Anchoring talent to regions

The role of universities in graduate retention through employment and entrepreneurship

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Abstract:	Drawing on the concept of human capital externalities, this paper investigates universities' contribution to regional economies analysing two types of graduate retention: 'labour retention' (graduates employed in the region where they studied), and 'entrepreneurship retention' (graduates starting-up businesses in the region where they studied). Using a panel of English universities (2010/11-2015/16), it examines the extent to which the diversification and specialization of the knowledge that universities offer influences graduate retention rates across metropolitan and non-metropolitan areas. Findings show that agglomeration dynamics affect labour and entrepreneurship retention differently, and that HEI knowledge supply (subject specialisation) matters differently across diverse geographical contexts.

Anchoring talent to regions:
Graduate retention dynamics through employment and entrepreneurship

Introduction

The contribution of universities and Higher Education Institutions (HEIs: hereafter used interchangeably) to regional economies is wide ranging and it has been the subject of increasing scholarly and policy interest over the last decade (e.g. Benneworth and Fitjar, 2019; Goddard et al., 2014; Uyarra, 2010). One of the most important and relatively less well-understood channels is the "human capital embodied in students graduating from the university" (Audretsch et al., 2005, p. 1115). Arguably, by educating students, HEIs build the stock of human capital and enhance the available knowledge and skills that fuel productivity and innovation (Bradley and Taylor, 1996). Although 'human capital externalities' associated with education have been discussed in literature over decades, their mechanisms in relation to local development across different organizational and geographical contexts are not well understood yet.

It has been demonstrated that university graduates are highly mobile (e.g. Faggian & McCann 2009a, b), and graduate retention is conditioned upon a variety of organisational and spatial factors (Boucher et al., 2003; Goldstein and Drucker, 2006; Lawton-Smith and Waters, 2019). Organisationally, different types of universities have different profiles in terms of the nature and breadth of subjects areas offered and discipline specialization (e.g. Rossi, 2009; Winters, 2014). They also show different aspirations and spatial trajectories: some universities tend to pursue "elite" reputations and may be more outward looking than locally connected (Brennan and Cochrane 2019). Spatially, graduate retention will be influenced by the characteristics of the region where the university is located. While economically successful regions benefit from a range of positive human capital and agglomeration externalities, other regions suffer from outflows of skills (Faggian and McCann 2009b) due to their inability to provide labour market opportunities that match the supply of graduates

(Boucher, et al., 2003). Ultimately, graduate retention rests on the ability of the place to create and absorb suitable knowledge locally (Breznitz and Feldman 2012). In this context, the factors associated with the contribution of graduates to regional economic development through retention are still not well understood (Faggian et al., 2017).

Persistent territorial imbalances demand better understanding of how to attract and retain human capital, as reflected by a growing policy interest in the career paths and destinations of graduates (Abreu et al., 2015; Centre for Cities, 2017; Government Office for Science, 2016; Lawton-Smith and Waters, 2019). In the light of these, the present work contributes to this special issue by investigating HEIs' contribution to regional development in English regions through graduate retention.[1] We define graduate retention at the university level and look at those graduates who settle to work in the place of their university study, regardless of their region of domicile. To acknowledge the different contribution of universities to their spatial surroundings, we distinguish two types of graduate retention: '*labour retention*', defined as graduates who are employed in the region where they studied; and '*entrepreneurship retention*', defined as graduates who start-up a business in the region where they studied. We then analyse how differences in terms of the diversity of knowledge offered by the university *(subject specialization or diversification*) and spatial contexts *(metropolitan or non-metropolitan areas*) influence regional graduate retention.

The paper empirically analyses the changes in graduate retention rates (*labour* and e*ntrepreneurship*) at the university level over six consecutive years (2010/11-2015/16) across England examining the organizational (HEIs) and spatial factors which affect graduates' regional retention. Our findings suggest that regional agglomeration dynamics matter but affect labour and entrepreneurship retention differently. The effects of subject specialization and graduate retention in metropolitan and non-metropolitan areas imply that different types of graduate retention strategies are needed in different geographical contexts.

[1] Throughout the paper, we employ the term 'region' to denote the sub-national surrounding environment of the university. While acknowledging the differences between different forms of spatial agglomeration, we argue that for the purpose of this paper these might be brought together by the concept of 'region' and its connotations.

Literature review

Universities are instrumental to build the human capital stock of their regions as suppliers of knowledge and skills, and therefore support human capital externalities. However, the mechanisms underpinning the local accumulation of human capital in relation to graduate retention are not fully understood. The following sections draw on entrepreneurship and regional development literature to identify factors at the organisational (university) and spatial (metro and non-metropolitan areas) levels influencing graduate retention.

Two types of graduate retention

Local benefits of graduate retention arise from two distinct channels. First, students can settle to work in the region where they studied: university graduates are skilled labour and therefore will directly raise levels of human capital endowment once entering the local labour market (Abel and Deitz, 2012). Second, a smaller but growing number of students may decide to start-up their own business. Graduate entrepreneurship is relevant for the regional economy because it not only contributes to creating new ventures, but also acts as retention mechanism of highly skilled individuals and as enabler of regional infrastructures for entrepreneurship (Bergmann et al., 2016; Breznitz and Zhang, 2019a).

The literature on graduate retention and on mobility of high-skilled graduates (e.g. Faggian and McCann, 2009a; Venhorst et al., 2010; Corcoran and Faggian, 2017; Faggian et al., 2017) suggests that locational choices of graduates are driven by many individual-specific and location-specific factors. Corcoran and Faggian (2017) identify three main determinants for student's decision: *social* (personal and family background, networks), *spatial* (push and pull factors of home, university and potential employment in destination regions) and *professional* (level and field of study, academic performance). Moreover, graduates' location choices occur twice: first, students decide where to study when they choose a location to attend university, and, second, they decide where to work after graduating. Studies suggest that students prefer to study in economically buoyant regions (Dotti et al., 2013). Sometimes students' choice of

study is influenced by their choice of work (Abreu, 2014), while in other instances proximity to home is a strong "pull factor" after graduation (Corcoran and Faggian, 2017).[2]

For graduates, starting up a business can be seen as an alternative opportunity where local job market options are constrained (Lazear, 2005; Poschke, 2013), or when there are limited jobs available in large corporations (Thurik et al., 2013; Maniam and Everett, 2017). Local contextual factors surrounding universities influence knowledge spillovers of academic venture start-ups (Audretsch and Keilbach, 2008; Audretsch and Lehman, 2013). Knowledge spillovers can then alter the composition of local labour markets by increasing the demand for specialized skills and by attracting business activity and further employment (Abel and Deitz, 2012). Local agglomeration dynamics also influence graduate entrepreneurs' location choices. For instance, Larsson et al (2017) show that in Sweden graduate entrepreneurs tend to stay in the metropolitan area where they studied (Larsson et al., 2017). This finding is also supported by Di Addario and Vuri (2010), in the case of young graduate entrepreneurs in Italy.

