



**Universiteit
Leiden**
The Netherlands

Localization, regionalization and globalization of university-business research cooperation in the United Kingdom

Tijssen, R.J.W.; Klippe, W. van de; Yegros, A.

Citation

Tijssen, R. J. W., Klippe, W. van de, & Yegros, A. (2020). Localization, regionalization and globalization of university-business research cooperation in the United Kingdom. *Papers In Regional Science*, 99(5), 1215-1236.
doi:10.1111/pirs.12531

Version: Publisher's Version

License: [Creative Commons CC BY-NC-ND 4.0 license](#)

Downloaded from: <https://hdl.handle.net/1887/4256410>

Note: To cite this publication please use the final published version (if applicable).

FULL ARTICLE

Localization, regionalization and globalization of university-business research co-operation in the United Kingdom

Robert Tijssen^{1,2}  | Wouter van de Klippe¹ | Alfredo Yegros¹

¹Centre for Science & Technology Studies (CWTS), Leiden University, the Netherlands

²DST-NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP), Stellenbosch University, South Africa

Correspondence

Robert Tijssen, Centre for Science & Technology Studies (CWTS), Leiden University, the Netherlands.
Email: tijssen@cwts.leidenuniv.nl

Funding information

UK Economic and Social Research Council, and the Office for Students and Research England, Grant/Award Number: ES/M010082/1

Abstract

This empirical study analyzes university-business co-operation (UBC) from a distance-based perspective. Focusing on the UK's 48 largest research universities, we collected data from author affiliate addresses in 2008–2017 university-business research publications (UBRPs). The spatial proximity between university and its business partners listed in these co-authored research publications concerns three main distance zones: “local” (0–99 km); “regional” (100–499 km); “global” (500 km or more). The annual UBRP trends reveal a tendency towards UBC globalization. Several universities show signs of UBC glocalization, where the numbers of their global UBRPs have increased more rapidly than local UBRPs.

Four common factors largely determine the UBRP quantities, irrespective of the zone: business sector R&D-intensity in the university's local geographical area; university's research size; university's high-end international citation impact; presence of university researchers with work experience in the business sector.

KEYWORDS

bibliometrics, economic geography, research co-operation, researcher mobility, spatial proximity

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2020 The Authors. Papers in Regional Science published by John Wiley & Sons Ltd on behalf of Regional Science Association International



JEL CLASSIFICATION

O31; O32; R12

1 | INTRODUCTION

1.1 | University-business co-operation from a distance perspective

In the current era of rapid digitalization, where knowledge and human resources became more geographically distributed and universities more globally connected, many research-intensive universities are now also subjected to government pressures and stakeholder expectations to contribute more to local and regional socio-economic development (e.g., Clark, 1998; Mejlgaard & Ryan, 2017). This study addresses this issue from the perspective of *university-business interaction* (UBI), with a focus on *university-business co-operation* (UBC) and spatial proximity between a university and its collaborative partners in the business sector.

UBC patterns and trends reflect complex dynamic social systems. Relatively little is known about the effect of geographic distance on UBC between the UK's research universities and R&D-active firms. A study conducted by Laursen and colleagues explored the effect of geographical proximity from the perspective of 8,724 firms located in the UK (Laursen, Reichstein, & Salter, , 2011). Their findings indicate that firms' decisions to collaborate with local universities are influenced by both distance and the scientific quality of those universities. Physical co-location with top-tier universities promotes research co-operation, but if faced with the choice these UK firms, especially the R&D-intensive ones, appear to prefer quality over distance. In their study of UK-based firms, D'Este, Guy, and Iammarino (2013) examined the role of distance in the formation of university-business partnerships. Their results suggest that when these firms are located in spatially dense clusters of R&D-intensive industries they tend to establish connections with universities largely independently of the university's location. However, firms outside such clusters are more inclined to engage with local universities.

Although the UK university research system is an integral part of international and global R&D networks (Adams & Gurney, 2016), virtually nothing is known about research co-operation patterns with firms located abroad. Nor is there any systematic comparative information on UBC patterns from a (local) UK university perspective. This paper addresses these information gaps by describing patterns and trends across the UK's largest research-intensive universities where we introduce a distance-based distinction between localization, regionalization and globalization.

1.2 | Objectives of this study and research questions

This quantitative, empirical study builds on our exploratory analysis of those same universities (Tijssen, Yegros, & Lamers, 2017). In this second stage of our studies, we aimed to identify specific determinants or general factors that have contributed significantly to observed UBC data. By examining research co-operation linkages in some detail we unearth the role of distance on cross-sectoral research collaboration. Focusing on university research co-operation patterns and trends, it is unclear how interacting processes of localization, regionalization and/or globalization have impacted on universities, research co-operation patterns and university-business interactions. Guided by our overarching research question—"which common factors are major contributors to evolving preferences for UK universities for either local, regional and/or global research partners in the business sector?"—our empirical study examines two derivative questions: (i) is the geographical distance between the university and its industry partners a meaningful parameter of a university's UBC profile? (ii) If so, how distance-dependent are the major explanatory variables describing the way research-intensive universities are engaging with R&D-active firms?



Any quantitative empirical study that attempts to address these questions faces major methodological obstacles and analytical constraints—most importantly, the scarcity of high-quality comparative empirical information. In this study we rely to two data sources: UK statistics on UK-based universities and bibliographical information on research publications produced by those universities which is extracted from the *Web of Science*, an international database. Combining these sources enabled us to address UBC patterns and trends at the meso-level of individual research-intensive universities in the United Kingdom, but also to produce macro-level aggregate data on that segment of the UK university system. This is the first time such an analytical approach is adopted. Our findings offer new data and unique insights on UBC patterns and trends within that system.

Our research design distinguishes two measurable aspects of UBC data that are adequately captured information derived from the *Web of Science* database: (i) university-business research co-operation; and (ii) ‘cross-sectoral’ mobility of university researchers. The corresponding UBC information items are:

- *University-business research publications* (UBRPs), reflecting productive and successful research partnerships, where the organizational affiliations of participating researchers were extracted from the author address(es) in the joint research publication (section 4.1 provides more details about UBRPs);
- *University-business mobile researchers* (UBM-Rs), individuals who have (or had) one or more university affiliation as well as and one or more affiliations in the business sector in recent years, where *university-business/multiple affiliated researchers* (UB/MA-Rs) represent the subset of those who hold simultaneous appointments in academia and a business enterprise.

