Birth and Survival of Graduate Enterprises and Universities

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Abstract

Arguably, local and national economic ecosystems rely on the influence of higher education institutions who - in turn - influence the birth and survival of graduate businesses. The first kind of influence can be rooted in academic research and development activities: innovators within academia transform the scientific advancements into spinoff companies, delivering a hypothetically significant market advantage. The second kind of influence can be related to the university graduates: new businesses are created providing graduate start-ups with competitive advantage built on new knowledge and skills developed during learning programmes. These graduate enterprises - once born - differ in their likelihood of survival, the number of employees they hire and in volume of turnover. The location of these start-ups (both within knowledge domains and geographic space) may be systematically influencing both birth intensity and survival trajectory. For example, urban areas - with more competition, variety in demand, and with a historical record of higher entrepreneurial activity - are often seen as providing the right environment for generating more successful entrepreneurs. In other regions, the lack of employment opportunities prevents certain enterprises from being born into the local economy; whilst at the same time promotes entrepreneurship founded in a necessity to create one's own job. Other locations also differ in availability of initial investment resources - again inhibiting or encouraging start-ups. With these local conditions in mind, we aim to question the survival rate of enterprises located in more and less favourable settings and explore the role of universities in this context as institutions expected to play a positive role in the improved business survival. We attempt to link the volume and orientation of academic research and development activities with graduate enterprises, analysing how certain research domains may be more effective compared to others in transferring knowledge and skills into the marketplace. We also provide a review of the local factors outlined above and propose a design for the econometric testing of university influence on graduate start-ups in the United Kingdom.

Key words: graduate, enterprise, survival, United Kingdom, university.

JEL Classification: I25, L26, O15, R23

1 Introduction

Universities are not only the creators and producers of valuable human capital, but they also can provide a locally present network of development 'actors' who bridge knowledge-sharing and practice. Their position and strength is shaped continuously, often reflected through their research activity. The UK is the first country to have introduced a national university commercialization policy (Geuna and Muscio, 2009) and, based on this policy initiative in the early 1980's, has introduced a chain of business incubators and technology transfer offices

connected to university campuses. The idea of spotting and exploiting opportunities within academic research - in the form of intellectual property exploited for economic gain - has flourished. Scientific conference attendance and publication remains an academic imperative, but so too have other outputs that foster the dynamics of innovativeness.

The early work of Audretsch and Fritsch (1999) reflects on the issue of regionally prevailing conditions and new firms formation, questioning the importance of geography in firm formation, concluding that certain industries do not react neutrally to regional factors. Additionally, there is evidence that the regionally induced start-up activity is closely related to particular industry-characteristics: capital-intensive industries result strongly in the start-ups' agglomeration impact; sector-level innovativeness and the start-up activity in this field respectively are not necessarily tied to population density.

Universities and regionally present conditions are interconnected

Universities are largely heterogeneous entities, both in terms of their own internal characteristics, as well as the relationships (connections) to their surroundings - their 'home' region. Being so intimately linked to their local environment, universities are exposed to a number of conditions that can define and form universities' role as engines of economic growth: the right combination of assets and resources can create the environment's ability to support a research institution in truly active economic, commercial engagement.

Drivers of such activity are internal and external. Rutten and Boekma (2009) identified national public policy and reward system setting; changes in the economy and preferred, rising sectors; and the attributes of a region (the business actors and networks, a skilled labour market, local systems of governance) as being of a key influence. The web of various pressures is highly complex and therefore the factors often difficult to grasp (Lendel, 2010).

A closer look at the characteristics that define how a university enrols in the process of supporting and positively influencing the success of academic-led start-ups is given by Colombo et al. (2010). These characteristics - such as the research orientation, strong (embedded) links to the commercial sector, and dissemination of research results through publications - can awaken the interest of the commercial sector and potential new businesses. The academic education together with experience in scientific research and a high absorptive capacity appear to be truly advantageous within the process of new firm creation and their success. In other recent research, it appears that city size matters as well. Smaller or medium sized city-regions are referred to as the most suitable for personal networks' growth and thus the greater possibility of mutual academia-to-entrepreneurial interaction (Smith et al. 2014).