At the organisational level, universities employ a range of strategies to increase their contribution to the economy and society (Holstein et al., 2018; Kitagawa et al., 2016). This includes enhancing graduate retention by a number of mechanisms through working with their stakeholders. First, universities can enhance the local labour retention by developing regional human capital and skills (e.g. student placement with local businesses, engaging industry with curricular development, filling skills gaps by providing specialist short courses). Second, universities promote entrepreneurship retention by developing a set of entrepreneurship strategies (e.g. promotion of enterprise education, investment in entrepreneurship infrastructure such as incubators and accelerators, attraction of external investment for entrepreneurship activities) (e.g. EC, 2011).

Human capital externalities and university knowledge offering

[2] Recent figures in the UK show that today the vast majority of graduates – 82 per cent – are living in their original home region a year after graduating, with just over half of those having studied at the university in their home region. The figures vary across different types of HEIs and demography of students (UK Department for Education, 2018).

For human capital externalities to accrue to local economies, a 'critical mass' of both skills supply and industry demand is needed to trigger interactions between highly educated workers and their complementary knowledge bases (Moretti 2004). To better understand factors aiding local human capital externalities, our analysis focuses on the supply side of the knowledge that universities offer to their students, assuming that the chances of universities to influence human capital retention rest upon their capacity to provide a set of knowledge relevant for the surrounding environment.

To do this, we examine the breadth of the knowledge that HEIs offer (*subject specialization* versus *diversification*), and the characteristics and dynamics of subject areas offered by HEIs. In the entrepreneurship literature, the breadth of an individual's curriculum and the balance of different skills and knowledge are identified as determinants of graduate entrepreneurship (see Breznitz and Zhang, 2019b, Hsu et al. 2007; Lazear 2004). Another key question remains regarding the extent to which universities match their knowledge offerings to perceived employment opportunities in the region to retain skills locally. Nevertheless, it remains unclear how changes in skill composition and diversification may influence growth in different spatial contexts (Faggian et al. 2017).

In terms of the educational offering, universities have to balance "contrasting pressures for specialization (to find market niches) and diversification (to capture wider range of student preferences)" (Rossi 2010, p 291), all the while responding to increasing stakeholders' needs (Rossi, 2009). Generally, older universities tend to provide a more diversified educational offer while new universities initially focus on specialized areas and then start to diversify (Teixeira et al., 2013). Furthermore, HEIs' specialization or diversification would be influenced by the number, type and complementarities between universities co-located in a region (Uyarra, 2010). Places with multiple universities may benefit from this combined effect and the relative advantages of cumulative knowledge spillovers. Thus metropolitan areas with multiple universities (hence, diversification of educational offering) demonstrate a broader capacity to anchor talent due to the HEIs' combined effects (Felsenstein, 1996; Abel and Deitz, 2012).

While studies on graduate retention tend to focus on urban contexts, more attention is needed to retention dynamics in peripheral regions and non-metropolitan areas. Benneworth and Fitjar (2019) show that, in peripheral regions, there are substantive challenges associated with the "absorption" of graduates on both the supply and demand sides, leading to skill mismatches and graduate underemployment (see also, Evers, 2019; Germain-Alamartine, 2019). Moreover, given their lower concentration of knowledge-intensive business services (KIBS) and high-tech manufacturing, peripheral regions tend to be less capable of absorbing graduates' supply (Pinto et al., 2015; Bonaccorsi, 2017).

The literature seems to suggest that places with a high number of universities and/or diversification of the curricula offered can support regional economies both through *labour* and *entrepreneurship retention*. On the contrary, in non-metropolitan (rural) contexts, diversification of educational provisions might pose challenges due to the lack of demand in the local labour market. Accordingly, we hypothesize that:

> *H1a: In metropolitan areas, diversification of university knowledge offer positively affects labour and entrepreneurship graduate retention.*
>
> *H1b: In non-metropolitan areas, specialization of university knowledge offer positively affects labour and entrepreneurship graduate retention.*

Dynamics of STEM and Humanities specialization

It is not only the level of human capital stock that matters, but also the specific type of human capital characteristics is deemed to be important. Previous works mostly have focused on the local stock of human capital in the form of science, technology, engineering, and mathematics (STEM) graduates (Moretti, 2013; Winters, 2014). A number of studies are concerned with identifying the relationship between STEM occupations and growth, and STEM degrees and entrepreneurship (see Breznitz and Zhang, 2019b), where STEM graduates are often regarded as a powerful proxy of innovation capacity for regional development.

However, recent studies identify the contribution that social sciences and humanities (SSH) can make to local development and innovation (Kempton et al., 2013; Olmos-Peñuela et al.

2014). For instance, SSH subjects have been acknowledged to contribute to people-based, problem-solving and community orientated activities (Hughes et al. 2011; Lawson et al. 2016), but also impacting on entrepreneurial activities by engaging with a range of external stakeholders (Abreu and Grinevich, 2013; 2014). Breznitz and Zhang (2019b) find a positive relationship between having a non-STEM degree and entrepreneurial activity, and that the relationship is significant in the case of start-up creation. This chimes with an emerging literature that highlightsthe contribution of creative graduates to regional development both in terms of technology transfer and of spillovers from creative human capital (Faggian et al., 2014; Comunian et al., 2015).

Graduates from STEM and business related fields have been found to be more mobile and earn higher wages than those graduates from the creative arts, education or law that are less mobile and on average earn less (Faggian et al., 2014). Ceteris paribus, evidence shows that STEM graduates have a lower probability of starting up a business than their non-STEM counterparts (Benedict et al., 2012). This holds particularly true across large metropolitan labour markets where a matching between STEM degree holders and STEM occupations is more likely to occur (Wright et al. 2017). In peripheral regions, while HEIs' specialization in STEM subjects might benefit local students, it also faces challenges, not least because of the relatively higher capital investments required to set up STEM facilities (Charles, 2016). Besides specializing in STEM, HEIs located in non-metropolitan areas may have two options. One option is to broaden and diversify their general education offering to better respond to both educational and employment needs of the local businesses and community. This may increase local graduate underemployment (Evers 2019) and graduate mobility (brain drain), if the local job demand is not growing sufficiently. Another option is to target and specialize in a smaller number of "less costly disciplines" (Charles, 2016) under SSH subject areas, including vocational subjects (e.g. education, tourism, and management). This option might improve the chances of graduate retention via employment or entrepreneurial opportunities.

