1. Introduction

Evolutionary economic geographers have developed a special interest in knowledge recombination dynamics leading to otherwise unattainable regional development paths (Balland et al., 2019; Grillitsch et al., 2018). Recognizing that innovative firms will normally draw primarily on knowledge they can easily assimilate, in terms of geographic and cognitive accessibility, policy makers may want to favour knowledge development activities that challenge such natural constraints (Asheim et al., 2011). At the same time, research and innovation policy are gradually moving from plainly boosting knowledge development, towards more selectively guiding socio-economic change (Foray, 2018; Foray, 2019; Schot and Steinmueller, 2018). This study considers the intersection of two major yet previously unconnected preferential policy developments, both concerned with steering collaborative knowledge development in supposedly promising directions.

First, investing in research on Key Enabling Technologies (KETs) is regarded to be a particularly sophisticated strategy for spurring the emergence of new competitive economic activities (Montresor and Quartraro, 2017; Evangelista et al., 2018). Due to KETs’ wide application potential, KETs-oriented R&D is likely to generate knowledge spillovers that may lift the prospects of a broad variety of activities in an economy (Foray et al., 2009). Second, there is a renewed and increasingly vast interest for innovation policies targeting grand societal challenges (Uyarra et al., 2019). The formulation of missions (Ergas, 1987), as popularized again by Mazzucato (2016; 2018a), provides a prominent way to engage diverse stakeholders in developing and diffusing innovative solutions for pressing problems. Installing directionality allegedly allows actors to identify unexploited complementarities and overcome the inertia that holds back desirable changes (Hekkert et al., 2020).

While clearly reflecting different policy traditions and ambitions, both KETs and missions are claimed to present opportunities for uniting geographically and cognitively disparate sets of capabilities. The effective exploitation of KETs, to begin with, asks for these advanced technologies to be coupled to the capabilities of an economy that is to be transformed (Antonietti & Montresor, 2019). As KETs themselves are mostly developed in a few particular places, research on new applications tends to draw on co-development processes involving also
actors and capabilities found in other places (Montresor and Quartraro, 2017; Wanzenböck et al., 2020a). Similarly, in the case of missions, aligning complementary capabilities to develop and diffuse solutions has been explicitly linked to achieving collaboration between actors spread across space (Coenen et al., 2015). This imperative is often accompanied also with the statement that answers to grand challenges require cross-disciplinary and cross-sectoral innovation (Foray, 2018; Mazzucato, 2018a). Wanzenböck and Frenken (2020, p.57) reckon that policies spurring the search for such answers may even be used as ‘a basis for regional diversification’. Altogether, both the pushing of new key enabling technologies as well as the pulling demand for new solutions can prompt boundary spanning mechanisms, thereby potentially propelling uncommon knowledge recombination.

What remains unexplored, at least so far, is in which stage of invention and innovation the acclaimed cross-overs come about. The available evidence and arguments discussed above mainly address novel network interactions in the stage of knowledge application. One could nevertheless imagine that, in order to be able to integrate knowledge from various domains and places, distant knowledge search needs to occur long before innovative KET applications or missions solutions are ready for deployment. The purpose of this paper is to examine whether, and to what extent, boundaries between places and knowledge bases are indeed spanned already in R&D projects concerned with early-stage development of new knowledge.

