spillover theory of entrepreneurship (Audretsch and Lehmann, 2005) we argue that the availability of "entrepreneurship capital" (Audretsch, Bonte and Keilbach 2008) manifests at two different and interconnected levels: the organisational context of the university where graduates are embedded, and the spatial context surrounding the university itself. We conceptualise the entrepreneurial capital in terms of the availability of different forms of entrepreneurial assets, at the regional and university levels, respectively. Furthermore, drawing on signalling theory (Spence, 1973, 2002), we argue that universities and their regional surroundings communicate the availability of entrepreneurship capital to both students and investors.

The rest of the paper is organised as follows: Section 2 sets the theoretical framework building on the Knowledge spillover theory of entrepreneurship and Signalling Theory; section 3 introduces the hypotheses of this study; while section 4 provides a description of the data and empirical strategy adopted, finally sections 5 and 6 discuss results and conclusion by identifying the factors that influence graduate entrepreneurship at organisational and spatial levels.

[1] Throughout the paper, we employ the term "region" to indicate the spatial surrounding of the university, e.g.: "an area of a country having definable characteristics but not always fixed boundaries" (Oxford dictionary). Broadly speaking, the term encompasses a variety of different geographical levels such as: cities, metropolitan areas, city-regions, provinces, commuting zones or administrative regions. While acknowledging the difference between these spatial units, we use the broader term "region" to stress the relevance of our argument across a diverse range of spatial contexts.

2. Theoretical framework

While motivations to start a company are inspired by a variety of personal traits and individual characteristics (Cooper 2003; Druilhe and Garnsey, 2004; Liñán et al., 2011) that affect opportunity recognition (Shane and Venkataraman 2000), contextual factors remain central in affecting "*what determines and how do we influence the level of demand and supply of enterprising individual in the society*" (Venkataraman 1994: pp 4).

The knowledge spillover theory of entrepreneurship (henceforth: KSTE) focuses on the contextual factors that influence the process of opportunity recognition and firm creation (Audretsch and Keilbach 2007). In this framework, incumbent organisations (such as companies or research organisations) generate knowledge but while some of the knowledge generated is immediately exploited by the existing players, some other remains untapped. This is due to the inherent characteristics of knowledge itself: uncertainty, asymmetries and transaction costs that enhance the perceived risk and inhibit incumbent organisations to pursue commercialisation avenues. The barrier created between knowledge and commercialisation represent the "knowledge filter" and entrepreneurship is the conduit to its exploitation (Audretsch et al. 2006). Entrepreneurs are knowledge workers that relax the existing opportunities from the knowledge filter and effectively allow them to spillover in the market.

Crucially, in the KSTE view entrepreneurs' opportunity recognition is a necessary but not sufficient condition and the inadequacy of physical and social support structures (such as legal restrictions, lack of early stage finance or socio-cultural rigidities) can hamper entrepreneurs' actions (Audretsch 2007). The capacity for knowledge to permeate the knowledge filter rests on the provisions of entrepreneurship capital (Acs et al. 1994; Audretsch, Bonte and Keilbach 2008) represented by the combination of formal and informal networks and institutions associated to legal, financial, commercial and social forces available in the context where the entrepreneurs operate (Saxenian 1994; Audretsch and Feldman 2004).

Audretsch and Keilbach (2004) define entrepreneurship capital as multifaceted and heterogeneous: "*a milieu of [regional] agents that is conducive to the creation of new firms. This involves a number of aspects such as social acceptance of entrepreneurial behaviour but of course also individuals willing to take the risk of creating new firms and the activity of bankers and venture capital agents that are willing to share the risks and benefits*" (2004, pp 420). Building on this view, entrepreneurship capital can be defined as the combination of available knowledge and the contextual endowments supporting the process of venture creation, including tangible and intangible networks and infrastructures. Accordingly, entrepreneurship capital is one of the elements that, in addition to labour and knowledge, affect economic growth (Audretsch and Keilbach, 2008). One implication of this is that contexts where entrepreneurship capital is high are more akin to exploit spillovers and develop entrepreneurial ventures, while contexts where the entrepreneurship capital is low are less successful (Audretsch and Keilbach 2007) which explains the different rates of firms growth across sectors (Audretsch 1995) and geographies (Audretsch and Feldman 1996).

While it is acknowledged in general that the provisions of entrepreneurship capital at the local level play a crucial role in start-ups development (Audretsch, Bonte and Keilbach, 2008), in the case of graduate entrepreneurship, context-specific opportunities can be identified at two levels: first, the university where students are embedded (Shah and Pahnke 2014) and second, the geographical surroundings where the university is located (Larsson et al. 2017). HEIs facilitate the creation of an entrepreneurial climate for their students (Bergmann et al., 2018). The university campus in itself is as an "ecosystem" framed by a combination of agents, assets, networks and institutional culture (Miller and Acs, 2017). It enables a variety of organisational contexts for student entrepreneurship activities including infrastructures such as pre-accelerators, accelerators, incubators as well as exposure to entrepreneurial education and alumni networking activities (Wright et al., 2017).

Existing evidence show that supporting infrastructural endowments can help penetrate the knowledge filter (Cumming and Johan 2010, Leyden and Link 2013) and that the number of graduates in a university is the most important factor for knowledge spillovers (Acosta et al. 2011). However, while the relevance of HEIs in contributing to the knowledge stock is acknowledged (Audretsch, Keilbach and Lehmann 2015; Cassia and Colombelli 2008), it is less clear how entrepreneurship capital operate in the actual institutional and spatial contexts. Indeed, given its heterogeneous nature, entrepreneurship capital is treated as an unobservable (latent) variable (Audretsch 2007) with various authors using start-ups as its manifestation (for instance, see: Audretsch and Lehamann 2005; Audretsch and Keilbach 2007; Bonaccorsi et al. 2013; 2014; Colombelli 2016).

While entrepreneurship capital is hard to capture and by no means directly measurable, we argue that its (underlying) intensity can be flagged to potential entrepreneurs via tangible contextual provisions. Here we adopt signalling theory (Spence 1973, 2002) as a framework to characterise how universities and regional surroundings communicate the availability of their otherwise unobservable entrepreneurship capital to students and potential investor. Signalling theory is widely adopted in economic, management and entrepreneurship literature to study markets where agents need to close a transaction but information asymmetries increase the risk involved in their decision (Connelly et al. 2011). In these instances, a problem arises because one of the parts involved in the transaction (receiver) is an outsider that lacks crucial information about another agent or organization (sender). To mitigate asymmetries and transmit positive organisational information, directly observable attributes (signals) are then used to convey information between sender and receiver and substitute for the latent characteristics that cannot be observed.

Ultimately, signals are carriers that reduce the risk of unsuccessful matching between one part and the other. Likewise, entrepreneurship capital both at the University and regional

level, cannot be directly observed, but potential entrepreneurs (such as graduates) can observe whether or not their immediate (HEIs) and further (region) surroundings signal a more or less supportive business climate. Accordingly, we consider that through the availability and alignment of entrepreneurial assets such as strategies, resources and infrastructures, certain entrepreneurship capital is signalled to potential stakeholders such as graduates and investors (e.g. business angels, venture capitalists).

3. HEIs and regional characteristics shaping graduates´ entrepreneurial contexts: hypotheses development

Following the review of the theoretical literature, this section identifies two sets of context specific factors (3.1): the organisational (3.1.1) and regional (3.1.2) levels, and the general economic environment (3.2), and the interplay between these factors (3.3) in shaping graduate entrepreneurship.