Accordingly, we hypothesize as follows:

H2a: In metropolitan areas, graduate labour retention is positively related to the diversification of university knowledge offering surrounding STEM subjects

H2b: In non-metropolitan areas, graduate entrepreneurship retention is positively related to the specialization of university knowledge offering surrounding SSH subjects

Data Sources, Variables and Methods

Data & Methods

We investigate the population of HEIs in the regions of England (UK) over six academic years (2010-11/2015-16), focusing on graduate *labour* and *entrepreneurship retention*. We draw data from a variety of sources (see Table A1 in the Annex for a detailed description) and then cluster them in metropolitan and non-metropolitan areas. In order to do so, we adopt a categorization using Primary Urban Areas (PUAs). Primary Urban Areas allow a meaningful comparison across municipalities according to criteria including the day-time (as opposed to resident) population of the city (135,000 threshold), and proximity of physical infrastructures. As such, PUAs do not necessarily correspond to administrative districts or Travel to Work areas, but rather proxy the size of an urban, economically active core, reflecting more closely the idea of agglomeration dynamics (Centre for Cities, 2016). Procedurally, we first assign universities to their NUTS3 region and we then match PUAs to NUTS3 regions and finally identify universities located in metropolitan (PUA) or non-metropolitan (non-PUA) areas. [3] In order to test the hypotheses, we use a robust General Least Square (GLS) random effects panel (clustered by region) and estimate the effect of our main independent variables on retention dynamics (Cameron and Trivedi, 2010).

Variables

Dependent variables: Labour retention & Entrepreneurship retention

Our main dependent variables measure the contribution of universities to regions distinguishing between the rates of *graduate labour retention,* based on the number of students

[3] The European Tertiary Education Register provides the geographical location of the universities based on the location of the main campus. In our analysis, there are 82 PUAs and 51 non-PUAs areas.

who are in full time employment in the region where they graduated; and *graduate entrepreneurship retention,* based on the number of students who started-up a business in the region where they graduated. Data is taken from the Destination of Leavers from Higher Education (DLHE) survey, carried out by individual HEIs and targeting graduates six months after the completion of their studies.[4] To ensure that DLHE results reflect real outcomes of students leaving education, HEIs are required to meet a target response rate[5] of 80% while extensive data quality checks are carried out by the UK Higher Education Statistical Agency (HESA) to monitor response rate distribution across different disciplines within the single HEI (HESA 2018).[6]

While the information from DLHE collects individual level responses, we build our dependent variables clustering by university. Accordingly, we compute an index measuring the percentage change between two consecutive years ($\frac{t1-t0}{t0}$) that provides rates of graduate (labour and entrepreneurship) retention at the single university level. For instance, the labour retention rate of the University of Manchester in 2011 measures the increase/decrease in the number of University of Manchester's graduates that settled to work in the university region between 2010/11 and 2011/12.

Independent Variables: University Specialization

To look at the relationship between HEI and regional retention rates among graduates in metropolitan and non-metropolitan areas, we focus on the portfolio of subject areas offered by the university. Accordingly, we create three variables reflecting on: the overall HEI specialization (*Specialization*) and the HEI specialization in scientific (*STEM Specialization*) or Humanities (*SSH Specialization*) oriented disciplines. We consider a university to be more specialized if it offers a narrow range of disciplines and more diversified if it offers a broader range of disciplines, relative to the overall possible range of disciplines. In doing so, we adopt

[4] DLHE distinguishes graduates "starting-up a business" from those registered as "self-employed". Accordingly, to compute "*graduate entrepreneurship retention*", we consider only students starting-up a business and exclude individuals who registered as "self-employed".

[5] Given the scope of this paper, we collected information only on Full Time graduates domiciled in the UK. Source: https://www.hesa.ac.uk/data-and-analysis/publications/destinations-2015-16/introduction

[6] The response rates of the six Academic Years analysed in this work are respectively: 78.8%; 79%; 78%; 78.4%; 78.7%; 77.7%. Source: https://www.hesa.ac.uk/data-and-analysis/publications/destinations-2015-16/introductionhttps://www.hesa.ac.uk/collection/c15018/instructions

a similar approach to Rossi (2010). While Rossi (2010) captures HEI specialization by comparing the extent to which a university specializes in each discipline relative to the average specialization of all universities in the system, we look at specialization as a measure of scope and compare the relative weight (investments in staff) carried out by the single HEI for each discipline over the total of available disciplines.

In line with these considerations, we build a Herfindahl-Hirschman index to analyse the subject specialization within HEIs in England. The nature of the index allows us to examine both specialization and diversification of the university knowledge offering as two opposite side of the (subject) concentration spectrum. Empirically, we use information on the total number of staff (full-time equivalent) employed by subject (disciplinary) areas. We base this on HESA's Cost Centre units, which group staff members into specific subject (disciplinary) area avoiding double counting of staff and teaching allocations. As such, considering the number of full-time equivalent staff per Centre group (x_i), the index provides a measure of the magnitude of the subject (disciplinary) area within the university:

$$a_i = \frac{x_i}{\sum_{j=1}^{N} x_j}$$

The information on the size of the Cost Centres within the single university is then linearly added to calculate a measure of HEI's subject Specialization as:

$$Specialization = \sum_{i=1}^{N} a_i^2$$

Lower values of the index represent universities with a more diversified portfolio (or low concentration of subject areas), while higher values reflect a more specialized supply. As this index is quite sensitive to size issue, taking more extreme values for smaller institutions, we then standardize it to improve the robustness of the results.

Similarly, to capture relative specialization in STEM versus SSH fields within the same university, we compute two different indexes following the same procedure. Specifically, to address the relative specialization in STEM subjects (STEM Specialization) we look at information of (FTE) staff in the following departments: Medicine, dentistry and health;

Agriculture, forestry and veterinary science; Biological, mathematical and physical sciences; Engineering and technology; Architecture and planning. Likewise, specialization in SSH subjects (SSH Specialization) is computed by using information on (FTE) staff in the following departments: Administrative, business and social studies; Humanities and language-based studies and archaeology; Design, creative and performing arts; Education.

Control variables

To control for observed heterogeneity, we include a set of variables at the university and regional level.[7] Studies in the UK have found that universities characteristics such as age and research intensity influence the level and type of engagement in their regions and localities (Huggins and Johnson, 2009; Kitagawa et al., 2016; Goddard et al., 2014). In addition each university is a path-dependent product of a distinct social, economic and institutional development process (Charles, et al., 2014; Marzocchi et al., 2019; Sánchez-Barrioluengo et al., 2019). Following Sánchez-Barrioluengo et al. (2019), we use two variables to capture different types of HEIs: *Russell Group (RG)*, representing old, research intensive universities, and *post-1992 HEIs* (*Post-92*), representing new universities, which tend to be more teaching focused. The latter also tend to attract more local students than the former.

Even universities with similar historical backgrounds might differ in terms of their teaching, research and external engagement strategies and geographical orientations, which may affect the extent to which they value graduate retention in their region. In order to control for these differences at the organizational level, we analyse three variables in our regression models, drawing on the data from the Higher Education Business-Community Interaction survey (HEBCI).[8] These are: *retention strategy, entrepreneurship training,* and *number of graduate start-ups created*. Finally, we include two measures of HEI size: the number of students (*size*), and percentage of STEM graduates *(% STEM grad*).

[7] Table A1 presents detailed definitions of the variables. Table A1, Summary statistics (Table A2) and Correlation matrix (Table A3) are available in the online Appendix.
[8] The HEBCI survey is a compulsory survey taken annually by the population of Universities in England.