2. Theory and hypothesis development

2.1. KETs and overcoming distances

Inspired by the literature on general-purpose technologies (‘GPTs’; Bresnahan, 2010), the European Commission (EC) has been pushing the idea of taking Key Enabling Technologies (KETs) as a starting point for (regional) economic development strategies (EC, 2012). The label KETs covers the latest generation of advanced technologies with the potential of being applied across highly different contexts. In the EC’s current policies, these KETs include industrial biotechnology, nanotechnology, micro- and nanoelectronics, photonics, advanced materials, and advanced manufacturing (EC, 2012). Already in the original Smart Specialisation strategy there was much attention for increasing the accessibility of such enabling technologies, as they were believed to offer a basis for regions to leverage their existing capabilities and diversify towards new directions (Foray et al., 2009; Boschma et al., 2014). Placing KETs at the centre of more recent strategies reflects the importance the EC attaches to KETs being a driver of economic competitiveness.
As pointed out by Foray et al. (2009), some regions may be expected to be leaders in the development of KETs, while others focus on the mere application of these KETs. This application requires identifying complementarities with local capabilities – a process involving co-invention and possibly the emergence of new technological specialisations (Montresor and Quatraro, 2017; Antonietti and Montresor, 2019). Rather than being a matter of plug and play, like in regular ICT-based automatization, actual development is needed when transferring KETs knowledge and fitting it to a utilization in a specific application domain. Thus, before there is a KET-based innovation to be tested and demonstrated for commercialization purposes, resources need to be invested in the research necessary to make the generic technology usable in a certain business context (Bresnahan, 2010). This holds importance for the combinations of firms involved in making the fit, by means of conducting collaborative R&D. Project partners from some places might possess knowledge bases relevant for the technology itself, whereas the capabilities of project partners from other places might be more specific for the usage for which a KET is being deployed (Wanzenböck et al., 2020a).

Based on the above we might expect that overall, most R&D projects involving KETs will be relatively diverse in terms of capabilities and places of the actors they unite. The influence of geographic and cognitive proximities will in that case be lower than for R&D projects concerned with an innovation not based on a KET.

Hypothesis 1a: Tie formation in collaborative R&D projects focused on a KET is less sensitive to geographic proximity than in R&D projects not focused on a KET.

Hypothesis 1b: Tie formation in collaborative R&D projects focused on a KET is less sensitive to cognitive proximity than in R&D projects not focused on a KET.

2.2. Missions and overcoming distances

By formulating mission statements with a clear direction and ambition level, policy makers can engage stakeholders in the development and diffusion of innovative solutions for complex societal problems (Kattel and Mazzucato, 2018). The notion of missions originally goes back to Ergas’ (1987) ‘big science for big problems’, suggesting to tackle those problems by drawing on state of the art knowledge (Mazzucato and Semieniuk, 2017). Hence, part of the currently vibrant debate on missions is devoted to deploying research, development, and innovation policies in order to mobilize and steer the innovation capacities within a country or region (Mazzucato, 2016; Fisher et al., 2018).
**Geographic proximity**

As mission-oriented research and innovation policies are back on the policy agenda only recently, the spatial perspective on missions is still emerging (Cappellano and Kurowska-Pysz, 2020). Available studies generally point at the importance of place-specificity when it comes to searching innovative solutions for societal problems. For instance, Coenen et al. (2015) discuss how both problems as well as innovative capacities tend to be marked by regional contextual factors. The solutions an innovation system can generate depend significantly on the specific set of capabilities it is endowed with, and how these are embedded in local networks.

Returning to the topic collaborative R&D in the (pre-commercial) stage of knowledge development, it is less evident that mission-focused research projects would draw mostly on regionally proximate firms. A starting point for many studies and strategies dealing with mission-oriented research policy is the idea that prioritizing certain widespread societal problems, as done in Europe’s ‘grand challenges’ and the United Nations’ Sustainable Development Goals, can bring together world-class innovator with dissimilar knowledge bases (Mazzucato, 2018b). The rationale here is that if individual societies are unable to tackle persistent societal problems themselves, and if the wickedness of these problems makes it hard to even know what solution direction to follow, perhaps there are answers to be found by mobilizing diverse actors at the global technology and knowledge frontier.

One major promise of missions is their potential to link frontier knowledge from one place to places that have not been able to solve a problem via locally present capabilities only. Long distance knowledge exchange might of course also occur in ‘regular’ R&D projects, but the question is whether missions can build on some inherent characteristic of problem-oriented R&D projects to unite geographically remote capabilities. If it is true that teams working on such projects are relatively inclined to consist of partners from distant places, this could be leveraged in policies guiding innovation by promoting problem-based directionalities. Here, we put this to the test by hypothesizing that collaboration in R&D projects concerned with a mission-related theme, without even being subjected to policies for the active pursuit of missions, are already relatively insensitive to the influence of geographic proximity.