Each of these three information items enables large-scale quantitative analytical approaches. The latter two enabled us to pay special attention to the “human factor” of cross-sectoral research co-operation. Where the numbers of UBM-Rs and UB/MA-Rs are relatively small in UK universities, the quantities of UBCs are sufficient large for comprehensive, comparative analysis across the entire set of universities and UBC distance zones. In doing so, we assume that UBC-based data offers a fair representation of general patterns and trends with UBRPs.

The next section presents the theoretical and analytical framework of this study. Section 3 describes the information sources and measurement models for gathering comparative data within and across the 48 selected universities in the United Kingdom. We present and discuss our main findings in section 4, while section 5 concludes with our general observations and recommendations. These two sections aim at academics with a general interest in the study’s methodology and outcomes as well as those specifically involved in issues related to UK university governance and policy analysis.

2 | THEORETICAL AND ANALYTICAL FRAMEWORK

2.1 | What is “local,” “regional,” “global”?

There are different “place/space” methods of defining or delineating geographical areas. In the existing scholarly bodies of literature – either on regional studies, economic geography, innovation studies, or otherwise - the concepts “local” and “regional” are often ill-defined or used interchangeably. Statistical offices, like Eurostat, usually apply their NUTS classification system, which provides a three-layered hierarchical system of intra-national administrative territories throughout Europe. Alternatively, the OECD also applies a system of “functional urban areas,” based on such as commuter travel-to-work time, that reflect spatial behaviour of individuals or organizations in a geographic space. However, many empirical studies of UBC actually refrain from defining the university’s “local region.” A recent example is the report by the European University Association (EUA), “The role of universities in regional innovation ecosystems” (Reichert, 2019), that covers a series of case studies on the outreach and effects of European universities on their local/regional innovation system. Carefully avoiding such a definition within these case studies enables a less



place/space constrained description of “local” and/or “regional” connections which in turn might be more appropriate to address specific issues or perspectives that are not place-bound in any strict sense.

However, when detailed comparisons or precise information are required, it becomes imperative to be as accurate as possible about a region’s territory and its geographical boundaries (e.g., Spiezia, 2003). Implementing geographical specifications becomes inevitable. In some cases NUTS-based definitions are likely to misrepresent the geographic extent of a university’s outreach, especially in those cases where the university is located in a border region and is likely to generate knowledge spillover effects on the adjacent country (Kalapouti & Varsakelis, 2015).

Generally one could argue, from a geographical perspective, that “local” always refers to close distances while “regional” and “global” usually represent much longer distances. The vast majority of above-mentioned scholarly literature on UBI and UBC patterns does not apply mutually excluding definitions or other distinctions between these three spatial descriptors. The boundaries between the three are either non-specified or tend to be fuzzy, especially between “local” or “regional.” In contrast, this paper applies clear-cut distance-based boundaries between “local,” “regional” and “global” (Table 1 presents these three classes with a further division into six categories). The next subsection’s literature overview, on geographic proximity, therefore uses the term “local” to capture relatively short distances and “global” is applied for relatively long distances, thereby avoiding the more ambiguous concept “regional.”

2.2 | Geographic proximity between universities and firms

Large research-intensive universities tend to be major partners and contributors to industrial and economic development in their cities and local areas; both in terms of spending, producing high-quality graduates for local labour markets, as well as dedicated R&D relationships with local industry and science-based contributions to business-led innovations. Many case studies have examined the role of these (close) proximities and associated “knowledge spillover” effects (e.g., Arundel & Geuna, 2004; D’Este et al., 2013; Ponds, Van Oord, & Frenken, 2010). While the increase in importance of geographic proximity and the globalization of science has been amply established in the research literature (e.g., Waltman, Tijssen, & Van Eck, 2011), the various case studies on the spatial proximity between universities and firms engaged in collaborative linkages—each using different methods and measures—show a wide range of distances between R&D partners. The study by Autant-Bernard, Billand, and Massard (2012) mentions an average distance of 1,175 km; D’Este and Iammarino (2010) reports an average distance of 354 km; Giuliani and Arza (2009), who examined firms in the wine sectors of Chile and Italy, report distances of 169 km and 146 km respectively. Hewitt-Dundas and Roper (2011) found that about 50% of firms were collaborating with universities within 100 miles (161 km) range of their geographical location. Mansfield and Lee (1996) apply a 100 mile distance to distinguish “local” from “non local” firms in the USA. Studies by Acs, Anselin, and Varga (2002) show that positive innovation effects occur as far as 50 miles (80 km) distance from an urban area’s administrative boundaries.

As for long-distance “global” relationships, a university’s geographical outreach has become an area of concern in our day and age where higher education and science have become increasingly affected by the megatrends of

TABLE 1 Distance-based delineation of geographical zones

Distance zone	General description (tailored to UK geographical circumstances)
0–49 km	Local—very short distance (town, city, metropolitan area)
50–99 km	Local—short distance (broader urban agglomeration or rural area)
100–199 km	Regional—moderate distance (regional area or neighbouring countries)
200–499 km	Regional—long distance (broader regional area or neighbouring countries)
500–4,999 km	Global—very long distance (domestic area, neighbouring countries, Europe)
> 4,999 km	Global—ultra long distance (cross continental, worldwide)



internationalization and globalization in science (e.g., Ahmad, 2014). An increasing number of students and academic staff are now of international origin, while research partners and users are more likely to be located in other countries or continents. In this “flattened world” has become a dominant feature of both geographical “space/place” views and models of developments in science-innovation systems (e.g., Florida, 2005; Friedman, 2005; Ghemawat, 2011; OECD, 2010; Storper, 2000).