3.1 Context-specific opportunities: organisational and regional contexts

3.1.1 Organisational context

The university campus is considered as an environment for opportunity recognition and value creation that offers a variety of assets (laboratories, technology transfer offices), capabilities (range of schools and curricula) and networking prospects (alumni, entrepreneurs in residence, business competitions) nurturing the entrepreneurial attitudes of both staff and graduates (Miller and Acs, 2017). While we generally agree that universities play key roles in the entrepreneurial ecosystems (Malecki, 2018; Spiegel 2017), it is less clear how different educational and research environments of universities contribute to entrepreneurship activities and how these legacies make an impact over time as part of a broader place-based entrepreneurial ecosystem (Stam, 2015). HEIs are heterogeneous in terms of characteristics,

resources and competencies and channel the entrepreneurial vocation of their students differently (Beyhan and Findik, 2017; Marzocchi et al, 2019).

While graduate start-ups differ from faculty's university spin-offs in many ways, they share and benefit from the same HEI-based mechanisms and support structures set in place to pursue successful academic ventures (Aernoudt 2004; Ratinho and Henriques 2010). For instance, science parks and incubators are considered critical to establish creative spaces for entrepreneurship development and job growth (Phan, Siegel and Wright 2005) and enhance the research productivity among companies (Siegel, Westhead and Wright 2003). It has been acknowledged that, as well as providing an effective place for university and industry to interact (Link and Scott 2003), administrators in science parks and incubators are a crucial resource to identify market opportunities, address intellectual property protection issues, and create collaboration channels between nascent and established entrepreneurs, while building bridges with venture capital communities (Franklin, Wright and Lockett 2001). Thus, by providing business advice, entrepreneurial training and intellectual property support, science parks and incubators enable the creation of an entrepreneurial value chain for new ventures (Phan, Siegel and Wright 2009). Moreover, while incubators and science parks are physical structures with diverse quality characteristics, they also offer intangible resources to their start-ups such as the value and extension of their entrepreneurial network or their capacity to access investments opportunities.

The combination of these tangible assets is the manifestation of the university entrepreneurship capital and will communicate to students the information about the available HEIs' entrepreneurial provisions. Concurrently, while building on tangible resources and research-related reputational effects, universities signal to both students and the external investors their reliability in offering a nurturing environment for all entrepreneurial endeavours. Accordingly, we hypotheses that:

Hypothesis 1: HEIs sending *stronger entrepreneurial signals* are more likely to support entrepreneurial outputs*:* creating more graduate start-ups (H1a); and attracting more external investment (H1b).

3.1.2 Regional context

The regional context can either positively influence start-ups activity by offering wider social structures (Jack and Anderson, 2002) for networking, learning and interaction opportunities (Qian et al., 2012), or curb entrepreneurial intentions due to a lack of resources and entrepreneurial climate. Regional contexts can enhance the "entrepreneurial learning" process by connecting graduates with the regional learning networks and support the exploration and exploitation of opportunities (Cope and Down 2010). In particular, the availability of factors associated to social capital, venture capital and other entrepreneurial support services are conducive to the establishment of a successful entrepreneurial culture that in turn benefits from the engagement with universities activities (Feldman 2001).

Regional economies include infrastructures and financial assets to support business, as well as the social and regulatory environments to promote entrepreneurship (Dodd and Hynes 2012). Access to venture capital funding is an important condition for the success of start-ups (Makela and Maula 2008) particularly when these funding are not publicly backed but private investments (Munari and Toschi 2015). Access and proximity to business support structures, including public and private incubators and accelerators, contribute to set out successful companies. By offering counsel for crucial activities such as intellectual property protection and securing funding, business support structures bridge ideas with value creation.

Summing up, regional entrepreneurship capital endowments represented by support structures and access to investments funding, capture the extent of available contextual opportunities. This can be seen as infrastructural endowment that favour knowledge spillover entrepreneurship (Cumming and Johan 2010). Accordingly, we hypothesise that:

Hypothesis 2: HEIs located in regions with *more entrepreneurship capital endowment* are more likely to produce *entrepreneurial outputs:* creating more graduate start-ups (H2a); and to attract more external investment (H2b).

3.2 General economic environment: labour market (or lack of) opportunities

While regional endowment of entrepreneurship capital support entrepreneurial activities, other broader economic conditions affect the likelihood to create a business (Audretsch and Keilbach, 2008). For instance, studies in the U.S. shows that up to 10% of entrepreneurs resolve to start their own business due to the lack of suitable alternatives rather than to pursue an identified market gap (Poschke, 2008; Lazear, 2005). Thurik et al. (2013) notice that the drop of available jobs in large corporations has affected university students' post-graduation opportunities (Maniam and Everett 2017). In line with this, Rizzo (2015) find that academic entrepreneurship might emerge due to the lack adequate employment opportunities, while Horta et al. (2016) show the existence of a positive relationship between academic spin-offs and the rate of skilled unemployment. Accordingly, also students will take into consideration wider labour market conditions, such as availability and quality of employment options, when considering the creation of new ventures as an alternative job path based on self-employment (Di Addario and Vuri, 2010).

The relationship between unemployment and self-employment has been studied extensively and recognised as complex and multi-faceted (Congregado et al., 2012). Empirical studies have produced contrasting interpretations on the relationship between unemployment and the creation of self-employment (Thurik et al. 2008), variably characterizing this relationship as positive (e.g., Fritsch et al. 2014; Wang 2006) or negative (Congregado et al. 2012). For instance, the ‘‘recession-push’’ hypothesis implies that unemployment and self-employment are positively related: self-employment increases with the unemployment rate as an alternative income source to paid employment (Wang 2006). However, in scenarios with high unemployment rates, the market demand on firms lessens, reducing the prospects of

capital availability (to start a firm) and potential turnover (due to shrinking levels of disposable income). This in turn increases the risk of starting a company or the risk for the new company to bankrupt quickly. In these cases, the drive to self-employment declines with increasing unemployment rate, resolving in a ‘‘prosperity-pull’’ hypothesis. Finally, prosperity-pull and recession-push might interact with each other depending on the austerity of the recession at hand. In severe recession periods, when a large number of firms is closing down, second-hand capital equipment may become available, reducing barriers to firm entry and thereby leading—once again—to a positive relationship between unemployment and self-employment.

This suggests that once a certain threshold of unemployment is reached there is a reverse shift from unemployment to firm creation (Hamilton 1989) and a swing from ‘‘prosperity-pull’’ to ‘‘recession-push’’ dynamics. Other studies have also focused on the push-pull dilemma suggesting that unemployment affects entrepreneurial rates in two ways: either by increasing the pressure to find a job, or being an indicator of weak economic performance at the regional level and therefore diminishing the incentives to start a new business (Dohse and Walter 2012, pp 886). In summary, the relationship between unemployment and venture formation can be non-linear (Horta et al., 2016).

Given these labour market constraints, graduate start-ups can be understood as a self-employment opportunity. In particular, graduates will take regional unemployment rates into account and might consider setting up a business as a viable employment alternative (Di Addario and Vuri, 2010; c.f. Faggian & McCann 2009)[2]. Depending on the regional context and its capacity to offer rewarding job opportunities after graduation, the decision to initiate an entrepreneurial venture can be linked to “push factors” associated with “necessity

[2] Naturally, this is not always the case as graduates tend to be more mobile and can choose instead to relocate in more attractive regions with more favourable job opportunities (Faggian & McCann 2008).

entrepreneurship" or "pull factors" related to "entrepreneurial opportunities". Therefore, we hypothesise that:

Hypothesis 3a: A *higher unemployment rate* at the regional level will *reduce* the probability to create graduate start-ups but only up to a set threshold after which the relationship is reversed.
Hypothesis 3b: A *higher unemployment rate* at the regional level will *reduce* the probability to attract external investment for graduate start-ups.

3.3 Relationship between organisational and regional contexts

There is a bi-directional relationship between universities and regions: the university influences the surrounding region through knowledge spillovers, but also regional characteristics shape university performance (Sánchez-Barrioluengo, 2014). In other words, HEIs are not passive actors but rather moderate their activity in response to their territorial contexts (Casper, 2013).