Universities as active players within the lives of their graduating students and potentially entrepreneurial academics are perceived as powerful in their influence - but only under certain conditions. Heblich and Slavtchev (2013) point out that a university can only be truly able to attract new entrepreneurs into a particular location when being their 'parent university'. It is not only a mere presence or accessibility and availability of university-born knowledge that offers a guarantee for new firm success, but also a vibrant network of living social ties and mutual personal contacts are necessary (ibid).

The research specialization and industrial field

The perception of universities as mere teaching institutions has now transformed and broadened into one of centres of scientific and research enquiry. This academic revolution

towards the research-oriented university has been supplemented by the idea that such enquiry can be extended into entrepreneurial activity (Etzkowitz, 2003).

According to Etzkowitz (2010), mutual cooperation leads to research groups' creation and these then operate commercially as entities that are comparable to firms. As a result, an effective knowledge and technology transfer into business is perceived as very likely to be closely tied to a particular field of research discipline (Martinelli et al., 2008). Unique clusters reflecting the parent university's research and innovativeness and the linkages to a particular industry, (or in some cases a brand new industry field emergent) have been created. Research departments and groups' work environment have been enhanced through the investments from leading commercial actors. Examples of this can be found both in the UK and in the USA: biotechnology clusters emergent at the universities and cities of Oxford and Cambridge; the rise of high-tech in London (Imperial College London, King's College London, London School of Economics, and University College London); and earlier evidence of biotechnology start-up activity at the American universities of Berkeley and Stanford in the 1980s (Jong, 2008).

There is further evidence that university spin-off or new business formation activity is focussed on specific subject or research domains. Kenney and Patton (2011) reveal that the computer sciences and electrical engineering outnumber other domains – the biomedical sciences, the field of engineering and physical sciences largely. In a further examination of the commercial research and academic start-up activity tied to a specific industry, Bonaccorsi et al (2013) present further evidence: they find that there is a broad positive effect among universities specialized in applied science and engineering respectively, with an especially strong positive influence on the area of service industries. Manufacturing industries show a strong connection to basic sciences, whilst a university's specialization on humanities and social sciences did not show any significant connection to new firms creation at a local level (ibid: p. 839).

The university size and specialization

It appears, then, that high quality and strength of the university research can (in many cases) significantly influence academic start-up activity (Di Gregorio and Shane, 2003). Research funded by industry sponsors in particular, provide the financial resources to fuel the development of new intellectual property and spin-out. There is also some empirical evidence that the availability and support provided by university incubators can fuel activity – but not at significant levels (ibid: p.222).

Besides the external support, it appears that the personal contacts or a living network of social ties within the academic environment form an equally important part of the start-up formation process at the universities. Moreover, in connection to this topic there is one additional factor questioned in literature - as being possibly influential. Attempting to investigate the level of the growth rate of the academic start-up, this very question concerns the faculty (or department) size. The empirical testing however proved only a negligible impact (Colombo et al. 2010) the staff size has on the actual start-up success.

Defining the size

To reflect this 'staff size', or the size of the research performance respectively, the number of patent registrations remains the most prevailing variable utilized. In some cases, the number of academic publications (Audretsch et al., 2005; Guerini et al., 2012) represent a preferred tool, side by side with other factors: such as the city size, student size, graduates' cohort, etc.

Reporting on the quantity of scientific publication (The second factor mentioned earlier) activity appears suitable, according the very recent empirical investigation, performed by Fini et al. (2013). Their results reveal one more, a very interesting fact. The ideas born in academia and then successfully transformed into new businesses are often not based on patenting at all. Authors present more than two thirds overall that are happening outside the formal intellectual property registration system. The non-patent based start-ups are distributed among a wide area of their authors' research specialization affiliation. In this way the authors shift the attention away from only patenting activity towards a range of hidden potential, based on publications. Consequently, the real relevance of intellectual property protection, the technology transfer offices, and strict legislation framework or administration comes into question at this point as well.