With regards to the globalization of science, research-intensive universities are among the most globalized institutions in many civic societies; the spatial distance between collaborators is steadily increasing. Results from a macro-level study, comprising all science worldwide, shows that the average distance between co-publishing research partners has grown fivefold since 1980 to some 1,300 km in 2009 (Waltman et al., 2011). A study of large R&D-intensive firms, involving co-authored publications with universities across the globe, found an average physical distance of 3,150 km in 2009 between pairs of co-authoring partners (Tijssen, Waltman, & Van Eck, 2011)—mostly a result of globalization processes in pharmaceutical R&D where partner networks involved in clinical trials often span several continents.

2.3 | Human resources, labour mobility and UBC

Unfolding UBC patterns requires a closer look at the “human factor,” which is often pivotal to creativity, ideation, scientific research and innovation. The human resource perspective is essential to understand the multidimensional nature of UBC patterns and its driving forces. The job mobility patterns of academics is one of those forces. Studies have shown that labour mobility of researchers correlates positively with higher productivity levels (e.g., Crespi, Geuna, & Nesta, 2007; Hoisl, 2007; Lenzi, 2009; Zucker, Darby, & Torero, 2002), where the prolific scientists tend to be more mobile than their colleagues and peers. Franzoni and colleagues (Franzoni, Scellato, & Stephan, 2012, 2014) produce empirical evidence that mobile and migrant researchers have a “mover’s advantage” over those who are non-mobile, in terms of higher propensities to establish international links and collaborate with co-authors across several countries.

As for university-industry mobility of academic researchers, while earlier research was framed within contributions to “science and technology human capital” development (Bozeman, Dietz, & Gaughan, 2001; Dietz & Bozeman, 2005), or university-industry co-operation (Rothaermel, Agung, & Jiang, 2007), more recent studies tend to focus on the role of mobility and prior employment in the private sector in university-industry relationships (Abreu & Grinevich, 2013; Bozeman, Fay, & Slade, 2013; Clarysse, Tartari, & Salter, 2011; Fernandez-Zubieta, Geuna, & Lawson, 2015; Gulbrandsen & Thune, 2017). Members of this heterogeneous group of boundary-spanning individuals are likely to be familiar with research practices in academic science as well as experienced in industrial R&D and able to appreciate business interests (Mangematin, O’Reilly, & Cunningham, 2014; Tijssen, 2018).

We may assume that cross-sectoral job mobility, and/or holding multiple affiliations simultaneously in academia and industry, not only enhances UBC levels but may also foster (further) development of industry-relevant knowledge and skills within universities. Academic researchers with business sector work experience are likely candidates to act as change agents within a university’s UBC profile. The industrial orientation and mindset of those who straddle the public and private domain may contribute to their developing more application-oriented research at universities, thus facilitating future interactions with industry as well contributing to scientific research and collaborations with industrial R&D partners. They may act as linchpins, boosting joint R&D and UBC, who can make the difference between success and failure in university-industry engagement and may help shape R&D commercialization processes later on.

An early study by Gulbrandsen and colleagues found that UBI activities are likely to be more common among academics who define their research profile as “applied” (Gulbrandsen & Smeby, 2005). In later years, a series micro-level UBI studies provided further information on characteristics of cross-sectoral researchers (D’Este & Fontana, 2007; D’Este & Perkmann, 2011; Gulbrandsen, Mowery, & Feldman, 2011; Perkmann et al., 2013). Inflow of industrial R&D staff to the university may vary from non-academic staff bringing “practitioner” corporate-



developed skills and experience into the university (for research and/or education) to prior academics (PhD student and postdocs) who have spent time in corporate R&D units. Some academics may switch between two sectors (once, or more regularly); others may have several part time positions simultaneously—either temporary or permanent. Although such (part time) external appointments of university staff are likely to be rare, they may signify relatively strong and institutionalized ties between academia and the R&D-active business sector (Yegros & Tijssen, 2014). At the level of professor, one would expect to find a concentration of multiple affiliations—where academics are part-time advisers or business consultants, or where senior corporate R&D staff hold part-time professorships.

2.4 | Studies in the United Kingdom

UBC output in the UK's R&D system is a relatively well-researched topic, especially in terms of business sector innovation (e.g., Laursen & Salter, 2004) or knowledge transfer from universities (e.g., Abramovsky, Harrison, & Simpson, 2007; Rosli & Rossi, 2016; Vick & Robertson, 2018). Results of these studies suggest that the engagement of universities in collaborative projects with the business sector, while remaining integrated in the academic scientific communities, constitute effective ways of knowledge transfer while creating network career structures at public/private R&D interfaces. Important contributing factors are the spatial proximity and co-location of universities and firms.

With regards to the human factor in UBI and UBC, a large UK survey among more than 20,000 respondents looked at their participation in different types of academic entrepreneurship (Abreu & Grinevich, 2013). The set of exploratory variables included previous work experience of each individual and prior employment in small firms or large firms. The results from this study showed that prior industrial work experience, particularly from small/newly established firms, is positively related to engagement in commercialization activities. Focusing on boundary-spanning academic researchers, studies carried out in the UK have emphasized the crucial role these "linked scientists" (Lam, 2011) play in connecting academic knowledge and know-how to a firm's internal R&D. Staff mobility within this university-industry interface contributes to creating an "overlapping internal labour market" (Lam, 2007) and supporting a "hybrid organizational space" (Lam, 2011) that are likely to have positive impact on research commercialization and academic entrepreneurship. Cross-sectoral labour mobility patterns depend on many variables, including the disciplinary background of academic staff and the socio-economic circumstances in the local region (Lawton Smith & Waters, 2011; Trippel, 2013).

Other UK surveys by Hughes and colleagues (Hughes, 2011; Hughes et al., 2010), and a more recent study by Guerrero, Cunningham, and Urbano (2015) indicate that socioeconomic impacts from UK universities are indeed significant.¹ A recent study of UK universities (Peacock, 2019), building on a database of 415 REF-based written impact case studies university-industry collaboration projects, identified the influence of partners' proximity on different types of impact; close-distance proximity was found to promote improvement in the partners' knowledge resources, whereas greater "organizational proximity" (i.e., similarity between the activities and objectives of partners) tends to improve their economic resources.