For instance, Fini et al. (2011) show that in the case of spin-offs, universities' own endowments (internal structures) substitute for the weak normative support available at the regional level, while regions with strong normative structures are found to complement the productivity of university spin-offs. Empirical evidence provided by Mueller et al. (2012) suggest that in less favoured regions, universities can effectively signal and compensate for a weaker access to entrepreneurship capital by attracting external resources for university spin-off ventures. In the context of spin-off creation by university researchers, the work done by Horta et al. (2016) suggests that the creation of academic ventures is positively associated with the skilled unemployment rate. However, the relationship between unemployment and graduate start-ups and the moderating role developed by contextual dimensions at the organisational (i.e., university) and systemic (i.e., regional characteristics) levels is still under-investigated. The question remains to be answered whether or not universities can compensate the lack of regional entrepreneurship capital for graduate start-ups under sub-optimal entrepreneurial

conditions or lack of regional opportunities due to high levels of unemployment, with their own entrepreneurial signals.

In this sense, HEIs can complement or substitute the regional capacity to support entrepreneurial ventures. In the context of this study, we expect that HEIs send signals about their available entrepreneurship capital along with their alignment of internal resources and infrastructures available for graduate entrepreneurship. Receivers of the signal, such as graduates starting-up a venture, can assess the risk associated to the transaction for starting-up a business via the availability (or lack) of provisions offered by the signal itself. HEIs' signals lower the perceived hazard for students, but also, arguably, for external agents investing in their business. In particular, from an external investor's perspective, the strength of the HEI's signal may complement the underlying quality of the business idea via the reputational effects of the university itself (Di Gregorio and Shane 2003).

Based on these arguments, we hypothesise that:

Hypothesis 4: *Entrepreneurial signals sent by universities* positively *moderate* the relationship between regional conditions for entrepreneurship and entrepreneurial outputs:

(H4a) Universities located in less favourable regions will be more likely to create graduate start-ups through entrepreneurial signals.

(H4b) Universities located in less favourable regions will be more likely to attract investments for graduate start-ups through entrepreneurial signals.

4. Empirical analysis: Datasets, variables and methodology

To address the hypotheses developed above, we use panel data representing the population of English HEIs and covering the academic years 2010/2011-2015/2016. The dataset matches information from different sources, including: organisational characteristics of the universities (HEB-CI; HESA; DLHE) and a range of regional characteristics at the NUTS1 level aimed to reflect the regional endowment of entrepreneurship capital (NESTA; BVCA) as well as the general socio-economic climate (Eurostat; UK Office for National Statistics). The following

section discusses in greater detail data sources and main dependent, independent and control variables adopted in the analysis.

4.1 Variables

4.1.1 Dependent variables

Our dependent variables aim to capture graduate entrepreneurship dynamics by looking at the number of graduate start-ups created and the amount of estimated external investments they attract each year. The source of information is the Higher Education Business-Community Interaction Survey[3] (HEB-CI) managed by the UK Higher Education statistical agency (HESA). According to the HEB-CI definition, graduate start-ups include all new businesses started by recent graduates (within 2 years after the graduation) regardless of where any intellectual property right resides, but only where: there has been formal business and/or enterprise support from the HEI; and the start-up is legally registered with the tax office[4] (HESA, 2015).

Graduate start up dynamics in HEIs (represented by the number of new graduate start-ups created per university each year; and the estimated external investment received by active graduate start-ups expressed in natural logarithm) have increased substantially during the period under consideration. The number of graduate start-ups created has almost doubled (with an incremental growth of 42%), while the external investments received by (active) graduate start-up achieved almost £1 million in AY 2015/16 a value 68.8% higher than in AY 2010/11 (Figure 1).

[3] In England, the Funding Council uses certain elements of the HE–BCI returns as part of the funding formulae that determines the allocation of the Higher Education Innovation Fund (HEIF) for each university. Accordingly, returns from this annual exercise cover the entire population of English universities.
[4] Although this common definition assures consistency across the data submitted by the individual universities, it is acknowledged that collecting accurate data on student and graduate start-ups can be challenging. In particular, it is noted that students may start-up their businesses in areas not related to their areas of studies, or on the other hand they may receive support from the universities but this may not be recorded as part of the formal support.

Venture creation and external investments vary substantially across regions. Figure 2 presents both dependent variables according to their quartile distribution. In the figure, the lightest blue denotes regions belonging to the first quartile of the distribution (i.e.: regions with fewer graduate start-ups created (left) or external investment received (right) respectively), while the darkest blue shade represents regions in the last quartile (i.e.: with the highest density of ventures created (left) and investment received (right) respectively). North-East, East Midlands and East of England are the regions where the universities have created the highest number of start-ups (between 29.2 and 50.8 per institution) while Yorkshire and the Humber, West Midlands and South-East created the smallest number of start-ups[5]. In terms of external investments Greater London, South East of England and the North West are the regions with the highest amount of external funding (between £472,000 and £939,900) during the time period considered, while Yorkshire and the Humber and West Midlands are again at the lower end of the distribution.

[Insert Figure 1 about here]

[Insert Figure 2 about here]

4.1.2 Independent variables

We build two main independent variables: the entrepreneurial signal sent by the HEIs (HEIs entrepreneurial signal), capturing the entrepreneurship capital available at the University, and the entrepreneurship endowments of the region where the university is located (regional entrepreneurship endowment) representing the provision of entrepreneurship capital at the regional level. Finally, we consider the effect of favourable/unfavourable labour market

[5] Density has been calculated by accounting for the size (represented by total student population) of the University.

conditions, e.g.: the general economic climate conditioning available (or lack of thereof) job opportunities for graduates, using the regional unemployment rate.

HEIs entrepreneurial signal. We proxy the entrepreneurial signal of the university through the variety of HEIs assets dedicated to foster graduate entrepreneurship. This is turn represents the contextual provision of entrepreneurship capital that is available to students while deciding whether or not to start a business. To do so, we use six dummy variables with the value of one if the university has incubators[6] (on-campus), science parks[7], seed funding[8], venture capital[9] and/or provides business advice and entrepreneurial training, and zero otherwise[10]. Figure 3 shows that there is a positive relationship between the number of available assets and the entrepreneurial activity of the university. In particular, universities with three or less infrastructures have created on average 11.9 graduate start-ups and attracted 70.2 (£000) in external investments. This suggests that as for spin offs (Aernoudt 2004; Ratinho and Henriques 2010, Phan, Siegel and Wright 2010), also in the case of graduate venture there is a relationship between the variety of organisational mechanisms and support structures set in place and the pursuit of successful students' ventures.

[Insert Figure 3 about here]

Based on previous dummy variables, we develop an index that captures the strength of the *entrepreneurial signal* at the university level. To develop the index we follow standard measurement theory (Hand, 2004) that suggests that items more difficult to implement (in a

[6] Incubators are defined as small office areas used as launch-pads for business ideas from students, staff and alumni that provide a mentoring environment and easy access to facilities (source: HEB-CI, Part A).
[7] Science park accommodations include high-specification, purpose built accommodations for start-ups or expanding companies, aimed at scientific research, technology, environmental, engineering, ICT and other knowledge sectors (source: HEB-CI, Part A).
[8] Seed corn investment (seed funding) refers to securities offerings, after proof-of-concept, used to launch a start-up enterprise (source: HEB-CI, Part A).
[9] Venture capital typically occurs after seed corn investment - as funding for the growth of an enterprise, and resulting in the owning of equity in the enterprise (source: HEB-CI, Part A).
[10] It is important to note that HEB-CI survey has separate questions about support structures dedicated to start-ups and spin-offs. Accordingly, only answers about graduate start-ups have been included to compute the variables.

behavioural or physical sense) should receive stronger weighting than those of easy implementation. In our case, the index takes simultaneously into account (at the single HEI level) the number of available assets while weighting the occurrence of these assets on the full population (Bozeman and Gaugham, 2007; Llopis et al., 2017). Accordingly, we look at the occurrence (b_j) of each asset at the single HEI level and then weight it against the overall occurrence in the population. The underlying assumption is that assets that are easier to implement will occur more frequently, while assets that involve a considerable amount of resources will occur relatively more rarely[11]. Hence, the estimated measure weights the strength of entrepreneurship capital at each single HEIs by comparing simultaneous availability and occurrence of assets relative to the whole university population in England.