The academic entrepreneur

Popular conceptions of start-ups or new business venture creation privilege the idea of the 'entrepreneur' as a sole actor taking heroic actions in the marketplace. However, starting a new business is not an exclusive activity - more one person can (and does) start a new venture. This collective work can also be perceived as entrepreneurial activity. Entrepreneurial activity does not therefore need to be identified with a 'single physical person' (Schumpeter, 1949 in Etzkowitz, 2003). Such group entrepreneurship turns out to be particularly risky for academic start-ups compared to independent private ones (Wright et al. 2006). Colombo and Piva (2008) suggest, based on their study of academic start-ups, that an exclusively academic group responsible for new research-led start-up creation is not a sufficient pre-requisite for success. They suggest (2008: p. 45) that these innovative academics should form mixed teams together with industry-specific or entrepreneurially experienced workers and managers in order to overcome gaps in knowledge and inevitable (business) weaknesses.

Kenney and Patton (2011) critique university-based innovation-ownership itself even further. Through their analysis of start-ups, the authors strongly suggest a new basis for an effective encouragement of spin-off creation, growth and success. They suggest that focus should lie in supporting an individual – by encouraging 'inventor ownership' rather than an institutional one owned by university department, or an industry. However, Kenney and Patton do acknowledge that a firm's affiliation to a university research environment still does offer advantages, allowing - for example - easier access to public funding and a connection to a network of key public actors.

There are, of course, university-based start-ups which do exhibit these attributes: start-ups led by students and graduates. Knowledge embodied and carried by graduates is valuable in several aspects and there are two significant reasons why a focus on graduate start-ups may be better examples of university-led innovation:

1. *Ownership and focus*. The idea, invention, business ownership stays in the hands of individuals and is not institutionalized. The connection to the market is more direct and able to better reflect its needs, problems and openness, and the changing mindset of customers. Graduates are not being distracted by other duties of an academic job and this uninterrupted focus can be a key to a sustainable, successful and responsive business idea. There is increasing evidence that graduate start-ups outperform their `senior` academic counterparts: there is an increasingly shorter time-delay in starting up after graduation Hsu et al. (2007). Whilst there *is* a temporal lag, it is only a lack of experience and resources that stop graduates from engaging in immediate start-up activity (Muller, 2010). Nevertheless, recent research results show that graduates tend to be statistically twice as likely to start their own business in comparison with the associated academic staff (Åstebro et al., 2012). What is more, these

authors argue that graduate start-ups remain more stable in time, performing better in quality and not reporting failures.

2. *Social capital*. Studying at university allows for the creation of a wide network of personal links and a culture (and personal experience) of cooperation, co-working and problem solving which arguably provides the right conditions for future start-up activity. These conditions have been recently reported in Broström (2013), Baltzopoulos and Broström (2013) as proof of a so-called 'alumni effect' - explaining the fact that over a half of nascent entrepreneurs choose to set up new business in the locality of their previous studies, even if that means they are away from home. Such an effect may go some way to understand why UK government policy strategies promote the idea of transforming universities to 'engines' of enterprise culture through entrepreneurship education development and graduate start-up support (Anderson et al., 2014).

Based on this evidence, we conclude it is sensible and useful for our research to focus on graduate start-ups both qualitatively and quantitatively. There are two key reasons for privileging graduate start-ups in research: firstly, they outnumber the academic ones, and secondly they theoretically possess a much more suitable mixture of attributes (personal connections and local conditions that help to shape their entrepreneurial intent), leading to higher success rates in survival. Moreover, we are interested in the inter-relationship between graduates and their parent university and the impact of this on their new business creation.