Based on the graduate mobility literature, we control for several factors likely to influence retention dynamics at the regional level. First, graduates' location choices are largely conditioned by labour market opportunities and agglomeration dynamics linked to metropolitan areas (Ahlin et al., 2014). As agglomeration dynamics linked to the concentration of skilled workers can promote their recursive accumulation, we include the percentage of working-age population having completed a tertiary education to control for the influence of skilled peers in the region (*Human Capital*). More densely populated regions are also expected to retain more graduates due to urbanization economies and specialized demand (Content et al, 2019). Accordingly, we control for big-city size effects using a dummy variable for cities with more than half a million inhabitants in the region (*City*). Other control variables are added to address the relevance and structure of regional labour markets and their push/pull capacity depending on employment characteristics and regional GDP differences (Rodríguez-Pose and Vilalta-Bufí, 2005). Respectively, we control for: the rate of unemployment (*Unemployment rate*) and the wages in the manufacturing sector (*Wages manufacturing*) to provide information about the wage distribution at regional level. To further capture the absorptive capacity of the region, we control for the percentage of available (private sector) jobs in KIBS (Bonnacorsi, 2017), and include the percentage of employment in KIBS in the region *(% emp. KIBS)*.[9] Finally, we control for universities' own agglomeration effect and control for places with more than one university. Accordingly, we build a variable (*Agglomeration*) summarising the total number of HEIs in the region.[10]

Analysis and Findings

Geographical patterns of retention

Retention rates of HEIs across English regions are very heterogeneous. For instance, in 2015-16 London and the North West were the regions with the highest percentage of graduates

[9] Regional absorptive capacity is linked to both high-tech manufacturing and KIBS employment, however due to collinearity issues between high-tech manufacturing employment and wages in manufacturing, we only include the latter in the analysis.

[10] One key feature of the geographical pattern of English university location is that the larger the city is, the more universities are likely to be there with a similar composition between pre-92 and post-92 HEIs (Goddard et al., 2014). In our data, London (UKI3&UKI4) hosts 28 HEIs followed by the next biggest cities Birmingham (UKG31) with 5 and Manchester (UKD33) with 3 respectively.

locally retained (66%) followed by the North East (56%) and West Midlands (55%). On the contrary, East Midlands and the South East were the regions with the lowest retention rates (42% and 44% respectively) (Universities UK, 2017). However, according to our data and across the period considered (2010/11-2015/16), the chances of graduates to work or start a business in the region of their university provider has cumulatively declined: from 2010 onwards, graduates settle increasingly less in the region of their university.[11]

Figure 1 shows the evolution of graduate retention growth for both labour (top) and entrepreneurship (bottom) in metropolitan and non-metropolitan regions. According to the graduate mobility literature, universities located in urban regions are expected to attract and retain more graduates. However, by separating *labour* and *entrepreneurship retention* we can observe different dynamics. Indeed, results show that universities in metropolitan areas tend to exhibit higher labour retention, while universities in non-metropolitan areas show increasing retention rates of graduates starting-up a business. In particular, the patterns between metropolitan and non-metropolitan areas become particularly marked from 2013 onwards, likely reflecting external 'shocks' surrounding both HEIs and places in the period considered such as the financial crisis in 2009 and the introduction of higher tuition fees in 2011.

[Insert Figure 1 about here]

Findings

Table 1 presents a summary of the regression results for *labour* (left) and *entrepreneurship* (right) retention.[12] M1, M2 and M3 focus on general university specialization, while M4, M5 and M6 distinguish between specialization in STEM and SSH. In both cases, M2/M5 and M3/M6 differentiate between metropolitan and non- metropolitan areas respectively.

In general terms, HEI specialization relates negatively to *labour retention* growth (M1a), meaning that the less specialized (that is, the more diversified) the university is in terms of disciplines, the greater retention is of graduates in the local job market. However, when investigating differences between metropolitan and non-metropolitan areas, university's

[11] See Figure A1 in the Annex providing more details on the geographical patterns of retention.
[12] See Table A4 in the Annex for the complete version of the regression results.

specialization loses significance (M2a and M3a) and does not capture any dynamic of regional retention.[13] In the case of *entrepreneurship retention* growth, the specialization index positively relates to entrepreneurship retention (M1b). In this case, the more specialized the university is, the more opportunities there are to increase its entrepreneurship retention capacity in both urban (M2b) and rural areas (M3b).[14] Therefore H1a and H1b can only be partially accepted – whether a university is more or less specialised is only significant for *entrepreneurship retention* (M2b, M3b) but not for *labour retention* (M2a, M3a) in relation to the university's location (i.e. metropolitan and non-metropolitan areas).

Once we look at specialization in STEM and SSH (M5a and M6a respectively) we see that both significantly contribute to graduate labour retention in metropolitan and non-metropolitan areas. Therefore, Hypothesis 2a is confirmed: the more diversified the university is in STEM fields in metropolitan areas (negative specialisation index), the greater the labour retention in the region. The same effect of specialization on labour retention holds true also for SSH fields in non-metropolitan areas. In the case of *entrepreneurship retention* (M5b and M6b), only specialization in SSH has an effect in both metropolitan and non-metropolitan regions (with H2b accepted). Conversely, specialization in STEM is not significantly related to *entrepreneurship retention* rates in both metropolitan and non-metropolitan areas. These results confirm previous literature on the impact of SSH in regional economies (Kempton et al., 2013; Olmos-Penuela et al. 2014). Our findings suggest that enlarging the variety of disciplines within the area of social science and humanities could increase the universities' contribution to regional retention growth particularly in non-metropolitan areas. Therefore, the result is in line with the argument proposed by Charles (2016) that an efficient strategy for HEIs in peripheral regions is to focus on less costly SSH subjects, which do not require high capital investment, unlike STEM areas.

[Insert Table 1 about here]

[13] In metropolitan areas the effect is driven by agglomeration dynamics linked to industrial structure (KIBS, wages in manufacturing, unemployment levels). See Table A4.

[14] To compare the coefficient parameters of specialization across both models, we followed a seemingly unrelated estimation procedure and performed a Wald test (Mullahy, 2015). Results indicate that the coefficients of specialization are significantly different between metropolitan and non-metropolitan areas (chi2=2.94; p-value=0.08), being higher the effect of specialization in non-metropolitan areas compared to metropolitan ones.

1.

Conclusions and implications

In this paper, we investigate how HEIs contribute to regional retention of graduates in different territorial contexts, aiming to shed light on the link between HEIs and retention dynamics, and reflect on how such dynamics have changed through time. We contribute to a growing body of literature on highly 'mobile graduate human capital' that has, over the last decade, identified an increasing concentration of talent in urban areas. The factors that contribute to the retention of graduates in the place of their study are less well understood (Faggian et al., 2017), particularly in non-metropolitan areas where graduates face constraints in terms of both supply and demand sides, leading to skill mismatches, graduate underemployment and/or brain drain (Benneworth and Fitjar, 2019).