We compute the HEI entrepreneurial signal in two steps. The first step looks at number of assets available at the university level (occurrence: b_j) where j represents the number of entrepreneurial assets available (j=0,…,5), n the single university and N the population.

$$f_i = \frac{\sum_{n=1}^{N} b_{n,j}}{N}$$

The second step involves the computation of asset-occurrence by looking at the frequency of non-occurrences $(1-fj)$ as follows:

$$Index = \sum_{j=1}^{J} (1 - f_i)$$

For example, 31.88% of English universities reports having science parks and, thus, having this asset has a weight of 68.12. Similarly, 71.08% of the sample reports providing bespoke entrepreneurial training and, thus, as this asset is more common, its weight is lower (28.92). Following Bozeman and Gaugham (2007), we consider this approach appropriate to reflect the

[11] For instance, according to the HEB-CI survey, in the full population of English HEIs, 31.88% of the universities have a science park, 47.04% have an incubator, 57.84% a seed funding point, 47.30% venture capital and 71.08% provides entrepreneurial training.

intensity of the HEI entrepreneurial signal. In particular, by measuring the adoption of one asset conditional to the difficulty of its implementation, this index represents the level of commitment of each HEIs to offer quality support mechanisms that foster the availability of entrepreneurship capital to graduates. Accordingly, we consider that the higher the value of the index, the stronger is the entrepreneurial signals the university sends.

Regional entrepreneurship endowment. The other context where knowledge spillovers occur and might spark graduate venture dynamics is the regional level. Thus, our second main independent variable looks at the provision of entrepreneurship capital offered by the region where the university is located. To compute it, we build a composite indicator using factor analysis techniques and based on the factor scores resulting from the combination of the following set of variables (Cronbach alpha=0.79): the number of public (not HEIs related) and private incubators[12], the number of public (not HEIs related) and private accelerators[13] and the amount of venture capital investment attracted in the region. All variables have been transformed using natural logarithms. The information are pulled from multiple sources. In particular, number of accelerators and incubators are drawn by census data collected by the National Endowment of Science, technology and Arts (NESTA) and the UK Science Park Association (NESTA, 2017). To harmonise the data, we matched addresses of business incubators and accelerators to their geographical location (NUTS1), and then calculated the

[12] Incubators include a) those that have an open-ended duration (exit usually based on the stage of the company, rather than a specific timeframe); typically rent/fee-based; focus on physical space over services; admissions on ad-hoc basis (not cohort-based); provision of services including mentorship, entrepreneurial training; often provide technical facilities such as laboratory equipment; selective (but typically less so than accelerators); and b) virtual incubators providing much of the same support as their physical counterparts except for the provision of work, office or laboratory space and with other services, such as mentoring and training, being provided online (source: NESTA, 2017).

[13] Accelerators include: a) pre-accelerator programmes providing pre-startup stage support to entrepreneurs which aim to join an accelerator programme in the future; b) accelerators defined as fixed duration programmes (usually between three and twelve months), typically growth-based (payment via equity rather than fees), focus on services over physical space, Admission in cohorts, provision of startup services (e.g. mentorship, entrepreneurial training) and highly selective; and c) virtual accelerators providing much of the same support as their physical counterparts except for the provision of work or office space and with other services, such as mentoring and training, being provided online (source: NESTA, 2017).

overall number of accelerators and incubators available in a specific region. The amount of venture capital funding attracted to the region is sourced via secondary data available from the British Venture Capital Association (BVCA) for each calendar year (2011-2016) (BVCA, 2016; 2015; 2012; 2011).[14]

Unemployment. To capture labour market conditions, we adopt a measure of regional unemployment (*unemployment rate*). The regional unemployment rate is calculated as the percentage of the regional (NUTS1) population between 15 and 74 years old that is unemployed in the labour force (Eurostat). Our analysis aims to test the significance of this variable in predicting start-ups dynamics (Hypothesis 3). As the hypothesis support a curvilinear impact of unemployment on start-ups, we use a quadratic term to account for it[15]. University and regional data are linked using the European Tertiary Education Register that identifies for each HEI the region (at NUTS2 level) where the headquarters of the university is located.

4.1.3 Control variables

In order to remove sources of observed heterogeneity, we add to the models a set of control variables both at the HEIs and regional level.

HEI-level controls. At the university level, the dataset includes characteristics associated to human and intellectual capital as well as entrepreneurship capital generated by Faculty as identified below. Controls related to the human capital include number of members on governing body that are from commercial business (HEB-CI), as well as number of graduates in Science, Technology, Engineering and Mathematics (STEM)[16] (HESA; Destination of Leavers of Higher Education survey). Intellectual capital refers to number of top 10% citations

[14] The VC data collected by the BVCA at the regional level has a response rate of more than 95%.
[15] As a robustness check, we obtain similar results to those presented here if we alternatively include the skilled unemployment rate (Horta et al., 2016) defined as ratio between the number of highly educated unemployed individuals (those with tertiary education) and the total number of unemployed individuals at the regional level.
[16] Graduates in STEM is computed as the sum of graduates in the following fields: Biological science, Computer science, Engineering & technology, Mathematical sciences and Physical sciences.

harmonised by field and by year divided by the number of research staff at the university (Leiden Ranking and HESA staff survey). Faculty entrepreneurship capital includes: number of spin-offs, patents granted and IP revenues (HEB-CI). We transformed the original variables using the natural logarithm to avoid bias in our results. Further controls are added, such as: size (total number of students: HESA), university's subject specialization (Marzocchi et al. 2019) measured according to the Herfindahl–Hirschman index (HESA), and research intensive universities (Russell Group).

Regional-level controls. At the regional level, we control for factors included in the production function, namely: capital and knowledge[17](Audretsch and Keilbach, 2008). In our particular case, the stock of knowledge is measured by looking at the retention capacity of the region in terms of the percentage of graduates that start up a business in the same region where they graduated (HESA: Destination of Leavers of Higher Education survey[18]). Region's R&D intensity is proxied through the total expenditures in R&D (natural logarithm of the intramural R&D expenditure (GERD) by habitant (Eurostat).

Following Audretsch and Keilbach (2008), as entrepreneurship and regional performance are linked recursively, we also include a measure of the economic performance of the region based on the gross value added measured as the natural logarithm of the % change on previous period (sources: UK Office for National Statistics and Eurostat), and a measure controlling for the size of the region based on the population density and computed as the natural logarithm of the inhabitants per square-km[19] (Eurostat).

Table 1 summarizes all variables and definitions presented in this section.

[17] The third factor included in the Cobb-Douglas production function used by Audretsch and Keilbach (2008) is labour, already captured through the unemployment rate.

[18] We take into account the year of graduation of respondents to merge with other regional data included in the analysis.

[19] Annex I includes the descriptive statistics of the variables as well as the correlation matrix. The correlation matrix evidences the low correlation between independent variables as a symptom of the absence of multicollinearity problems.

[Insert Table 1 about here]

4.2 Methodology

Random effects panel are used to estimate the effect of our main independent variables on graduate entrepreneurship dynamics (Cameron and Trivedi). In particular, according to their distribution we employ a negative binomial and left-censored Tobit model to estimate the number of start-ups created and the amount of the external capital attracted (in natural logarithm) respectively.