The strategic intent and ability to create such impacts is increasingly seen as a key performance measure of individuals, teams and organizations—as exemplified by micro-level impact stories within the UK's *Research Excellence Framework* (REF), and the objective of the proposed *Knowledge Exchange Framework* (KEF) to increase efficiency and effectiveness in the use of public funding for knowledge exchange activities at UK universities.²

¹These impacts include the research done by the non-selected "non-research intensive universities," part of which may include "applied research" or "application oriented research" that involves UBC but is not necessarily published in international scientific journals.

²Research England selected 21 English universities to take part in a pilot Knowledge Exchange Framework, which ran in the first half of 2019. The results of this pilot, and final decisions on how the KEF should progress in 2019–2020, have not yet been made public when this paper was finalized (November 2019). The UK higher education community is now also preparing for the 2021 edition of the Research Excellence Framework. The findings of the "Real Time REF Review Pilot Study," published in June 2019, indicate moderately negative academic attitudes toward a next REF (Weinstein, Wilsdon, Chubb, & Haddock, 2019).



3 | RESEARCH METHODOLOGY

3.1 | University-business co-operation data

Our UBRP-based approach derives its empirical information from research publications in scientific, scholarly and technical journals. In the “pre-competitive” stages of the R&D process, research results are still published in open scientific and technical literature where researchers, engineers and scientists also publish research findings that are (possibly) industrially relevant and may ultimately become economically useful. University researchers need to publish for career purposes and to share research outputs with colleagues and peers worldwide. As a consequence, many of their successful joint research projects, often including those involving active co-operation with corporate R&D staff, eventually lead to publications in journals, conference proceedings or other (printed or online) outlets. This includes PhD graduates who have moved to jobs in industry but still publish (temporarily) with both their old and new affiliate address (Roach & Sauermann, 2010).

UBRPs represent dedicated capabilities and inputs of the research partners, their ability to co-operate and share resources, and the effort and willingness to disseminate results to the scholarly community. Ponds et al. (2010) examined the relative importance of social proximity, as proxied by being partners in producing such co-authored research publications. One may further assume that the ability to produce large UBRP quantities reflects the research profile and attractiveness of specific universities as sources of research-based knowledge for R&D-intensive industries. The scale and scope of those UBC profiles, and the quality of that research (either “discovery oriented” or “applied”) makes difference. Being a large research-intensive university, with a notable reputation among firms, clearly with raises the likelihood to produce large numbers of UBRPs. Universities with an industry-aligned research specialization profile have a much higher chance of successfully engaging with the business sector. Since business partners will engage in joint research with academics if they are sufficiently convinced of their research capabilities—in terms of quality, potential utilization value, and (cost) effectiveness—UBRPs therefore also partially reflect the degree in which universities are able to comply with quality standards and specifications imposed by industrial R&D.

On the business sector side, UBRPs in general tend to arise from co-operation with large, R&D-intensive firms in industrial or manufacturing sectors, or local science-based spin-off or start-up companies in a local science park. UBRPs are also more likely to occur when universities co-operate with larger firms (and less so with small and medium-sized firms); the data therefore are biased in favour of successful science-based co-operation with large R&D-intensive firms. Some UBRPs represent “one-off” small-scale interactions, while others relate to large-scale R&D efforts in longstanding international consortia; some of those joint publications are co-authored with one or more colleagues in the business sector, others may carry multiple affiliate addresses of the author.

Overall, UBRPs in particular present a wealth of relatively easy-accessible empirical information on collaboration patterns and trends between universities and businesses worldwide. The abovementioned studies of UBC in the UK, suggest that UBRP volumes and patterns are likely to be affected by spatial proximity between firms and universities; the closer the distance, the larger the likelihood of generating UBRPs.

3.2 | Information sources, measurement and university selection

Examining UBC patterns and trends from a UBRP perspective, we focus our investigation on research publication outputs. Using the affiliate address information from those publications opens up possibilities for designing metrics and associated indicators that enable large-scale, quantitative “bibliometric” measurement of UBC patterns and trends (Lundberg, Tomson, Lundkvist, & Brommels, 2006; Tijssen et al., 2011; Tijssen, Van Leeuwen, & Van Wijk, 2009). We extracted those publications from our in-house version of Clarivate's *Web of Science Core Collection* (WoS) database (more specifically, the SCI, SSCI and ACHI indexes within this database). Extracting information from



this source implies that our analytical framework is not only biased towards knowledge creation, but also “successful science” of the kind that was accepted by peers for publication in the WoS-indexed international scholarly and scientific journal literature.

From the publication year 2008 onwards, the WoS includes the direct link between the author and his/her corresponding affiliation(s). Based on this information, and our own classification of affiliations in universities or industry, we are able to identify the mobility of academic researchers across these two institutional sectors. We use an in-house author-identification algorithm (Caron & Van Eck, 2014) that identifies the set of publications produced by the same individual researcher, regardless of the different name variants used in the author's publications. The business sector is defined as those author affiliate addresses that refer to for-profit business enterprises, with the exception of those in the medical and health sector (Tijssen, 2011).

The major advantage of UBRP-based metrics is its relatively large volume that allows for large-scale comparisons at the macro level of individual universities but also for micro-level of individual researchers. UBRP counts provide statistical data for comparisons between universities. UBM-Rs and UB/MA-Rs occur much less frequently in research publications, and may suffer from inaccuracy or incompleteness, which renders this source too volatile as a key performance indicator for comprehensive studies. We track down UB/MA-Rs from the author address affiliations in UBRPs. For each author we identify the organization(s) to which they are or have been affiliated to in the pre-specified period of time (Yegros & Tijssen, 2014). Some UBM-Rs may also feature in UBRPs (as UB/MA-Rs or otherwise), but may also publish under their separate, consecutive affiliations—either the university or their (prior) business enterprise address. The number of UB/MA-Rs and UBM-Rs at the university is therefore related to UBRP counts.