This paper makes a theoretical contribution to the concept of human capital externalities and their link to graduate retention by distinguishing two types of retention: '*labour retention*', defined as graduates who are employed in the region where they studied; and '*entrepreneurship retention*', defined as graduates who start-up a business in the location of their university. In order to understand the organisational and spatial mechanisms behind both types of graduate retention, we examined the change in retention rates of individual HEIs across metropolitan and non-metropolitan areas using a panel of data of English universities over a six-years period. Our empirical findings show that agglomeration dynamics affect *labour* and *entrepreneurship retention* differently, and with a diverse effect depending on whether a university specialises more in STEM or SSH subjects. Accordingly, we argue that the influence of graduate retention on local development can be mediated by the capacity of HEIs to support the accumulation of human capital externalities.

At the spatial level, we find that universities in metropolitan areas show higher growth rates of graduate *labour retention*, while universities in non-metropolitan areas show higher growth rates of graduate *entrepreneurship retention*. At the organizational level, among the different factors potentially affecting graduate retention, we focused on the range of knowledge that universities offer in terms of subject specialization and diversification (e.g. Rossi, 2010) and the nature of knowledge offering (e.g. Winters, 2014; Breznitz and Zhang,

2019b). When we analyse the local impact of subject specialization taking into account the spatial context, a more complex picture emerges. First, labour retention is linked to diversification across and within the disciplinary range but with a distinction: in metropolitan areas such dynamic is driven by STEM while in non-metropolitan areas it is driven by SSH. Conversely, entrepreneurship retention is driven by specialisation, in particular, by SSH specialisation, both in urban and peripheral contexts.

One caveat here is that the present work is not able to capture the extent to which HEI specialization corresponds to the specific regional labour demand. However, our findings seem to be aligned with the literature, which suggests that the cognitive distance between organizations supplying skills (i.e. HEIs) and organizations absorbing them (local industrial knowledge base) could constrain local economic development processes (Nooteboom et al., 2007). Furthermore, a recent study investigates the links between regional industrial relatedness and regional entrepreneurship as a possible spillover mechanism leading to the creation of new jobs (Content et al., 2019). Therefore, our results seem to suggest the significance of HEI specialization on *entrepreneurship retention* and the needs for further investigation in relation to the local industrial and labour market structure.

These results carry different implications for regional economies and the strategies that both HEIs and governments at different levels could adopt to benefit from knowledge spillover effects. For human capital externalities to accrue locally, universities need to acknowledge location-specific knowledge assets and their spillover mechanisms linked to labour and entrepreneurship retention. HEIs in metropolitan areas need to broaden their engagement with local businesses both in terms of curricular development and student work experiences particularly for SSH subjects. Entrepreneurship strategies targeting student retention seems to be particularly vital for HEIs in non-metropolitan areas. This could include combining enterprise education with SSH subject provisions and networking with entrepreneurial actors and intermediaries. In order to counter regional economic imbalances, different types of HEIs and other education providers in a non-metropolitan region need to collaborate, for example, by developing and sharing graduate start-up infrastructure and training provisions and by

embedding students in local networks while supporting the creation of new ones by creating graduate start-ups networks.

Policies should aim to boost demand for high-skilled workers, including both private and public sectors. This involves addressing the mismatch between university curriculum, often informed by past industrial specialisms, and current skills needs of the region; improving graduates' awareness of existing opportunities and developing support services (such as placement programmes), particularly with Small and Medium Enterprises (SMEs). Improving local infrastructure and other place-based conditions is also important as these influence the attraction and retention of investment and talent – at local, national, and international levels. Better understanding of the geographic scope and dynamics of human capital externalities linked to graduate attraction and retention is needed to tackle regional imbalances across multiple levels of governance.

There are several policy implications stemming from this study which resonate with recent policy developments in the UK. Beyond the concept of universities anchoring talent for their region, recent policy reports call for more joined up approaches between universities and other actors (i.e. businesses, investors, and local and national governments) to better respond to "place-based challenges" (Government Office for Science, 2016, p.18). Those place-based challenges require multi-disciplinary solutions, informed both by both STEM and SSH fields. The "civic anchor role" of universities is deemed to be particularly important considering current processes of devolving health and social care services from national to local bodies in certain parts of England (Civic University Commission, 2019). The focus on entrepreneurship retention is relevant given the recent policy focus on enterprise and entrepreneurship education in the UK (QAA, 2018) and the growing role of incubators and accelerators for student start-ups (Centre for Entrepreneurs, 2017). The findings in this study emphasise the importance of entrepreneurship in non-metropolitan/peripheral regions to boost graduate retention.

This study is still exploratory in nature and presents limitations. Firstly, this paper does not sufficiently reflect on the complex relationship between attraction and retention of graduates,

as we only examined graduates' location choices after graduation, and did not consider the origins of graduates and pre-study migration patterns. Origins, demography and other attributes (e.g. gender, areas of study, parental backgrounds) of students as well as the types of HEIs are important areas of investigation for the future. Similarly, graduate retention and destinations need to be captured long-term to understand the dynamics of human capital externalities throughout the life cycle of graduates' careers. Second, the dichotomy between metropolitan/non-metropolitan and urban/rural contexts needs cautious analysis. Some rural areas are wealthy with plenty of entrepreneurial opportunities for graduates, often with less competition, while other rural areas and small towns, old industrial places lack entrepreneurial support and institutional mechanisms. A more *granular understanding of the place, particularly the diverse nature of non-metropolitan and remote areas* will help better understand (the lack of) mechanisms of human capital externalities. Finally, as mentioned already, the extent to which specialization/ diversification of HEIs knowledge benefits regional economies would depend on external demand and job opportunities. Building on this, a fruitful area of investigation would be related to the ways in which HEI specialization corresponds to the specific regional industrial structure and labour demand.

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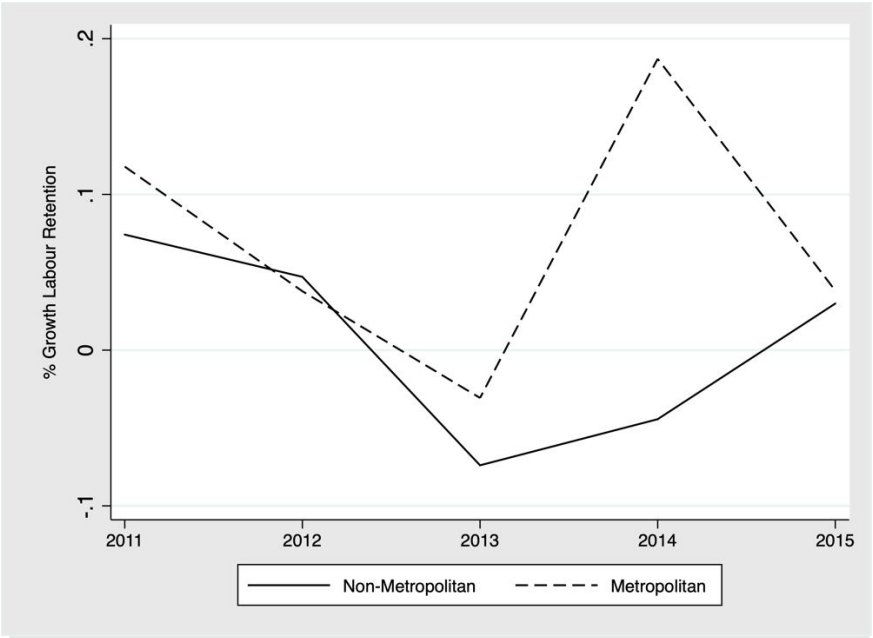
Figure 1. Evolution of labour and entrepreneurship retention