2 Data and Methods

Our study draws on publicly available datasets that enable us to understand the role of universities in the development of new businesses – specifically drawing on the UK's annual 'Higher Education Statistics Agency's HE-BCI Survey (Higher Education Business and Community Interaction Survey)', and more specifically, using records from the '2012/13 survey - Part B'. Our interest is the section dedicated to 'intellectual property' including records on spin-off activity, which invite individual universities to submit data on their performance in this area and which is subsequently aggregated and analysed.

We drew data from the 'all new business started by recent graduates within two years' category and which covers a reporting period between August 1, 2012 and July 31, 2013. The first dataset used are 'current year graduate start-ups' (a count variable recorded for total of 204 higher education institutions; the second dataset is the number of all active firms; the third dataset is 'estimated current employment of all active firms' and the fourth and fifth datasets include 'estimated current turnover of all active firms' and 'estimated received external investment from external partners during the reporting period, excluding any investment from HEFCE/BIS third stream funds', respectively (HESA, 2014).

Tab. 2.1 Geographical location of HE students, all active and new graduate businesses, employment which they generate, their turnover and investment received. Regional percentage share in each column.

NUTS1 Region	HE Students	New bus.	All bus.	Employment	Turnover	Investment
East of England	5.5	12.0	5.2	3.8	1.7	0.5
East Midlands	6.8	14.8	10.3	7.6	7.8	1.3
London	15.8	20.8	18.7	27.2	13.9	49.8
North East	4.2	3.6	7.8	10.0	17.0	2.0
Northern Ireland	2.2	-	-	-	-	-
North West	9.8	10.7	12.8	15.3	11.2	2.8

Scotland	9.1	4.3	5.3	4.7	6.4	29.3
South East	17.2	10.3	11.7	6.1	9.9	7.8
South West	6.5	7.3	5.3	5.5	13.6	2.3
Wales	6.5	6.9	10.8	10.4	9.8	-
West Midlands	8.3	5.6	6.3	4.8	4.0	2.8
Yorkshire and Humber	8.2	3.8	5.8	4.7	4.6	1.3

Source: HE-BCI Survey 2012/13.

Table 2.1 provides the summary of data covering graduate start-up birth and survival within the UK's 'Nomenclature of Territorial Units for Statistics' (NUTS1) statistical regional system. One of the noticeable features shown in the data is a clear domination of London metropolitan region over the rest of the UK in virtually all dimensions - most notably external investment, accounting for nearly half of all investments across the UK. Another noticeable issue is the apparent lack of start-up activity in Northern Ireland.

Our second key data source included is publication data extracted from the Web of Science database (Thomson Reuters, 2014), using 'Analyze results' functionality. This function allows us to cross-query an author's affiliation and research area aligned to a particular research domain. Top-level research domains are identified as 'Science & Technology', 'Social Sciences', and 'Arts & Humanities' with subsequent second-level domains including 'Life Sciences & Biomedicine', 'Physical Sciences' and 'Technology' itself as a subset of 'Science & Technology'.

We performed a multiple search query of the UK universities included in HE-BCI Survey 2012/13 (162) revealing 316,977 academic publications from years 2012 and 2013, categorized into 152 research areas, mutually overlapping within and between five research domains, as illustrated in Table 2.2. The top five UK institutions (in volume of output) during that period were: The University of Oxford (20,464 publications), The University of Cambridge (17,952), University College London (17,298), Imperial College of Science, Technology and Medicine (15,571), and The University of Manchester (13,442). Statistical distribution of publications is highly unequal with the top five universities accounting for 26.7 per cent of all publications, and the top ten for 42.3 per cent. Inevitably, inequality among universities naturally translates into inequality within a regional (geographical) system. Table 2.2 shows the varying degrees of output in geographical regions.

Tab. 2.2 Web of Science higher education institutions publication output 2012/13, classified into major research domains. Regional percentage share in each column.