**Hypothesis 2a:** Tie formation in collaborative R&D projects focused on a mission is less sensitive to geographic proximity than in R&D projects not focused on a mission.
**Cognitive proximity**

In their discussion of the nature and design of mission-oriented R&D programs, Foray et al. (2012) stress the importance of support for knowledge development as early as in the basic research stage. They also make the point that while private funding might increase when (technological) solutions are ready for commercialization and dissemination, firms already have a role to play in the stages of research and development as well. In order to increase the chance of identifying and applying successful solutions, missions benefit from competing industries conducting R&D on diverse ideas. In a more recent article, Foray (2018) explains how mission-oriented R&D policy can drive the search for solutions emerging from complementarities between different sets of actors and their capacities. As opposed to industrial policies targeted at particular sectors, missions are special because of their potential to spur research activities at the interface of parts of different sectors (which apart from yielding innovative solutions could also help to transform these sectors). A similar claim is found in Mazzucato and Penna (2016). Principles like setting concrete directions can enable the alignment of different types of capabilities, which in turn may yield innovative responses to grand societal challenges.

Briefly stated, while much of the current debate on missions is devoted to how to govern them, there appears to be some optimism again that innovation efforts focused on solutions for societal challenges are by themselves already more cross-sectoral than regular innovation efforts. To test this assumption, we hypothesize the following:

*Hypothesis 2b: Tie formation in collaborative R&D projects focused on a mission is less sensitive to cognitive proximity than in R&D projects not focused on a mission.*

3. **Data and methodology**

In our empirical analysis, we use gravity model regressions to investigate tie formation in collaborative R&D projects in the Netherlands. The dataset we study, retrieved from the administration of the Dutch Public-Private Research Allowance scheme, includes the majority of public-private R&D projects taking place between 2013-2018 (n = 1989 organisations with 8037 ties, out of 1,773,786 possible ties). In 2019, all existing subsidized projects in the allowance scheme have been labelled according to the KET and the mission theme they are associated with. By looking at the location and sectors of project partners, we inspect to what extent the R&D projects are subjected to (respectively) geographic and cognitive proximity – and how this differs for projects with a KET or mission label.
4. Results

The figures below show to what extent geographic proximity (GEO) and cognitive proximity (COG) influence tie formation. The results first demonstrate this for the KET and Mission variables as such (Figure 1), and then for specific KET types (Figure 2) and specific Mission types (Figure 3).

Figure 1: Coefficients of GEO (left panel) and COG (right panel) with a 95% confidence interval.

Figure 2: Coefficients of GEO (left panel) and COG (right panel) across key enabling technologies, with a 95% confidence interval.

Figure 3: Coefficients of GEO (left panel) and COG (right panel) across missions themes, with a 95% confidence interval.

5. Conclusions

The empirical investigation confirms that both proximity types are significant predictors for tie formation. Furthermore, while for some KETs we find indications that geographic and cognitive proximity are relatively less important (for tie formation) than in R&D projects not focused on a KET, the reverse seems to hold true for missions.
By showing the geographic and cognitive boundary spanning potential to be modestly present for some KETs, and mostly absent or even negative for missions, this paper primarily contributes to the current debate on driving uncommon R&D collaboration. As the latter is believed to be a basis for economies to diversify into promising directions (Grillitsch et al., 2018), our findings highlight an additional reason to target innovation policies at KETs research (besides their innate potential to transform sectors). In as far as also mission-oriented innovation policy is legitimized based on its potential to drive cross-overs in the stage of R&D, more caution seems to be required.

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Graduate Students as Boundary Spanners: How Academic Engagement can influence Firm Innovation