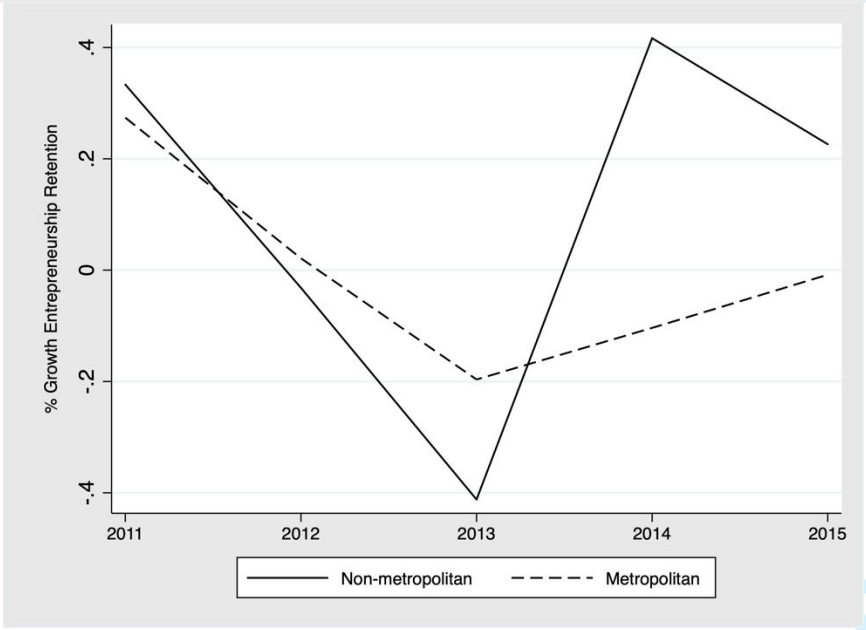


Table 1. Specialization coefficients from regression results (summary)

	LABOUR RETENTION						ENTREPRENEURSHIP RETENTION					
	M1a TOTAL	M2a NON-METRO	M3a METRO	M4a TOTAL	M5a NON-METRO	M6a METRO	M1b TOTAL	M2b NON-METRO	M3b METRO	M4b TOTAL	M5b NON-METRO	M6b METRO
SPECIALIZATION	**-0.016****	-0.051	-0.02				**0.156*****	**0.572****	**0.118*****			
	[0.01]	[0.04]	[0.01]				**[0.04]**	**[0.27]**	**[0.04]**			
STEM SPECIALIZATION				**-0.015*****	-0.191	**-0.018***				0.043	0.774	0.019
				[0.01]	[0.13]	**[0.01]**				[0.04]	[0.48]	[0.05]
SSH SPECIALIZATION				-0.011	**-0.024*****	-0.015				**0.099*****	**0.253***	**0.073****
				[0.02]	**[0.01]**	[0.02]				**[0.03]**	**[0.13]**	**[0.03]**
CONSTANT	0.091	0.343	0.891	0.076	0.242	0.84	0.219	**3.203****	-0.26	0.169	**2.793***	-0.156
	[0.29]	[0.24]	[0.72]	[0.28]	[0.22]	[0.67]	[0.58]	**[1.40]**	[0.49]	[0.58]	**[1.59]**	[0.53]
WALD CHI2	31.598	1520.27	43.093	463.901	64598.405	566.657	184.318	331.915	200.846	198.465	191.682	362.68
DF	14	13	14	15	14	15	14	13	14	15	14	15
P-VALUE	0.005	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0	0
OBSERVATIONS	471	115	356	488	119	369	326	72	254	340	74	266

Random effects GLS with regional clustering. All models include University and Regional controls. A full version of the table is available in the Annex (Table A4). Standard errors in parentheses.
* p<0.10, ** p<0.05, *** p<0.01.

Supplementary Material

Annexes. Table A1. Definition of control variables

VARIABLE	DEFINITION	SOURCE
ENTREPRENEURSHIP TRAINING	Dummy variable with the value 1 if the university reports offering such training activities related to entrepreneurship and 0 otherwise (Part A of the survey)	HEBCI
RETENTION STRATEGY	Dummy variable with the 1 if the university specifically has an institutional strategy to retain students, 0 otherwise (Part A of the survey)	HEBCI
GRADUATE START-UPS	Number of graduate start-ups created. HESA defines graduate start-ups as all new businesses started by recent graduates (within 2 years after 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.	HEBCI
% STEM GRAD.	Ratio between graduates in Science, Technology, Engineering and Mathematics (STEM) and total graduates	HESA
SIZE	Total number of students	HESA
RG	1 if the university is a part of the Russell Group, 0 otherwise	
POST-92	1 if the university was born after 1992, 0 otherwise	
HUMAN CAPITAL	% working age population who completed a tertiary education	Eurostat
UNEMPLOYMENT RATE	Rate of unemployment	Eurostat
CITY	Presence of a city with more that 500K habitants	Eurostat
WAGES MANUFACTURE	Wage in the manufacture sector (in million EUR)	Eurostat
% EMP. KIBS	% Employment in Knowledge Intensive Business Sectors (KIBS) divided by total employment. KIBS include the following NACE codes: 50-51, 59-63, 69-74, 78, 80.	Eurostat
AGGLOMERATION	Number of universities in a region	HEBCI