NUTS1 Region	HEI Publications	Arts & Human.	Life Sci. & Bio.	Physical Sci.	Social Sciences	Technology
East of England	8.3	8.2	7.4	10.1	7.2	9.4
East Midlands	6.0	7.2	5.5	5.3	6.8	7.3
London	21.5	17.0	26.1	14.7	19.6	18.6
North East	3.2	4.4	2.6	4.0	3.4	3.4
Northern Ireland	1.8	1.6	1.8	1.8	1.7	2.2
North West	9.1	7.9	8.9	10.0	9.0	9.0
Scotland	11.9	12.6	12.7	12.1	9.5	10.8
South East	14.9	15.8	13.4	18.0	15.9	14.9
South West	6.2	6.5	5.9	6.8	6.5	6.3
Wales	3.8	3.4	4.0	3.7	4.4	3.8
West Midlands	5.6	6.5	4.9	5.9	6.6	5.4
Yorkshire and Humber	7.8	9.0	6.8	7.8	9.4	8.8

Source: Thomson Reuters, 2014.

The linkage between research domains and university affiliation of authors is defined by means of a two-mode network, geographically localized. Life Sciences & Biomedicine dominate the network with 44.5 per cent of flow weights , followed by three similar domains Physical Sciences (17.0), Technology (16.7), and Social Sciences (16.1). Arts & Humanities only account for 5.6 per cent of flow weights.

We interrogate systematic differences among universities in graduate start-up performance (new businesses; all active businesses; employment; turnover; external investment) and their dependence on the coordinates in geographic (NUTS1) regions and knowledge space (research domains) through a mixed modelling strategy. We consider the appearance of zero values, in all cases, to be a natural part of the differences analysed. We consider that no graduate enterprises, no new start-ups in reference period, no employment, no turnover, or no external investment, (singularly or in combination) nevertheless indicates an institution-specific technology transfer setting. Therefore we first generalize all five dependent variables into dummy variables entering binomial logistic models. These allow us to predict the likelihood of a plain occurrence of graduate start-ups, and their other survival indices in a similar manner. Non-zero observations in the second step once again enter a standard count modelling procedure, employing Poisson and negative binomial regression.

3 Results

Estimated results point at several details of how graduate entrepreneurship is organized in geographic and knowledge space. In the first part we review determination of natural zero values, which indicate situations with no active graduate entrepreneurship occurring.

A significant positive effect of student cohort size in all logistic models suggests intuitive regularity determining occurrence of entrepreneurship. Either in the short-term or in long-term, graduates are more likely to start a business at larger institutions than not at all. Similarly, the occurrence of 'jobs created' by these companies also positively depends on university size, as does the occurrence of 'turnover' and 'external investment'.

When we consider the hypothesis of variance in entrepreneurial intentions related to research domains, we see a significant negative effect of publication in Arts & Humanities concerning business birth and survival, as well as in the hiring of employees. Similarly the variant 'turnover' is more noticeable in the Life Sciences & Biomedicine research domain. However, the variable 'Investment' does not seem to be directly influenced by broad sector differences; the practical interpretation here being that there is no statistical evidence of any visible barrier to securing investment for start-ups depending on the specific knowledge focus of academics at universities. Whilst we can be confident in our assumption around broad research groups, our analysis cannot be necessarily applied at a granular (sub-discipline) research level.

Geographical regions generate their effects on a highly selective basis. Few of them appear to be significantly supporting entrepreneurship compared with the reference region, London – it remains a leading start-up region. However, investment seems to be not influenced by geography; long-term survival seems to be more likely at the universities in the East Midlands, South East, South West, Wales, or Yorkshire & Humberside. Additionally, new companies are more likely in the North West, but not in the South East. After studying at a university in the East Midlands, South West or in Wales, it is more likely that graduate start-

ups will create new jobs; Turnover – as a differentiator - is more likely to appear in East Midlands and South West. All of these regions are more supportive environments for graduate start-ups than the otherwise usually dominating London. If we control the variables 'student cohort size' and 'output into research domains' we find that no UK region - including Northern Ireland - appears to be systematically undermining entrepreneurial intentions of graduates; a potentially substantive finding.