5. Results and Discussion

Table 2 presents the results of the econometric analysis for both dependent variables: left columns show Negative Binomial regression models analysing the determinants of graduate start-ups creation, while the right columns show left-censored Tobit results related to external investments attracted by active graduate start-ups. In particular, M1, M3 and M4 look at the main effects alone of: context-specific entrepreneurship capital at the HEI-level (HEIs entrepreneurial signal) and regional level (regional entrepreneurship endowment) as well as at the labour market conditions (unemployment), while M2 and M5 show the results with the full set of organizational and geographical controls. Finally, M6 presents the full model including HEI and regional signals as well as unemployment combined with the full set of controls. Table 2 follows the same format while adding interaction effects to test hypothesis 4.

Results suggest that the HEIs' entrepreneurial signal is a robust predictor of new venture creation for graduate start-ups (Table 2). This supports our H1a and suggests that universities can be an entrepreneurial ecosystem of their own and that the campus is an environment for opportunity recognition (Miller and Acs 2017; Stam 2015) where the intensity of entrepreneurship capital nurtures graduate endeavours to start a business. The results remain

robust even when controlling for human capital, intellectual capital and additional flows of (Faculty) entrepreneurship capital available at the university (M2).

However, the results show an inverted u-shaped relationship between the HEI entrepreneurial signal and graduate venture creation (see Annex II for the graphical representation of the linear versus quadratic model). This curvilinear relationship suggests that HEIs that signal too much their entrepreneurship capital sort a negative effect on students' intentions to start a business. In particular, while moderate amounts of HEI entrepreneurial signal are well-received by perspective graduate entrepreneurs, over a certain threshold the effect of the HEIs signal weakens and might reverse the likelihood to support student entrepreneurship. A potential explanation for this non-linear relationship can relate to inefficiencies and duplication effects: when the amount of available resources is excessive, the search effort and the risk of information overlap might increase for the student the individual cost to start a business. For instance, other work has pointed out that the normative support outside universities and from other local support mechanisms can act as complements or as substitute (Brunitz et al. 2008; Degroof and Roberts 2004; Fini et al. 2011).

At regional level, regional entrepreneurship endowment is also a strong predictor of start-up creation and external investments attraction, while socio-economic conditions (represented by labour market dynamics/unemployment levels) are not. This results is different from other findings associated to academic entrepreneurship where spin-offs were seen as an outcome linked to the lack of available opportunity in the job market (Rizzo 2017; Horta et al. 2018). In particular, the entrepreneurship endowment of the region where the university is located plays an important role in the creation of graduate start-ups confirming H2a and suggesting that HEIs located in regions where the entrepreneurship capital endowment is higher will be more likely to produce entrepreneurial outputs. This result fits with the current literature showing that also for graduates entrepreneurial support services, infrastructures and

financial assets offer a regulatory geographical framework that is conducive to the establishment of a successful entrepreneurial culture (Feldman 2001, Dodd and Hynes, 2012).

Also, the results suggest that HEIs can channel their entrepreneurship capital to facilitate perspective entrepreneurs to break the knowledge filter. While regional labour market conditions characterized by high levels of unemployment negatively affect the creation of graduate start-ups, our results do not confirm the curvilinear effect of unemployment on start-ups creation (M4) and this negative relationship is diluted when other regional controls are included in the regression models (M5). Hence, although H3a cannot be confirmed, our results tends to go in line with the ‘‘prosperity-pull’’ hypothesis (Congregado et al. 2012).

Finally, M6 presents results of the full model with both HEIs and regional main independent variables and controls, confirming previous findings and corroborating that provisions of context-specific entrepreneurship capital (at university and regional level) affect entrepreneurial outputs.

The second group of results focus on the determinants of external investment attracted by active graduate start-ups (right hand-side of Table 2). HEIs entrepreneurial signal appears a determinant of investment attracted by start-ups in M1 but the effect vanishes once other university characteristics such as graduates in STEM and IP revenues are included (M2). This result does not allow to support H1b. At regional level, only regional entrepreneurship endowment positively and significantly affects external investment (M3, M5), supporting H2b. In this sense, our results confirm previous findings about the relevance of agglomeration economies and contextual factors associated with existing entrepreneurship activity (Jack and Anderson, 2002) and their role in attracting external investment for nascent graduate ventures. As in the case of venture creation, labour market conditions do not have an effect on university external investment, and also H3b is rejected (M4, M5). In fact, once we look at the full model

(M6) we see that only the regional capital endowment influences the amount of funding that graduate start-ups attract. Interestingly the HEI entrepreneurial capital squared is significant – Fini et al.?

[Insert Table 2 about here]

In order to assess H4, we look at the interaction effect between the entrepreneurial signal sent by HEIs and the two main regional variables (Table 3) namely regional entrepreneurship endowment and unemployment. Results suggest that only the interaction between HEI entrepreneurial signals and unemployment rates is significant in the case of graduate start-ups creation. The interaction is graphically represented in Figure 4. The interaction is positive and significant showing that universities located in regions with less favourable conditions for entrepreneurship (that is: with high unemployment rates) that provide strong entrepreneurship capital (e.g.: send higher entrepreneurial signals) are more likely to create start-ups. This supports H4a: *entrepreneurial signals sent by universities* positively *moderate* the relationship between regional conditions for entrepreneurship and entrepreneurial outputs, compensating the lack of favourable socio-economic climate. However, this does not hold true in terms of attraction of external investments, rejecting H4b. The significant interaction effect between the institutional and geographical level helps to put some light in the unclear understanding of the complementary versus substitutive relationship between university and local support mechanisms (Brunitz et al., 2008; Degroof and Roberts 2004, Fini et al. 2011).

[Insert Table 3 about here]

6. Conclusions

Given a growing interest in graduate entrepreneurship (Astebro et al., 2012; Siegel and Wright, 2015; Wright et al, 2017; Morris et al., 2017), there is a dearth of empirical evidence

on the characteristic supporting creation and growth of student ventures, as well as the role that the organisational and spatial contexts play in facilitating these entrepreneurial endeavours. The entrepreneurship literature seems to agree that context-specific opportunities for entrepreneurial activity and a favourable general economic environment are determinants of entrepreneurial activity (Audretsch and Keilbach, 2008). However, the influences of context-specific opportunities at the organisational level, and wider geographical environment level remain unclear. In the context of academic entrepreneurship, some authors have suggested that it is not clear whether university and local support mechanisms act as complements or substitutes (Fini et al. 2011; Brunitz et al., 2008; Degroof and Roberts,2004). This paper disentangles the effect of institutional and contextual environments in promoting graduates' entrepreneurship activities.

Drawing on knowledge spillover theory of entrepreneurship and signalling theory, we conceptualised the factors influencing graduate start-ups by focusing simultaneously on two contexts to capture the heterogeneous nature of the universities and their entrepreneurship capital on one hand, and the opportunities and job constraints offered by the region on the other. In doing so we look at the moderating role played by universities in the relationship between regional opportunities for entrepreneurship and entrepreneurial outputs.

Our findings suggest that there is indeed a contextual influence on two levels and that both HEIs and regional conditions facilitate graduate ventures. In particular, we find that HEIs entrepreneurship capital favours the creation of start-ups while regional endowments of entrepreneurship capital act as facilitator for the attraction of external investments. This means that to support graduate ventures, the availability of context-specific opportunities (stronger provisions of regional entrepreneurship capital) is more important than a favourable socio-economic climate. At the same time, our results also suggest that strong HEIs signals partially

help the creation of graduate ventures in regional contexts with non-favourable labour market conditions.

By taking a longitudinal approach, this study aims to shed light on the complex factors at work influencing graduate start-ups, particularly the relationships between the institutional and regional contexts. The contributions of this paper are twofold. On the one hand, this work contributes to the theoretical literature on knowledge spillover theory of entrepreneurship showing that, for graduate start-ups, the entrepreneurship capital occurs at two interconnected levels: the university context that aligns infrastructure and resources to send graduates entrepreneurial signals and the regional context that positively contributes to increase entrepreneurial outputs. Second, it also gives some broader managerial implication on the further contribution of university to economic growth via its support to entrepreneurial mechanisms and the chances to be a breaker of the knowledge filter for its graduate students via the variety of entrepreneurial signals aligned to stimulate venture creation and compensate for low general economic conditions due to high levels of unemployment.