Table A2. Correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 SPECIALIZATION	1														
2. STEM SPECIALIZATION	0.835***	1													
3. SSH SPECIALIZATION	0.374***	-0.184***	1												
4. ENTREPRENEURSHIP TRAINING	-0.070*	0.004	-0.142***	1											
5. RETENTION STRATEGY	-0.111***	-0.046	-0.101***	-0.108***	1										
6. GRADUATE START-UPS	-0.058	-0.034	-0.043	0.005	0.144***	1									
7. % STEM GRAD.	-0.234***	-0.022	-0.370***	0.165***	0.0740**	0.542	1								
8. SIZE	0.201***	0.022	0.321***	-0.181***	-0.171***	-0.037	-0.472***	1							
9. RG	-0.0356	0.051	-0.129***	0.108***	-0.045	-0.080**	0.356***	-0.173***	1						
10. POST-92	-0.163***	-0.119***	-0.084**	0.050	0.196***	0.135***	-0.0540	-0.150***	-0.420***	1					
11. HUMAN CAPITAL	0.253***	0.102***	0.283***	-0.198***	-0.220***	-0.044	-0.279***	0.245***	-0.015	-0.273***	1				
12. UNEMPLOYMENT RATE	-0.010	-0.034	0.006	0.162***	-0.335***	-0.083**	0.038	-0.031	0.096***	0.005	-0.242***	1			
13. CITY	0.201***	0.052	0.263***	-0.125***	-0.220***	-0.074**	-0.213***	0.180***	0.038	-0.210***	0.497***	0.447***	1		
14. WAGES MANUFACTURE	-0.203***	-0.092**	-0.218***	0.113***	0.204***	-0.017	0.231***	-0.180***	0.040	0.173***	-0.578***	0.119***	-0.195***	1	
15. % EMP. KIBS	0.192***	0.121***	0.164***	-0.138***	-0.025	-0.003	-0.151***	0.133***	0.037	-0.143***	0.565***	-0.214***	0.283***	-0.253***	1
AGGLOMERATION	0.290***	0.106***	0.329***	-0.181***	-0.302***	-0.186***	-0.314***	0.354***	0.034	-0.326***	0.847***	-0.023	0.573***	-0.396***	0.564***

Note: * p<0.10, ** p<0.05, *** p<0.01.

Table A3. Descriptive statistics

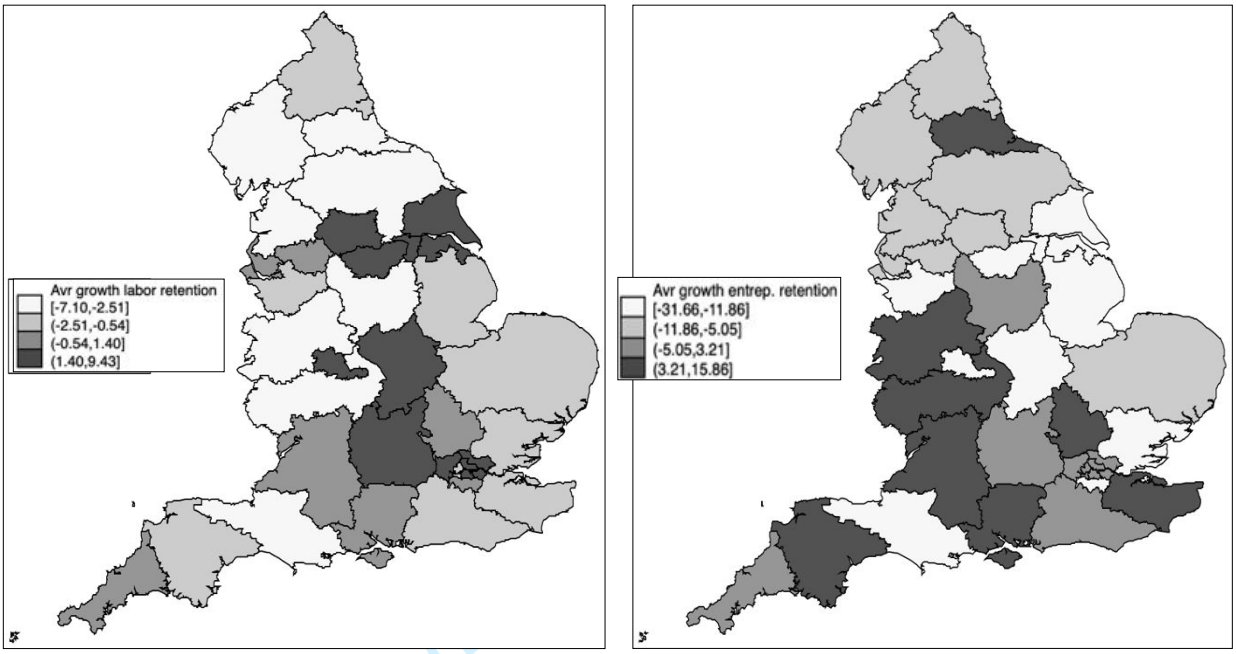
	MEAN	SD	MIN.	MAX.	OBS.
LABOUR RETENTION	0.05	0.82	-.0,86	19.2	575
ENTREPRENEURSHIP RETENTION	0.009	0.70	-1	5	426
SPECIALIZATION	0.38	0.50	0.11	11.82	739
STEM SPECIALIZATION	0.14	0.47	0	11.82	767
SSH SPECIALIZATION	0.23	0.28	0	1	767
ENTREPRENEURSHIP TRAINING	0.71	0.45	0	1	778
RETENTION STRATEGY	0.47	0.50	0	1	778
GRADUATE START-UPS	24.54	49.51	0	371	776
% STEM GRAD.	17.98	12.72	0	70.93	766
SIZE	95.56	217.10	1	995	766
RG	0.15	0.36	0	1	778
POST-92	0.49	0.50	0	1	772
HUMAN CAPITAL	39.09	8.95	30.13	69.86	33
UNEMPLOYMENT RATE	6.46	1.70	4.4	10.18	33
CITY	0.27	0.45	0	1	33
WAGES MANUFACTURE	2024.04	1044.97	353.93	4339.33	33
% EMP. KIBS	13.70	6.31	5.43	38.28	33
AGGLOMERATION	3.91	3.85	1	23	33