EXTENDED ABSTRACT

Literature analyzing university-industry interactions has primarily focuses upon the university and its impact upon society. Key topics have been how and why the university can positively impact societal benefits and economic development (Salter & Martin 2001; Bozeman et al. 2015), how it can become entrepreneurial (Etzkowitz 2013), and why the university’s role changes due to institutional and scientific transformation (Gibbons et al. 1994; Genua 2001; Etzkowitz 2004; McKelvey & Holmén 2009). In impacting the economy, much focus has been upon commercialization, including academic entrepreneurship such as start-up companies as well as how universities handle patents, license agreements and foster entrepreneurial behaviors among academics (Perkmann et al. 2013), and the variety of mechanisms for technology transfer (Laredo 2007; Ambos et al. 2008; Rosli & Rossi 2016). Our focus is different, that is, we follow the modern literature on academic engagement with industry (Perkmann et al. 2013, 2019), here defined as knowledge-related interactions with external organizations. Perkmann et al (2019) find that few extant studies study academic engagement in terms of impacts upon the firm. While this phenomenon includes a large variety of forms of interaction, such as collaborative research, consulting and ad hoc advice, previous work has found that male, senior academics, such as professors, are primarily involved in academic engagement (Perkman et al. 2013, 2019). This category of faculty of course tends to have graduate students, who have been shown in some studies to be important for collaborations between universities and firms (Thune 2009; Thune & Børing 2014; McKelvey et al. 2015). Given the lack of previous studies on how graduate students contribute to academic
engagement, we will explore how their activities, including both academic and firm-specific work, create interaction between firms and universities.

More specifically, this paper explores the activities of graduate students as a specific form of academic engagement, and we do so in order to investigate how these interactions may affect the development of firm capabilities for innovation, here operationalized as absorptive capacity. We thus see graduate students as constituting one form of academic engagement, between firms and universities. The existing literature on graduate students in relation to knowledge and innovation tend to focus on what happens after graduation, such as the impact of degrees on income and career paths, as well as whether and why those who chose to later work in a firm do, or do not, continue to publish later in their career (Cruz-Castro & Sanz-Menéndez 2005; Roach & Sauermann 2010; Garcia-Quevedo et al. 2011). Some previous studies analyze PhD students working on firm-related problems in order to investigate the characteristics, their educational experience and learning outcomes (Wallgren & Dahlgren 2007; Thune 2009; Borrell-Damian et al. 2010; Gustavsson et al. 2016).

We investigate a particular type of graduate students –namely, firm employed PhD students in engineering – which we consider as individuals who are engaging in boundary spanning between the firm and university in such a way as to potentially impact the absorptive capacity of the firm. During their PhD studies, they should do research on problems of interest to both engineering science and to the firms involved. The concept of absorptive capacity links the individual to the organization, and specifically suggests that certain individual can bring external knowledge into the firm. In the seminal definition, absorptive capacity refers to the ability to 1) recognize the value of, 2) assimilate and 3) exploit new external knowledge (Cohen & Levinthal, 1990). This means that specific individuals can act as boundary spanners, and they are interesting in relation to firm innovation, because they may create opportunities for organizational learning (Cohen & Levinthal, 1990). They may play different roles, since the
firm must translate and transform knowledge into innovation throughout their innovation journey (Cheng & Van de Ven, 1996; Van de Ven 2016). Recent literature on innovation management in relation to search has explored how firms search for relevant new knowledge externally, analyzed in terms of breadth and depth (Laursen, 2012), and especially search over organizational boundaries (Lakemond et al. 2016; Lopez-Vega 2016). Hence, while existing literature has stressed that firms have reasons to obtain external knowledge in order to innovate, we currently know little about how the activities and roles of graduate students may bring external knowledge into the firm in this specific form of academic engagement. Therefore, we will explore how their activities – including both academic and firm-specific work – create interactions between firms and universities.

The research project is a qualitative case study of one phenomenon (Yin, 2014), where our phenomenon is this specific form of academic engagement. Our aim is to develop an in-depth understanding of firm employed PhD students’ experiences in regards to contributing to firm innovation during their education. Note that the focus here is on the university-firm interaction per se as well as how the interaction affects the development of firm capabilities for innovation, operationalized as absorptive capacity. The case study includes a group of firm employed PhD students within a large engineering faculty in Sweden, which is hereafter called The University, in order to denote the university side of the interaction. Engineering is chosen due to its long tradition of collaborating with industry and hosting of firm employed PhD students.