The paper presents some limitations. First, while the unit of analysis is the university and we measure entrepreneurship though the accountability of start-ups created and external investment received, we do not have any information about the start-up itself: type of technology exploited, survival rates, location, etc. which, unfortunately limit in an important manner the conclusions to infer from the present work. Further studies could analyse in detail particular ventures distinguishing how contextual factors could potentially affect differently the creation of enterprises depending on its particular circumstances. Second, this paper lacks of information about mobility of graduates and the place where the venture is installed. In particular, we do not have information about the location of the star-up and it is our assumption that the start-up is located in close-distance to the university where the student has graduated because, according to the definition in the HEB-CI survey, a venture is considered a graduate

start-up of the university if "there has been formal business and/or enterprise support from the HEI". To avoid biased results, we have controlled for the retention capacity of the region, measured as the percentage of students that started up a business in the same region where they graduated: future analysis could further investigate the regional factors influencing the retention of high-skilled human capital and how entrepreneurship capital might affect the capacity of HEIs to anchor talent to regions.

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Figure 1. Evolution of the average number of start-ups created and external investment received (2010/11-2015/16)

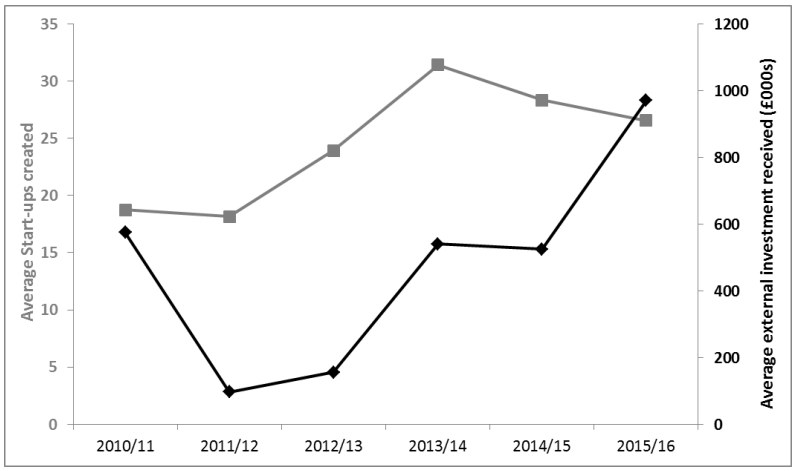


Figure 2. Quantile distribution of graduate start-ups created (left) and external investment received (right) per university (2010/11-2015/16)

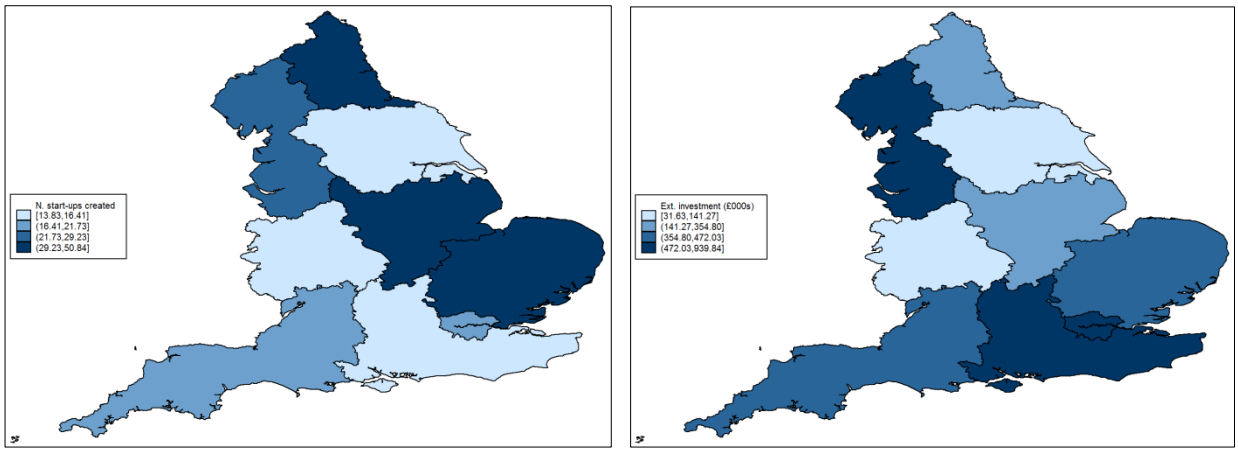


Figure 3. Entrepreneurial signal of the university and graduate start-ups: creation of ventures (left) and external investment received (right)

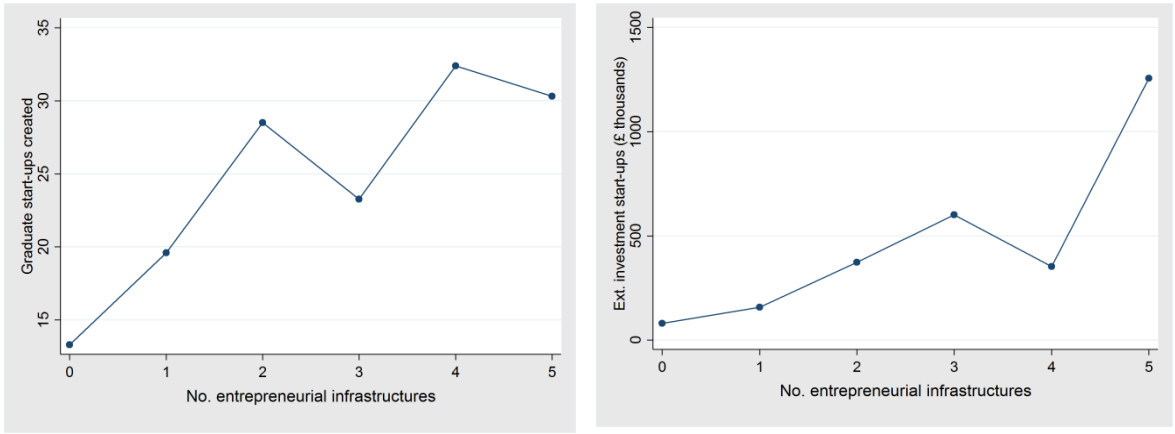


Table 1. Summary of the variables

Variable Definitions	
Panel A – Dependent Variables	
GSU Creation	Total number of new Graduate start-ups created (by academic year)
GSU Investments	Total number of external investment attracted by Graduate start-ups (estimate: by academic year)
Panel B – Explanatory Variables	
HEIs entrepreneurial signal	Entrepreneurship capital available in the university context. Measured via the HEI's strategic commitment (strength/intensity) to create incentives (material and immaterial assets) to specifically support Graduate start-up
(HEIs entrepreneurial signal^2)	Measured by creating an index looking at weighted adoption of: on-campus incubators, science parks, seed funding, venture capital, bespoke business advice and entrepreneurial training for graduate start-ups
Regional entrepreneurship endowment	Entrepreneurship capital available in the regional context where the university is located Measured (factor scores) by: number of public (not HEIs related) and private incubators, number of public (not HEIs related) and private accelerators, amount of venture capital investment attracted in the region
Unemployment rate	Percentage of the regional (NUTS1) population between 15 and 74 years old that is unemployed
(Unemployment rate^2)	
Panel C – Controls	
HEI level:	
Gov. Board mem. from business	Members on university governing body that are from commercial business (number)
Graduates in STEM	Graduates in Science, Technology, Engineering and Mathematics. Includes: Biological science, Computer science, Engineering & technology, Mathematical sciences and Physical sciences
Publications per researcher	Number of top 10% citations harmonised by field and by year divided by the number of research staff
Spin-offs	Number of spin-offs generated by Faculty Staff
Patents	Patents granted
IP revenues (ln)	Revenues from Intellectual Property rights
Size (stud.)	Size of the University measured by the total number of students
Subject specialization	Subject specialisation of the university measured via Herfindahl–Hirschman index
Russell Group	Proxy for research intensive universities
Regional level:	
Grads. start-up retention	Retention capacity of the region in terms of the percentage of graduates that start up a business in the same region where they graduated
GVA	Gross value added (% change on previous period; natural logarithm)
Total R&D exp	Intramural R&D expenditure (GERD) by habitant (natural logarithm)
Density	Inhabitants per square-km (natural logarithm)