UBRP frequencies are often size-dependent: large research-intensive universities tend to produce many UBRPs. When correcting for the size of the university, that is, the total research publication output, the share of UBRPs within that total output enables meaningful comparisons across universities. A single UBRP may include more than one university and more than one industrial partner. In these cases we have assigned a complete publication to each of the involved organizations. In the UBRP counting scheme, the frequency counts refer to the quantity of pairwise interactions that each university has had with businesses as represented through university-business co-authored publications. Multiple counting will occur when there are multitude of business sector affiliations are mentioned in the author addresses on the same UCB publication. As a result, a UBRP can be assigned to several distance-categories simultaneously if the author addresses mentions two or more firms based at different geographical locations. Calculating the geographic distance between a university and each of the co-authoring business enterprises, is done by means of geo-coding and subsequent classification of companies according to their physical location (local branches of multinationals are considered a “local firm”).

Applying a distance metric to pairs of author addresses in UBRPs – where one address refers to the affiliated university and the other address to a firm – spans a statistical distribution of observed distances and the number of occurrences of each distance. For analytical purposes, this UBRP “distance density” distribution was reduced to a small set of mutually-exclusive zones, each demarcated by a lower and upper distance. Such a distance-based metric enables a tailored system that can operate independently of geographical borders and offering an exhaustive range of geographic zones—from a ultra-short distance “local zone,” marked by co-locations of universities and firm, to an ultra-long distance “global zone” where partners could be located on different continents. Table 1 presents the set of kilometre-based zones we applied in the UK case study. The distinctions between “local,” “regional” and “global” zones are mainly designed to accommodate geographic size of the United Kingdom and its distance to overseas neighbouring countries and the European continent.

The UBC study concerns a broad selection of the UK's largest research universities, each one characterized by its own unique organization profile (mission and goals, available resources, research specialization profile, etc.). Their motives and opportunities for engaging in UBI and UBC will differ, driven by university-specific external determinants and affected by general framework conditions (geographical, cultural, political, economic or infrastructural). Table A1 of the Appendix presents the list of the selected universities. Several of these universities have a long history of successful R&D partnerships with industry.



Drawing its information from the Web of Science and three other sources, this study has assembled a wide range of university performance indicators and background variables. Table 2 has grouped those into four broad categories: “Local/regional R&D environment” “Business sector income streams”; “Research”; “Technological development, entrepreneurship and innovation.” Although several other indicators and variables exist (usually of lesser quality) we assume that this selection is adequate to help identify common factors underlying UBI patterns and trends. The distinction between small and medium-sized enterprises (SMEs) and other (large) firms enables a closer look at relationships between a firm's size and the propensity or ability to interact and co-operate with universities. The variable “Top 10% highly cited publications” is meant to reflect a university's international scholarly impact and visibility.

4 | CASE STUDY OF RESEARCH UNIVERSITIES IN THE UNITED KINGDOM

4.1 | General patterns

We apply our methodology and data analysis to UK-based universities selected from the 2017 edition of the *Leiden Ranking* (www.leidenranking.com). These 48 universities are the UK's largest in terms of WoS-indexed research publication output in international peer-reviewed journals. Collectively they account for the large majority of UBRPs originating from the UK science base. Across the 10-years period of our study (2008–2017), each of the 48 universities produced an average of 1,664 UBRPs, 181 publications list an UBM-R and 81 publications with at least one UB/MA-R. The UBRP output represents an average 7.6% of all research publication output per university, UBM-Rs occur in 2.0% of all publications, and 0.4% of the total output contained at least one UB/MA-R. Table A1 in the Appendix provides an overview of these three UBC statistics per university, revealing large differences in UBC profiles. For instance, the 13% share of UBRPs in the total publication output of Imperial College London (ICL) is significantly higher than the 1.6% at the London School of Economics and Political Science (LSE). Clearly, the type of university is one of the important determinants of such differences: ICL is a comprehensive university with many science departments, whereas LSE specializes in the social and behavioural sciences.

In addition to a university's research specialization profile, several other determinants should be taken into consideration to explain UBC patterns and trends—notably the scale of research capabilities and activities, strategic priorities and UBC dedicated resources, and the level of R&D expenditures by the local or regional business sector. Table 3 presents descriptive statistics of each indicator and variable according to the measurement units presented in Table 2.

To what degree can these selected indicators and variables explain the distribution of UBRPs across the various distance zones? Addressing the issue, we conducted a regression analysis for each of the separate UBC distance zones mentioned in Table 1. Because the distribution of UBC quantities across the 48 universities shows right-skewed Poisson distributions, that is, where the level of statistical variance exceeds the value of mean, we applied a negative binomial model. We selected “interaction effects” to define the model parameters, rather than the “main effects” option, where the effect of each variable on UCB outputs is examined independently of the other variables. The overall fit of the regression model and the effects of each variable are presented in Table 4.

Although direct causal relationships cannot be attributed to these aggregate-level model-based findings, five general observations emerge from this table that help to describe UBRP patterns in terms of spatial proximities:

- the local area's level of business sector R&D appears to be a major common factor, which is surprisingly independent of the geographic distance to research partner firms. This outcome strongly suggests that the local/regional R&D system in the UK, and its UBI environment, constitutes an important framework condition for UK universities to successfully co-operate with firms anywhere worldwide;

**TABLE 2** Overview of quantitative information on universities

Performance indicators and variables	Data source (reference year) ^a	Unit of measurement
University-business co-operation		
University-business research publications	Web of Science (2016–2017)	Frequency counts
UBM researchers	Web of Science (2016–2017)	Frequency counts
UB/MA researchers	Web of Science (2016–2017)	Frequency counts
Local/regional R&D environment		
Regional business R&D expenditure ^b	UK Office Nat. Statistics (2016)	£ million, 2016
Business sector income streams		
Business sector funding—total	ETER (2014)	Local currency (PPP)
IP revenues—total	HE-BCI (2014/2015)	£ million, 2016
Contract research—SMEs	HE-BCI (2014/2015)	£ million, 2016
Contract research—other (large) firms	HE-BCI (2014/2015)	£ million, 2016
Consultancy—SMEs	HE-BCI (2014/2015)	£ million, 2016
Consultancy—other (large) firms	HE-BCI (2014/2015)	£ million, 2016
Research		
Research publication output—total	Web of Science (2013–2017)	Frequency counts
Research publication output—medical	Web of Science (2013–2017)	Frequency counts
Research publication output—STEM fields	Web of Science (2013–2017)	Frequency counts
Top 10% highly cited publications	Web of Science (2013–2017)	Frequency counts
Technological development, entrepreneurship and innovation		
Inventions—disclosures	HE-BCI (2014/2015)	Frequency counts
Inventions—new applications	HE-BCI (2014/2015)	Frequency counts
Inventions—new patents	HE-BCI (2014/2015)	Frequency counts
Spin-off and start-up firms—new	HE-BCI (2014/2015)	Frequency counts
Spin-off and start-up firms—still active	HE-BCI (2014/2015)	Frequency counts