Our interpretation of the findings of this study is that these graduate students can be interpreted as a specific type of academic boundary spanners that may influence firms’ absorptive capacity (Cohen & Levinthal 1990). More precisely, these graduate students influence the early phases of firms’ absorptive capacity through activities related to both the direct and indirect pathways to innovation. However, they do not pursue activities influencing the final phase of absorptive
capacity, the exploitation of new external knowledge (Cohen & Levinthal 1990), largely because firms already have many people in technical and product development. Thus, these individuals primarily function as boundary spanners to academia, and they do so by creating, developing and absorbing new engineering knowledge. In carrying out the activities that we have identified, the individuals appear to contribute to developing firm capabilities, in particular by recognizing the value of new external knowledge and also, to some extent, assimilating new external knowledge (Cohen & Levinthal, 1990; Todorova & Durisin, 2007). Furthermore, we make two points, which are propositions about how to further interpret our results so far, and which define interesting areas for future research. The first proposition identifies a fruitful avenue for future research in terms of analyzing inter-firm variation in routines, which may help explain different ways in which Mode 2 science is enacted within engineering (Gibbons et al 1994). The second proposition point out that future research should examine in detail interactions between different elements of absorptive capacity – inside the firm. In other words, these firm employed PhD students need to be matched with organizational routines and other firm employees who do possess the ability to act upon the technological opportunity presented to them and thereby execute the firm’s selection capability (and later on the capabilities connected to implementation).

The results from this study also have implications for practitioners and public policy, with regards to the ongoing discussion of the university and its impact upon society. Public policy can enable more successful collaboration between universities and firms with regards to this type of academic engagement through supporting a competitive grant system that includes requirements in relation collaboration characteristics.

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Graduate start-ups as knowledge spillover: the interplay between the university entrepreneurial ecosystem in the regional innovation context

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1- Introduction

Highly successful innovations and new entrepreneurial firms are closely linked. Entrepreneurship is a major stimulant of economic growth and social transformation, and as well as innovation, it is conditioned by a number of contextual factors (Autio et al., 2014). The roles higher education institutions (HEIs) play in entrepreneurship, innovation and economic growth have been attracting both policy and scholarly attention across the world (Breznitz and Feldman, 2012). Universities have been extensively investigated as sources of knowledge spillovers to both existing companies and new ventures, suggesting a strong relationship between university knowledge output, innovation and entrepreneurship (Audretsch and Feldman 1996; Audretsch and Lehman, 2005; O’Shea et al., 2007). Two principal knowledge spillovers mechanisms occur between universities and firms: first, the scientific knowledge produced at universities; second, the creation and absorption in the regional workforce of human capital recently trained (Audretsch and Feldman 2004).

Academic entrepreneurship, such as spin-offs by university researchers, have been largely studied in the literature (Siegel and Wright 2015), and subject of science, technology and innovation (STI) policy. However, less is known about the knowledge spillover “embodied in students graduating from the university” (Audretsch et al., 2005, p. 1115), its contribution to entrepreneurship and the STI policy that would best support these business endeavours. Graduates are a specific type of entrepreneur: they have relatively limited business experiences and resources. Recently, a growing literature has started to critically address this gap by examining the magnitude of graduate start-ups in relation to faculty spin-offs (Astebro et al. 2012; Marzocchi et al. 2019) and seizing their value for local economies (Larsson et al. 2017; Krabel and Flöther 2014). This paper investigates the knowledge spillover process through the lenses of graduate start-up. In doing so, it looks at the organisational (university) characteristics and the contextual factors of the region to understand their impact on student start-up creation.
2- Literature

Empirical evidence has been growing on the characteristics supporting creation of student ventures, as well as the role that the organisational and spatial contexts play in facilitating these entrepreneurial endeavours (Astebro et al., 2012; Siegel and Wright, 2015; Wright et al, 2017; Morris et al., 2017). The entrepreneurial ecosystem literature offers new insights on how to understand the factors that underlie successful entrepreneurship (Spiegel, 2017). As Miller and Acs (2017) suggests, universities can be seen as entrepreneurial ecosystems of their own and recent studies examine universities’ “student start-up ecosystems” (Wright et al., 2017) including infrastructures, networking opportunities and institutional culture to support graduates’ business endeavours (Shah and Pahnke, 2014; Breznitz and Zhang 2019; Morris et al., 2017; Mason et al., 2020). Many universities deploy entrepreneurship strategies by promoting enterprise education, investing in entrepreneurship infrastructure such as incubators and accelerators, attraction of external investment for entrepreneurship activities.