Table 2. Results of main effects

	Binomial Negative regression: Start-ups created						Tobit left-censored: Start-ups ext. investment attracted (ln)					
	M1	M2	M3	M4	M5	M6	M1	M2	M3	M4	M5	M6
HEIs entrepreneurial signal	0.748***	0.664***				0.659***	1.885**	1.326				1.387
	[0.17]	[0.18]				[0.17]	[0.80]	[0.83]				[0.84]
HEIs entrepreneurial signal^2	-0.139***	-0.130**				-0.152***	-0.419	-0.368				-0.444*
	[0.05]	[0.05]				[0.05]	[0.26]	[0.26]				[0.27]
Reg. entrepreneurship endowment			0.496***		0.365**	0.371**			1.294**		2.041**	2.069**
			[0.12]		[0.16]	[0.17]			[0.57]		[0.87]	[0.90]
Unemployment rate				-0.442**	-0.258	-0.308				1.179	0.797	1.379
				[0.20]	[0.20]	[0.21]				[1.43]	[1.51]	[1.51]
Unemployment rate^2				0.014	0.004	0.009				-0.08	0.004	-0.014
				[0.01]	[0.01]	[0.01]				[0.07]	[0.08]	[0.08]
University controls												
Gov. Board mem. from business (ln)		-0.193				-0.131		0.782				1.002
		[0.17]				[0.16]		[0.87]				[0.89]
Graduates in STEM (ln)		0.116**				0.044		0.566**				0.469
		[0.05]				[0.06]		[0.28]				[0.29]
Publications per researcher		0.095*				0.097*		0.147				0.008
		[0.06]				[0.05]		[0.31]				[0.30]
Spin-offs		0.052***				0.037**		0.027				0.013
		[0.02]				[0.02]		[0.10]				[0.10]
Patents		-0.005				-0.002		0.018				0.023
		[0.00]				[0.00]		[0.02]				[0.02]
IP revenues (ln)		-0.016				-0.002		0.304*				0.354**
		[0.03]				[0.03]		[0.17]				[0.17]
Size (stud.)		-0.011				0.006		0.363				0.355
		[0.06]				[0.06]		[0.34]				[0.34]
Subject specialization		-0.045				0.014		0.568				0.488
		[0.14]				[0.13]		[0.49]				[0.51]
Russell Group		-0.698***				-0.808***		0.215				0.096
		[0.26]				[0.27]		[1.73]				[1.77]
Regional controls												
Density (inb./km2)					7.147	5.861					-30.328	-33.753
					[6.40]	[6.97]					[32.02]	[34.14]
GVA					0.131*	0.123					-0.349	-0.575
					[0.07]	[0.08]					[0.43]	[0.44]
Total R&D exp.					0.026	0.294					2.984	2.77

					[0.61]	[0.67]					[3.56]	[3.71]
% Grads. start-up retention					0.001	0.001					-0.019	-0.013
					[0.00]	[0.00]					[0.02]	[0.02]
Year dummies	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Region dummies	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Constant	**-0.685*** **	**-0.687*** **	**-0.726*** **	**-0.716*** **	**-0.743*** **	**-0.724*** **	**2.956*** **	**2.848*** **	**2.915*** **	**2.946*** **	**2.917*** **	**2.807*** **
	[0.17]	**[0.17]**	**[0.16]**	**[0.16]**	**[0.16]**	**[0.17]**	**[0.16]**	**[0.15]**	**[0.15]**	**[0.15]**	**[0.16]**	**[0.15]**
Log-likelihood	-2,354.3	-2,144.3	-2,325.3	-2,330.8	-2,286.6	-2.077.7	-855.259	-794.494	-852.147	-853.694	-833.609	-769.94
Wald chi2	76.391	103.668	129.297	123.616	118.455	153.683	46.218	61.186	51.207	47.81	50.765	70.92
df	7	16	14	15	20	31	7	16	14	15	20	31
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	776	713	770	760	760	697	776	713	770	770	760	697

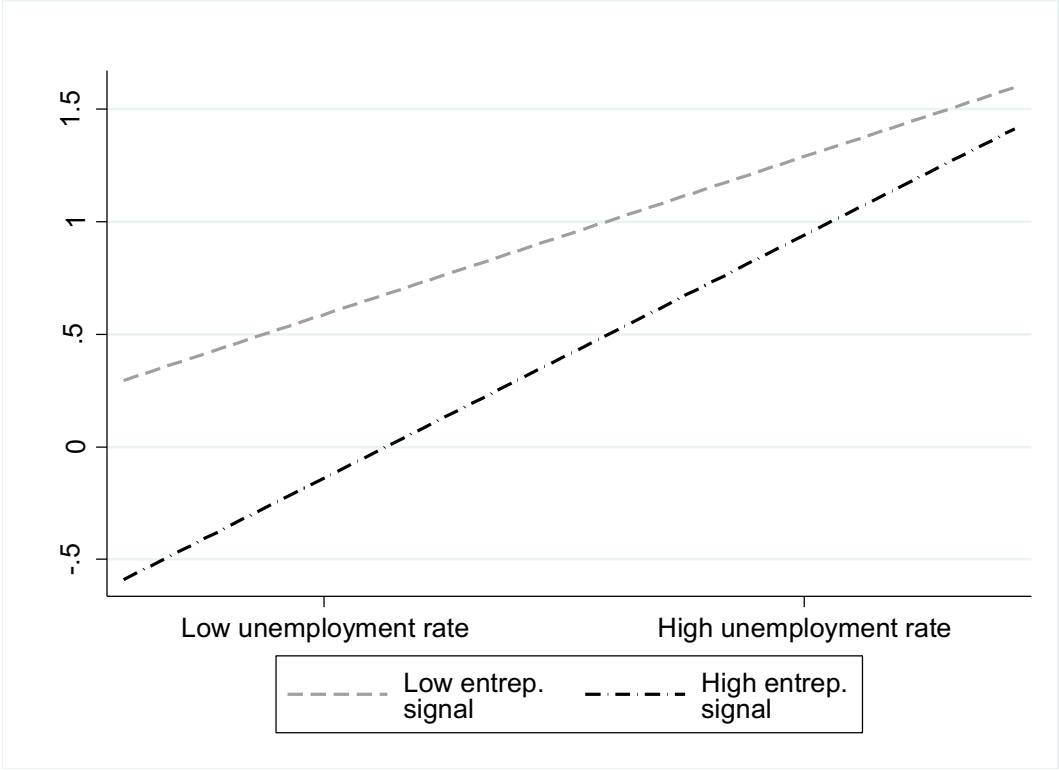
Standard errors in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Table 3. Results of interaction effects