Notes:

^aData sources: HE-BCI database (www.hesa.ac.uk); European Tertiary Education Register (www.eter-project.com); UK Office of National Statistics database (www.ons.gov.uk).

^bBusiness sector R&D expenditure in the NUTS1 region of the university's location.

- a university's orientation on the business sector, as reflected by the various income streams from that sector, seems distance-dependent. While the two generic streams of revenues (either “total funding level” or “total IP revenues”) fail to provide any added explanatory value across the entire range of distances, the breakdown by type of income stream and size of partner firms are a significant factor: consultancy contracts with SMEs are a particularly important explanatory factor of ultra-short distance UBRPs; contracts with larger companies help explain the numbers or UBRPs with business partners across many of the distance zones;
- individual connections and affiliations of a university's researchers are a major explanatory factor, especially with regards to local and regional UCB in zones up to 500 km. Multiple affiliation researchers (UB/MA-Rs) are important in closer distance relationships up to 100 km. Mobile researchers (UMB-Rs) seem to be of significance in all zones between 50 and 400 km, albeit of declining relevance as the physical distance to partner firms increases;
- a university's research size, in terms of total publication output, is important in most distance zones, as is its level of research quality (proxied by highly cited research publications). The disciplinary specialization profiles also



TABLE 3 Descriptive statistics of UBC indicators and background variables

	Mean (measurement units)	Standard deviation (measurement units)
University-business co-operation		
UBRPs—0-49 km zone	44	67
UBRPs—50-99 km zone	28	40
UBRPs—100-199 km zone	36	43
UBRPs—200-499 km zone	66	68
UCRPs—500-4,999 km zone	138	134
UCRPs—beyond 4,999 km zone	169	187
UBM-researchers	61	80
UB/MA-researchers	33	39
Local/regional R&D environment		
Regional business sector R&D expenditure	2,304	1,562
Business sector income streams		
Business sector funding—total	30,863,848	48,011,939
IP revenues—total	2,589	6,338
Contract research—SMEs	8,493	11,510
Contract research—other (large) firms	841	1,092
Consultancy—SMEs	859	1807
Consultancy—other (large) firms	1,674	2021
Research		
Research publication output—total	5,230	4,607
Research publication output—medical fields	3,797	4,254
Research publication output—STEM fields	4,205	3,511
Top 10% highly cited publications	1,627	1,667
Technological development, entrepreneurship and innovation		
Inventions—disclosures	74	90
Inventions—new applications	40	46
Inventions—new patents	18	29
Spin-off and start-up firms—new	3	3
Spin-off and start-up firms—still active	22	18

- makes a difference: the degree of specialization—either medical sciences, and/or STEM (Science, Technology, Engineering and Mathematics) fields—is a major explanatory factor of UBRP counts with foreign firms located at distance of 500 km or more; and
- university performance in the area of “technological development, entrepreneurship and innovation” provides some relevant information on explanatory factors. The presence of longer distance UBRPs (with corporate research partners located a more than 200 km from the university) correlates with a university's ability to create spin-off and start-up firms, especially those firms with a high survival rate. Both phenomena refer to a strong, industry-oriented research base at the university. The above-mentioned specialization in the medical sciences and/or STEM increases the probabilities of generating spin-off and start-up firms. As for short-distance UBRPs (less than 50 km distance), new applications of inventions seems to be relevant, which could refer to those new local firms but a convincing explanation for this outcome requires further (case study) research.

**TABLE 4** Negative binomial estimation of UBRP outputs (2016–2017)

	Dependent variable: UBRP output per distance zone					
	0–49 km	50–99 km	100–199 km	200–499 km	500–4,999 km	> 4,999 km
University-business co-operation						
UBM-researchers	2.07	2.38*	2.50*	2.67*	0.85	3.23*
UB/MA-researchers	2.51*	2.35*	1.39	0.00	1.04	0.00
Local/regional R&D environment						
Regional business sector R&D expenditure	9.95**	26.14**	15.52**	11.73**	28.30**	29.70**
Business sector income streams						
Business sector funding—total	1.44	0.08	0.04	2.23	1.53	2.20
IP revenues—total	0.10	1.46	0.11	2.19	1.05	0.85
Contract research—SMEs	1.48	0.00	0.11	0.01	3.08*	0.87
Contract research—other (large) firms	2.07	0.01	0.69	2.72*	0.06	2.69
Consultancy—SMEs	2.84*	0.22	0.11	2.38	0.06	0.88
Consultancy—other (large) firms	4.60**	0.03	2.76*	2.37	2.19	4.09*
Research						
Research publication output—total	5.15**	1.21	4.96*	3.74**	1.53	3.07*
Research publication output—medical	0.05	1.13	0.65	2.60*	10.35**	11.71**
Research publication output—STEM	0.30	0.07	0.65	1.73	3.80**	4.61**
Top 10% highly cited publications	1.51	2.60*	5.46*	3.41*	4.45**	6.99**
Technological development, entrepreneurship and innovation						
Inventions—disclosures	0.86	0.03	0.28	0.21	3.96**	1.00
Inventions—new applications	2.88*	0.13	1.45	0.91	0.68	0.25
Inventions—new patents	0.20	0.00	0.01	0.09	4.01**	1.46
Spin-off and start-up firms—new	1.05	0.24	1.46	2.42	4.68**	6.22**
Spin-off and start-up firms—still active	0.74	0.39	0.69	15.44**	30.83**	20.07**
Goodness of fit measures						
Log Likelihood	–198.9	–182.70	–196.11	–250.67	–291.31	–296.27
Akaike's Information Criterion	433.7	401.40	428.21	537.34	618.62	628.55

Notes:

** $p \leq 0.05$;* $p \leq 0.10$.

(Type I interaction effects)

Statistical analysis was conducted with “Generalized Linear Models” module of the “IBM SPSS statistical analysis 25” package.