At the same time, graduate start-up processes are contingent upon their surrounding institutional contexts (Wright et al., 2017; Bergman et al. 2018). However, relevant elements that facilitate knowledge spillovers through graduate entrepreneurship are yet understudied. A systematic view of the mechanisms of knowledge spillovers may have central consequences through the interactions between the university level start-up support and regional innovation characteristics and supporting mechanisms. The knowledge spillover theory of entrepreneurship (KSTE) recognizes that knowledge spillovers are not enough: positive economic growth depends on “regional entrepreneurship capital” (Audretsch and Keilbach, 2008). In this sense, context-specific support mechanisms both at the university and regional level are key determinants of entrepreneurial activity (Jack and Anderson, 2002; Qian et al., 2012), which affect not only the opportunity recognition of individual entrepreneurs (Welter 2011; Venkataraman 1994), but also condition the strength of ties developed with local actors and supporting institutions (Brown and Mason, 2017). In some cases, universities ecosystems may even complement or substitute regional and/or local business provisions in students access to the entrepreneurship capital (Audretsch and Keilbach, 2008).

3– Empirical strategy

Empirically the work focuses on England and employs a number of sources to develop an original database collecting longitudinal characteristics at the university and regional level between the academic years 2008/2009 to 2015/2016. Our main dependent variable is the number of graduate start-ups created per university per year. The university-based
entrepreneurial ecosystem variable includes organisational structures to foster graduate entrepreneurship (e.g. entrepreneurship courses, incubators, science parks and accelerators), as well as university level indicators to signal the capacity to enable graduate ventures (e.g. grants and business competitions; HEIs seeding funding). At the regional level, the context-based support mechanisms indicator combines incubators, accelerators and venture capital investment attracted by the region. While controlling by other university and regional characteristics, this study employs a pooled negative binomial model to examine the relationship between graduate start-ups, the university ecosystem and the region support mechanisms.

4- Results

Results suggest that both university-level ecosystem and regional-level innovation characteristics affect dynamics of graduate start-up creation. Notably, once controlling how stronger entrepreneurial ecosystem affect start-ups creation (quadratic term), the result shows an inverted u-shaped relationship between university entrepreneurial ecosystem and graduate venture creation. This curvilinear relationship suggests that HEIs efforts to invest in graduate start-ups support structures have diminishing returns and might sort a negative effect on students’ intentions to start a business. In particular, while the initial accumulation of university entrepreneurial ecosystem positively stimulates perspective student entrepreneurs, stronger provisions of graduate entrepreneurship infrastructures will at first weaken and then reverse the likelihood to support student ventures. Regression models also suggest that although there is a positive sign in the interaction term between the university ecosystem and the regional support structures, this result is not significant. Based on these it is important to incentivize the creation of graduate ventures to consider the joint impact of different forms of support, i.e.: the combination of assets offered by universities and by regions.

5 - Policy and managerial implications

The findings in this study would lead to a better understanding of the mechanisms of knowledge spillovers that arise from graduate start-ups and the different levels – organisational and geographical - from which they arise. This study provides implications both for regional policy as well as university management and practice. While the positive impact that universities’ support mechanisms exert on graduates and the relevance of the university entrepreneurial ecosystem are acknowledged in the literature, careful designing of the university entrepreneurial ecosystem is needed both in the short and long term. A growing
number of studies suggests the importance of student-led entrepreneurship activities, extra-curricular activities, and experiential learning (Gianiodis and Meek, 2019) for the creation of graduate start-ups. However, universities need to recognise the value of external resources and connectivity at the regional level, for instance: the involvement of local entrepreneurial networks, mentoring and seed funding opportunities. Early results suggest that universities should carefully design their entrepreneurial support and training provisions, as overlapping entrepreneurship activities and organizational complexity can act as a deterrent and revert efforts to back students’ entrepreneurial efforts. Ultimately, a more granular understanding of the long-term effects of the university entrepreneurial ecosystem in relation to the regional innovation contexts is needed for better connect graduate entrepreneurship with innovation and entrepreneurship policies.

Selected References