	Binomial Negative regression: Start-ups created			Tobit left-censored: Start-ups ext. investment attracted (ln)		
	M6	M7	M8	M6	M7	M8
HEI Entrepreneurial signal	**0.689*** **	0.187	-0.643	1.034	0.766	0.296
	[0.18]	[0.21]	[0.59]	[0.94]	[1.18]	[3.12]
HEI Entrepreneurial signal^2	**-0.160*** **	**-0.205*** **	0.057	-0.368	**-0.481***	-0.321
	[0.05]	**[0.05]**	[0.18]	[0.28]	**[0.27]**	[1.02]
Regional entrepreneurship endowment	**0.419** **	0.263	**0.278***	**1.862** **	**1.931** **	**1.933** **
	[0.18]	[0.17]	**[0.17]**	**[0.93]**	**[0.92]**	**[0.92]**
Unemployment rate	-0.298	-0.282	**-0.391***	1.513	1.437	1.375
	[0.21]	[0.21]	**[0.22]**	[1.52]	[1.51]	[1.56]
Unemployment rate^2	0.009	-0.004	-0.003	-0.018	-0.031	-0.03
	[0.01]	[0.01]	[0.01]	[0.08]	[0.09]	[0.09]
Interaction effects						
HEI Entrepreneurial signal * Regional entrepreneurship endowment	-0.037 [0.06]			0.222 [0.27]		
HEI Entrepreneurial signal * Unemployment		**0.103*** ** [0.03]	**0.244** ** [0.10]		0.112 [0.15]	0.188 [0.49]
HEI Entrepreneurial signal^2* Unemployment			-0.04 [0.03]			-0.026 [0.16]
University controls						
Gov. Board members from business (ln)	-0.124	-0.182	-0.16	0.945	0.978	0.981
	[0.16]	[0.16]	[0.17]	[0.89]	[0.89]	[0.89]
Graduates in STEM (ln)	0.044	0.032	0.031	**0.482***	0.466	0.461
	[0.06]	[0.06]	[0.06]	**[0.29]**	[0.29]	[0.29]
Publications per researcher	**0.097***	**0.103** **	**0.107** **	-0.003	0.014	0.016
	[0.05]	**[0.05]**	**[0.05]**	[0.30]	[0.30]	[0.31]
Spin-offs	**0.037** **	**0.031***	**0.033***	0.015	0.015	0.015
	[0.02]	**[0.02]**	**[0.02]**	[0.10]	[0.10]	[0.10]
Patents	-0.002	-0.001	-0.001	0.022	0.025	0.024
	[0.00]	[0.00]	[0.00]	[0.02]	[0.02]	[0.02]
IP revenues (ln)	0.001	0.009	0.004	**0.355** **	**0.351** **	**0.352** **
	[0.03]	[0.03]	[0.03]	**[0.17]**	**[0.17]**	**[0.17]**
Size (stud.)	0.002	0.012	0.008	0.372	0.358	0.354
	[0.06]	[0.06]	[0.06]	[0.34]	[0.34]	[0.34]
Subject specialization	0.013	0.02	0.011	0.484	0.48	0.477
	[0.13]	[0.13]	[0.13]	[0.50]	[0.51]	[0.51]
Russell Group	**-0.814*** **	**-0.849*** **	**-0.824*** **	0.086	0.065	0.086
	[0.27]	**[0.28]**	**[0.28]**	[1.77]	[1.77]	[1.77]
Regional controls						
Density (inb./km2)	5.028	0.538	0.949	-32.25	-38.897	-38.087
	[7.15]	[7.05]	[7.06]	[34.15]	[34.83]	[35.18]
GVA	0.124*	0.11	0.105	-0.626	-0.578	-0.583
	[0.07]	[0.08]	[0.08]	[0.45]	[0.44]	[0.44]
Total R&D exp.	0.253	0.186	0.174	2.904	2.741	2.693
	[0.67]	[0.66]	[0.66]	[3.71]	[3.71]	[3.72]
% Grads. start-up retention	0.00	0.00	0.00	-0.01	-0.012	-0.012
	[0.00]	[0.00]	[0.00]	[0.02]	[0.02]	[0.02]
Year dummies	Included	Included	Included	Included	Included	Included
Region dummies	Included	Included	Included	Included	Included	Included
Constant	**-0.731*** **	-0.696***	**-0.680*** **	**2.804*** **	**2.807*** **	**2.807*** **
	[0.17]	[0.17]	**[0.17]**	**[0.15]**	**[0.15]**	**[0.15]**
Log-likelihood	-2,077.5	-2,071.8	-2,070.7	-769.6	-769.655	-769.642
Wald chi2	154.3	159.8	158.2	71.8	71.2	71.2
df	32	32	33	32	32	33
p-value	0.000	0.000	0.000	0	0	0
Observations	697	697	697	697	697	697

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Figure 4. Interaction effect between entrepreneurial signal and regional characteristics.



Annex I. Descriptive statistics and correlation matrix

Descriptive statistics	Mean	Std. Dev.	Min	Max	Obs.
University level variables					
Start-ups created	24.54	49.51	0	371	776
External investment	475.89	3,298.87	0	55,000	776
Entrepreneurial signal	1.31	0.93	0	2.72	778
Gov. Board members from business	7.91	2.92	0	20	778
Graduates in STEM	1,134.44	1,054.73	0	6405	766
Publications per researcher	471.36	1,044.68	0	7094.09	756
Spin-offs	0.90	2.10	0	21	776
Patents	5.74	18.81	0	244	778
IP revenues	685.48	3,503.49	0	64,127	778
Size	95.57	217.10	1	995	766
Subject specialization	0.38	0.50	0.12	11.82	739
Russell Group	0.15	0.36	0	1	778
Regional level variables					
Entrepreneurial region	0.10	0.82	-0.99	1.81	9
Unemployment rate	6.79	1.40	5.07	9.17	
Density (inb./km2)	921.95	1,682.45	226.65	5,402.02	9
GVA	1.78	0.76	0.7	3.33	9
Total R&D exp.	455.57	214.52	215.36	871.27	9
% Grads. start-up business	74.00	8.19	61.61	85.96	9

Correlation matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.Start-ups created	1																
2.External investment	0.0281	1															
3.Entrepreneurial signal	0.122***	0.098***	1														
4.Gov. Board members from business	0.139***	-0.043	0.097***	1													
5.Graduates in STEM	0.154***	0.199***	0.440***	0.087**	1												
6.Publications per researcher	-0.016	0.032	0.037	0.001	0.122***	1											
7.Spin-offs	0.103***	0.280***	0.290***	0.034	0.332***	0.140***	1										
8.Patents	-0.019	0.423***	0.161***	-0.194***	0.360***	0.194***	0.517***	1									
9.IP revenues	-0.040	0.139***	0.003	-0.159***	0.142***	0.020	0.230***	0.452***	1								
10.Size	-0.037	-0.041	-0.280***	0.056	-0.424***	-0.026	-0.071**	-0.1089***	-0.061*	1							
11.Subject specialization	-0.058	0.024	-0.131***	-0.058	-0.209***	-0.010	-0.014	0.013	0.013	0.201***	1						
12.Russell Group	-0.080**	0.222***	0.256***	-0.085**	0.517***	0.131***	0.327***	0.525***	0.239***	-0.173***	-0.036	1					
13.Entrepreneurial region	-0.023	0.054	-0.363***	0.000	-0.205***	0.043	-0.028	0.091***	0.081**	0.188***	0.223***	-0.072**	1				
14.Unemployment rate	-0.079**	-0.053	0.094***	0.011	-0.008	-0.038	0.060*	-0.101***	-0.087**	0.090**	0.063*	0.063*	-0.155***	1			
15.Density (inb./km2)	-0.035	0.030	-0.325***	0.007	-0.240***	0.017	0.014	0.019	0.036	0.258***	0.254***	-0.043	0.789***	0.321***	1		
16.GVA	0.019	-0.016	-0.367***	0.015	-0.151***	0.010	0.002	0.030	0.040	0.155***	0.194***	-0.054	0.489***	-0.001	0.524***	1	
17.Total R&D exp.	0.018	0.033	-0.165***	-0.031	-0.093**	-0.011	-0.007	0.143***	0.133***	0.003	0.014	-0.123***	0.296***	-0.547***	0.027	0.179***	1
18.% Grads. start-up business	0.044	-0.002	0.120***	0.014	0.148***	0.033	-0.022	-0.086**	-0.067*	-0.145***	-0.111***	0.082**	-0.512***	-0.067*	-0.501***	-0.384***	-0.416***

Annex II. Predictive margins: linear versus quadratic model for start-ups creation