Table A4. Regression results

	LABOUR RETENTION						ENTREPRENEURSHIP RETENTION					
	M1a TOTAL	M2a NON-METRO	M3a METRO	M4a TOTAL	M5a NON-METRO	M6a METRO	M1b TOTAL	M2b NON-METRO	M3b METRO	M4b TOTAL	M5b NON-METRO	M6b METRO
SPECIALIZATION	**-0.016****	-0.051	-0.02				**0.156*****	**0.572****	**0.118*****			
	[0.01]	[0.04]	[0.01]				**[0.04]**	**[0.27]**	**[0.04]**			
STEM				**-0.015*****	-0.191	**-0.018***				0.043	0.774	0.019
SPECIALIZATION				**[0.01]**	[0.13]	**[0.01]**				[0.04]	[0.48]	[0.05]
SSH				-0.011	**-0.024*****	-0.015				**0.099*****	**0.253***	**0.073****
SPECIALIZATION				[0.02]	**[0.01]**	[0.02]				**[0.03]**	**[0.13]**	**[0.03]**
ENTREPRENEURSHIP	0.108	**0.031****	0.146	0.101	0.011	0.142	-0.045	0.106	-0.072	-0.032	0.07	-0.052
TRAINING	[0.10]	**[0.01]**	[0.14]	[0.10]	[0.01]	[0.14]	[0.07]	[0.12]	[0.08]	[0.07]	[0.14]	[0.08]
RENTION STRATEGY	0.06	-0.006	0.082	0.052	-0.021	0.076	0.034	0.171	0.057	0.047	0.113	0.071
	[0.08]	[0.02]	[0.10]	[0.07]	[0.02]	[0.10]	[0.04]	[0.18]	[0.05]	[0.04]	[0.17]	[0.05]
% STEM GRADUATES	-0.003	0.000	-0.008	-0.003	0.002	-0.008	0.001	0.006	0.001	0.001	0.001	0.002
	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.01]	[0.00]	[0.01]	[0.00]	[0.00]	[0.01]	[0.00]
START-UPS	0.012	-0.011	0.02	0.012	**-0.014****	0.018	0.014	-0.028	0.012	0.015	0.001	0.014
CREATED	[0.02]	[0.01]	[0.02]	[0.02]	**[0.01]**	[0.02]	[0.01]	[0.04]	[0.01]	[0.01]	[0.05]	[0.01]
UNIV. SIZE	0.003	0.009	-0.01	0.003	0.007	-0.01	-0.01	0.303	0.000	0.004	0.166	0.016
	[0.01]	[0.01]	[0.02]	[0.01]	[0.01]	[0.02]	[0.01]	[0.19]	[0.01]	[0.01]	[0.20]	[0.01]
RG	-0.006	0.035	0.056	-0.008	0.036	0.054	-0.051	0.192	-0.05	-0.044	0.095	-0.052
	[0.04]	[0.03]	[0.08]	[0.04]	[0.03]	[0.08]	[0.05]	[0.24]	[0.05]	[0.04]	[0.23]	[0.05]
POST-92	0.043	0.001	0.088	0.038	0.001	0.082	-0.003	0.245	-0.038	-0.008	0.123	-0.043
	[0.05]	[0.02]	[0.09]	[0.05]	[0.03]	[0.09]	[0.03]	[0.15]	[0.03]	[0.03]	[0.16]	[0.04]
HUMAN CAPITAL	-0.005	-0.001	-0.01	-0.005	-0.001	-0.01	-0.005	-0.009	-0.002	-0.005	0.042	-0.003
	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.01]	[0.01]	[0.02]	[0.00]	[0.01]	[0.05]	[0.00]
UNEMPLOYMENT	-0.027	**-0.010****	-0.05	-0.028	**-0.010****	-0.051	-0.014	-0.066	-0.004	-0.007	-0.008	0.004
RATE	[0.02]	**[0.00]**	[0.04]	[0.02]	**[0.00]**	[0.04]	[0.02]	[0.05]	[0.02]	[0.02]	[0.02]	[0.02]
CITY	0.04		0.062	0.046		0.075	0.026		0.038	-0.011	-0.05	-0.009
	[0.04]		[0.07]	[0.03]		[0.06]	[0.05]		[0.05]	[0.05]	[0.06]	[0.05]
AVERAGE WAGES IN	0.022	**-0.055***	-0.026	0.026	-0.038	-0.02	0	**-0.467****	0.036	-0.007		0.013
MANUF	[0.03]	**[0.03]**	[0.05]	[0.03]	[0.03]	[0.05]	[0.04]	**[0.20]**	[0.03]	[0.04]		[0.04]
% EMP KIBS	0.002	**0.004****	0.001	0.002	**0.004****	0.001	0.005*	**0.017*****	0.004	**0.006****	**-0.372***	0.004
	[0.00]	**[0.00]**	[0.00]	[0.00]	**[0.00]**	[0.00]	[0.00]	**[0.01]**	[0.00]	**[0.00]**	**[0.22]**	[0.00]
AGGLOMERATION	0.006	**0.026*****	0.009	0.006	**0.025*****	0.008	-0.006	0.068	-0.005	-0.005	**0.015****	-0.003
	[0.01]	**[0.01]**	[0.01]	[0.01]	**[0.00]**	[0.01]	[0.01]	[0.05]	[0.00]	[0.01]	**[0.01]**	[0.00]
CONSTANT	0.091	0.343	0.891	0.076	0.242	0.84	0.219	**3.203****	-0.26	0.169	**2.793***	-0.156
	[0.29]	[0.24]	[0.72]	[0.28]	[0.22]	[0.67]	[0.58]	**[1.40]**	[0.49]	[0.58]	**[1.59]**	[0.53]
WALD CHI2	31.598	1520.27	43.093	463.901	64598.405	566.657	184.318	331.915	200.846	198.465	191.682	362.68
DF	14	13	14	15	14	15	14	13	14	15	14	15
P-VALUE	0.005	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0	0
OBSERVATIONS	471	115	356	488	119	369	326	72	254	340	74	266

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

Figure A1. Geographical distribution of the average annual growth retention rates



Note: maps represent quartile geographical distribution of the average annual growth rate (AGR) for labour retention (left) and entrepreneurship retention (right). The AGR is calculated by dividing the slope by the retention rate by the regression line formed by the matrix corresponding to the years of study 2010/11-2015/16 and the retention rates by the universities located in a specific region. In the figure, the lightest shade denotes regions belonging to the first quartile of the distribution (i.e.: regions with fewer growth in labour retention rates (left) or entrepreneurial retention rates (right) respectively), while the darkest shade represents regions in the last quartile (i.e.: with the highest positive growth in labour retention (left) and entrepreneurship retention (right) respectively).

The above figures present the quartile distribution of the average annual growth rate (AGR)[1] between 2010/11 and 2015/16 by NUTS2 region. White areas represent the first quartile of the distribution (i.e.: regions with fewer growth in labour retention rates (left) or entrepreneurship retention rates (right) respectively), while the darker grey areas represent regions in the last quartile (i.e.: with the highest positive growth in labour retention (left) and entrepreneurship retention (right) respectively). Two thirds of English regions exhibit negative rates, meaning that these regions have continuously deteriorated their capacity to retain graduates since 2010/11. In particular, Derbyshire and Nottinghamshire, Cumbria and York exhibit the highest negative change, that is: the lowest rate of retention of graduates in work, losing more than 5% of their capacity to contribute to the local workforce in six years. Cornwall and Isles of Scilly, South London, Hampshire and Isle of Wight, Bedfordshire and Hertfordshire and Merseyside keep their retention capacity almost constant (between -0.5% and 0.5% AGR). Finally,

[1] The AGR is calculated by dividing the slope by the retention rate. The slope is determined by the regression line formed by the matrix corresponding to the years of study 2010/11-2015/16 and the retention rates by the universities located in a specific region.

Leicestershire, Rutland and Northamptonshire and East and North of London are the regions with the highest positive growth in terms of labour retention with increments above 9%.[2]

In terms of entrepreneurship retention, Cheshire, East Yorkshire, Northern Lincolnshire and Leicestershire, Rutland and Northamptonshire have decreased their entrepreneurship retention capacity of more than 20%, while Devon, Shropshire and Staffordshire, Tees Valley and Durham and Bedfordshire and Hertfordshire have more than doubled it (from 0.06% to 0.20% in the last case for example).

[2] For instance, East and North of London increased labour retention from 21.40% in 2010/11 to 33.84% in 2015.