Summarizing, the collective UBC profile of these 48 universities is, not surprisingly, affected by different distance-dependent configurations of internal and external determinants. Overall, we find four common “structural” factors that seem to largely determine UBRP quantities irrespective of distance zones: business sector R&D-intensity in the university’s local geographical area; university’s research size; university’s high-end international citation impact; presence of university researchers with work experience in the business sector. The latter highlights the importance of such cross-sector researchers in the UK science system.

4.2 | General trends in the UK university system

How have UBRP growth patterns evolved in recent years. Is this publication output localizing, globalizing or glocalizing? Figure 1 exhibits the annual trends in the relative number of UBRPs in the period 2008–2017. The four “local” zones show a declining share in the total number of these publications. The three most localized universities are the LSE, University of Cambridge and City University London, where more than 20% of their UBRPs involve business sector partners located within a 50 km zone. Extending the range to 100 km increases that share to 30% or more. Owing to urban agglomeration effects, most of the London-based universities typically have a 15% share of partners within the 0–49 km zone, and another 20% within the 50–99 km zone. What these three most localized universities have in common is the relative high density of R&D-active companies in their spatial surroundings. University of Glasgow is the least localized university—only 16% of its UBRPs involve business sector research partners within 500 km. Low shares are also found at other “geographically peripheral” universities: University of Edinburgh, University of Dundee and Queen’s University Belfast, all of which located at comparatively large distances from R&D-active firms in the Greater London area or the UK industrial heartland. The UBRP profiles of the London-based universities illustrate the comparative advantages of being located in a country’s capital city—in the vicinity of many firms, but also benefitting from clustering effects of its science parks, technology centres or innovation hubs (Minguillo, Tijssen, & Thelwall, 2015).

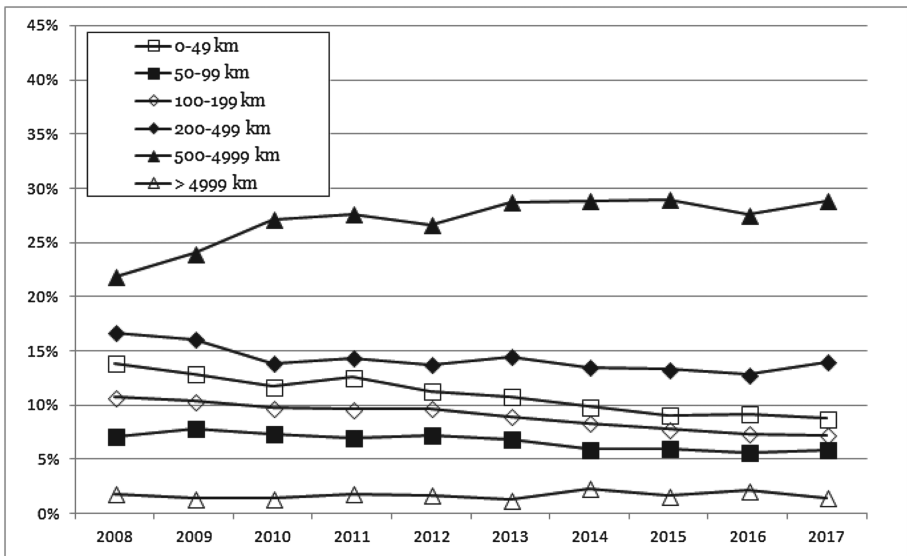


FIGURE 1 Annual trends in UBRP shares by distance zone (% of total UBRP output; total of the 48 universities)
Note: The UBRP data include multiple counts of publications corresponding to the number of firms mentioned in a publication’s author addresses and whether or not those firms are located in different geographic areas



Close distance to high-tech industrial hot spots outside the metropolitan area may also strongly affect UBRP patterns, such as in the case of University of Cambridge. In the case of the much smaller Cambridge area, the degree of localization emphasizes the “knowledge and innovation hub” dimension of the local university that attracts and generates such companies. London’s physical infrastructure is far less well-developed than in the Cambridge area (or Oxford): the science parks near or in the capital are a few biotech incubators (e.g., at Royal Vets and Queen Mary University), while Imperial College London’s new campus, at White City, is of relatively recent date.

The share of UBRPs in the ultra-long distance zone (> 4,999 km) remained stable, but at a very low level. The UBRP growth during these 10 years occurred mainly within the 500–4,999 km zone. Undoubtedly this significant trend was partly driven by EU-funded research programmes, notably by the large framework programmes that are specifically meant to support and foster international co-operation within the European Union. Part of those programmes concern university-industry consortia with partners across Europe, producing UBRPs that involve UK universities and firms located on the continent.

Overall, the absolute scale of UBRP publication output has increased by 79% between 2008 and 2017 (overall CAGR = 9%). Various determinants may have contributed to this increase, such as the expansion of journal coverage of our bibliographic database (*Web of Science*), but also a growing number of WoS-indexed publications from these 48 universities that contain an author address referring to a business enterprise.

Figure 2 displays the annual trend in UBRP output volumes, showing a sizeable amount of the research publications and an 8.4% annual increase overall. The CAGR differs per distance zone: 3.3% (0–49 km); 6.4% (50–99 km); 4.0% (100–199 km); 6.5%; 12.1% (500–4,999 km); 13.3% (>4,999 km). These growth rates indicate that UBRP output at these UK universities is simultaneously localizing, regionalizing and globalizing, but above all it reflects a process of “Europeanizing”—the share of the 500–4,999 zone (partners located mainly in continental Europe) in the total UBRP output has gradually increased from 27.6% in 2008 to 37.2% in 2017.