Table 3.1 Coefficient estimates for logistic and count models. Standard errors are in parentheses. Statistically significant coefficients at ***0.01, **0.05, and *0.1. Observation units are individual HEI's

			Logistic models		
	New bus.	Active bus.	Employment	Turnover	Investment
Constant	-1.782 (0.494)***	-2.197 (0.553)***	-2.099 (0.521)***	-1.833 (0.483)***	-1.861 (0.493)***
HE Students	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)*
Research domain:					
Arts & Humanities	-0.004 (0.002)*	-0.006 (0.003)*	-0.005 (0.002)*	-0.003 (0.002)	-0.003 (0.002)
Life Sciences & Biomedicine	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)*	0.000 (0.000)
Physical Sciences	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)
Social Sciences	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.000 (0.001)
Technology	-0.001 (0.001)	0.000 (0.001)	-0.001 (0.001)	0.000 (0.001)	0.000 (0.001)
NUTS1 Region:					
East of England	0.726 (0.836)	0.395 (0.864)	0.686 (0.851)	-0.162 (0.854)	0.418 (0.846)
East Midlands	2.418 (1.166)**	2.427 (1.203)**	2.609 (1.180)**	2.496 (1.166)**	0.479 (0.868)
North East	18.030 (1587.000)	18.240 (1540.000)	17.670 (1703.000)	2.409 (1.735)	0.649 (1.063)
Northern Ireland	-17.57 (1781.000)	-17.970 (1711.000)	-17.440 (1769.000)	-16.420 (1084.000)	-16.420 (1926.000)
North West	1.669 (0.822)**	0.850 (0.808)	0.919 (0.782)	0.668 (0.739)	0.335 (0.755)
Scotland	0.677 (0.651)	0.325 (0.701)	-0.063 (0.691)	-0.318 (0.690)	0.304 (0.690)
South East	0.937 (0.680)	1.557 (0.756)**	0.664 (0.697)	0.893 (0.674)	-0.059 (0.762)
South West	2.455 (0.916)***	3.551 (1.184)***	2.629 (0.932)***	2.572 (0.905)***	0.507 (0.773)
Wales	2.676 (1.180)**	2.932 (1.218)**	2.030 (0.960)**	1.338 (0.851)	-16.720 (1193)
West Midlands	0.528 (0.771)	0.585 (0.813)	0.234 (0.784)	0.402 (0.766)	0.393 (0.778)
Yorkshire & Humber	1.987 (0.931)**	1.982 (0.988)**	0.432 (0.827)	0.066 (0.813)	-0.433 (0.939)

			Negative binomial models		
	New bus.	Active bus.	Employment	Turnover	Investment
Constant	3.948 (0.318)	4.468 (0.338)	5.378 (0.356)	7.364 (0.416)	6.595 (0.442)
HE Students	0.000 (0.000)	0.000 (0.000)**	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)
Research domain:					
Arts & Humanities	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.002)	0.006 (0.002)***
Life Sciences & Biomedicine	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)**	0.000 (0.000)
Physical Sciences	0.000 (0.000)	0.000 (0.000)	-0.001 (0.000)***	-0.001 (0.001)	0.000 (0.001)
Social Sciences	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)	-0.001 (0.001)
Technology	-0.001 (0.000)	-0.001 (0.000)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
NUTS1 Region:					
East of England	0.387 (0.581)	-0.204 (0.624)	-1.024 (0.638)	-0.783 (0.871)	-3.008 (0.804)***
East Midlands	0.318 (0.521)	0.112 (0.534)	-1.111 (0.550)**	-0.477 (0.652)	-1.968 (0.779)**
North East	-0.634 (0.605)	0.259 (0.616)	-0.512 (0.629)	0.516 (0.778)	-1.556 (0.916)*
Northern Ireland	-	-	-	-	-
North West	-0.438 (0.457)	-0.172 (0.506)	-0.320 (0.519)	-0.407 (0.631)	-1.94 (0.704)***
Scotland	-1.018 (0.484)**	-0.528 (0.511)	-0.684 (0.568)	0.132 (0.719)	-1.952 (0.666)***
South East	-0.388 (0.476)	-0.344 (0.478)	-0.964 (0.538)*	-0.222 (0.653)	-2.916 (0.769)***
South West	-0.724 (0.469)	-0.957 (0.474)**	-1.437 (0.498)***	-0.485 (0.591)	-3.102 (0.745)***
Wales	-0.644 (0.477)	-0.203 (0.494)	-0.467 (0.524)	-0.001 (0.640)	-
West Midlands	-0.634 (0.519)	-0.484 (0.535)	-1.182 (0.574)**	-1.180 (0.675)*	-1.439 (0.707)**
Yorkshire & Humber	-1.092 (0.510)**	-0.669 (0.522)	-1.072 (0.586)*	-0.442 (0.742)	-3.057 (1.049)***

Source: HE-BCI Survey 2012/13, and Thomson Reuters, 2014.

We performed a second series of analyses of all non-zero observations – that is instances where there is occurrence of certain attributes, reducing the number of observations in

instances of new businesses (98 universities), active businesses (98), employment (86), turnover (80) and external investment (42) compared with full set of observations (162 universities). Graduate companies appear in 6 out of 10 of the UK's universities, and employment only at approximately 5 in 10, some turnover at less than 5, external investment at less than 3. (We can employ count models since all five variables are expressed as non-negative counts – e.g. start-ups, employees, thousands of £). In all five cases, negative binomial model performs better than the Poisson model, indicated by significant likelihood ratio tests. The Poisson regression includes the assumption of conditional mean equal to variance, but addition of a dispersion parameter in negative binomial model allows dropping of this assumed equality. Likelihood ratio test compares the two easily.

Through these analyses we find that count models lose the significant positive effect of student cohort size in case of new start-ups, and external investment respectively. The intensity of new entrepreneurship and investment doesn't seem to be scaling with university size in a straightforward manner; a small university (low student cohort) can have relatively many new companies forming, whilst a large university can spawn few new companies. (It is worth noting that this does not apply to survival, jobs, and turnover: these counts scale in an expected way: systematically with student cohort size).

When we focus on research domains, we found three significant effects on start-up activity. Firstly, 'Employment' is *reduced* by institutions specialized in Physical Sciences, 'turnover' is *supported* by Life Sciences & Biomedicine, and finally external financing is *attracted* above standard by Arts & Humanities research environments.

Geographical effects on start-up activity vary: the survival of graduate businesses seems to be diminished by a location in the South West; new start-ups creation in diminished in Scotland, Yorkshire & Humber; turnover is reduced, (specifically when compared with London), in the West Midlands; and 'employment' and 'investment' appear reduced significantly in many places when compared with London: investment in all regions compared with London, and employment in half of them - East Midlands, South East, South West, West Midlands, and Yorkshire & Humber.

4 Conclusions

It has been shown that the probability of birth and survival of graduate start-ups scales systematically with the size of the student cohort: more students generate more economically viable ideas. However, this systematic scaling effect disappears once entrepreneurship (frequency of births and attraction of external investment) is seen to be present in a region. Symmetry is re-established when we consider the long-term performance (survival) of start-ups, the hiring of employees or volume of their business. The existence of start-ups is less likely in Arts & Humanities, but once born, these start-ups attract more investment than others. The hiring of employees is less frequent in Physical Sciences. On the other hand, Life Sciences & Biomedicine not only generate turnover (they become established businesses) but more turnover than other subject domains. No UK region with a university, (including a university that has spawned no start-ups), is systematically undermining entrepreneurial intentions of graduates, if controlled for student cohort size, and output in research domains. However, intensities of birth and survival indices are often systematically diminished in contrast with London. This mostly applies to availability of external investment, and employment.

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