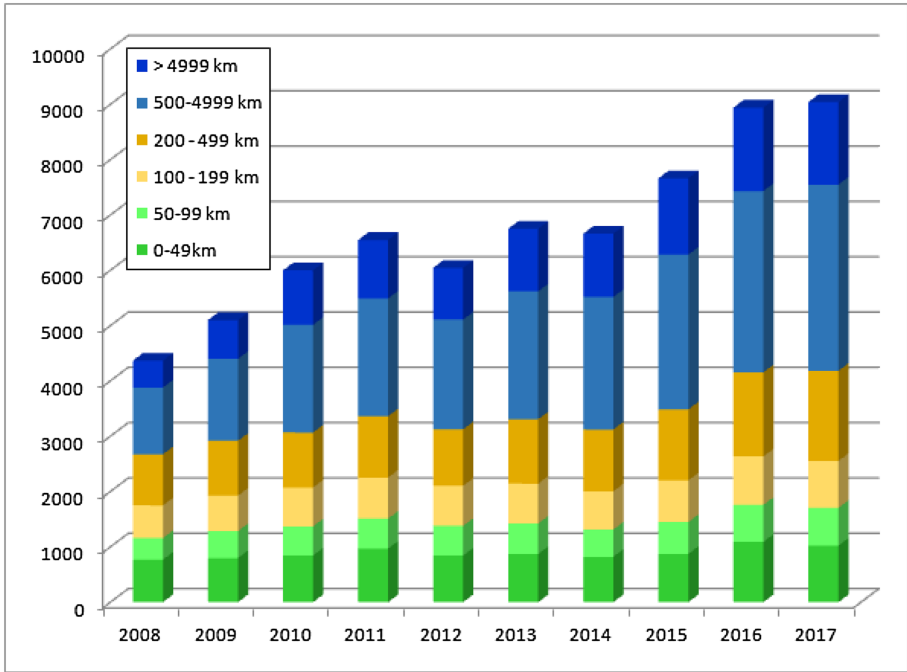


FIGURE 2 UBRP output growth by distance zoneNote: The UBRP data includes cases of multiple counting of publications, either because of multiple firms mentioned in a publication’s author addresses and/or firms are located in different distance zones



4.3 | Determinants of UBRP output trends

To identify and examine common factors behind the observed growth patterns, each of the 48 universities were assigned to one of four categories based on their observed CAGR profiles across the three zones:

- 1 “UBRP localization/regionalization” (2008–2017 CAGR values of >5% in the local and/or regional distance zone, and less than 10% growth in the global zone);
- 2 “UBRP globalization” (2008–2017 CAGR values in the global zone of at least 10%, and less than 5% in the local and/or regional zone);
- 3 “UBRP glocalization” (more than 5% growth in the local and/or regional zone, and more than 10% in the global zone);
- 4 “other” (variety of “no growth” or “low growth” patterns); and
- 5 the breakdown across the universities is as follows: “localization/regionalization” (9 universities); “globalization” (9 universities); “glocalization” (20 universities); “other” (10 universities).

We applied discriminant analysis to assess which common factors may determine a university's membership of either category. Seven predictor variables were selected from the regression analysis, those with the highest degree of significance across the distance zones: UBM-researchers; regional business sector R&D expenditure; consultancy—other (large) firms; Research publication output—total; publication output—medical fields; Top 10% highly cited publications; spin-off and start-up firms—still active. In view of the observed major importance of the local external R&D environment on UBRP patterns (captured by regional business sector R&D expenditure), we added one variable referring to whether the local area contains a university science/technology park.

The discriminant model is composed of three discriminant functions, each based on linear combinations of those predictor variables that provide the best discrimination between these four groups. The canonical loading of each variable represents the correlation coefficient between the observed variables and the unobserved discriminant function. Wilk's lambda is used as a test of statistical significance of the canonical correlation coefficient. Table 5 presents the main results of the discriminant analysis, for the first two functions only. The model's fit to data is reasonable as far as the first function is concerned, which sufficiently discriminates between the groups (chi-square statistical significance = 0.14). The associated category centroids (group means) present a reference to interpret the canonical loadings of the variables on this first function. The predictor variables most strongly associated with localization or regionalization (i.e., those variables with negative discriminant function scores) are: total research output, and researchers with affiliations in the business sector (UBM-Rs); and international citation impact. In other words, the recent growth in localization or regionalization tends to occur at UK universities that fit this profile. In contrast, globalization and glocalization tends to be associated with positive function scores on the variables: “Publication output—medical fields,” “University science/technology park” and “Spin-off and start-up firms—still active.” These are typically the universities with medical faculties and teaching hospitals with associated research commercialization activities and academic business infrastructures.

5 | GENERAL OBSERVATIONS AND CONCLUDING REMARKS

University-business interactions are part of complex multi-layered dynamic social systems. The international body of scholarly literature identifies a wide range of (interacting) UBI determinants, among which the R&D environment, the nature of proximities between research partners, and the effectiveness of those connections. In this empirical study we applied a quantitative indicator-based mapping of UBC patterns in the United Kingdom. It taps into a rich source of comparative empirical information on the UK's research-intensive university sector, especially with regards to research co-operation patterns and cross-sectoral mobility of academic



TABLE 5 Results of discriminant analysis: canonical loadings (sorted in ascending order on the first function)

Predictor variables	Discriminant function 1 Canonical loadings	Discriminant function 2 Canonical loadings
Research publication output—total	−2.99	0.23
UBM-researchers	−1.10	0.26
Top 10% highly cited publications	−0.87	−0.69
Consultancy—other (large) firms	0.38	−0.10
Regional business sector R&D expenditure	0.49	0.03
University science/technology park (0—no; 1—yes)	0.60	−0.35
Spin-off and start-up firms—still active	1.17	−0.33
Publication output—medical fields	3.93	1.34
Group centroids		
1. UBRP localization or regionalization	−1.34	0.24
2. UBRP globalization	0.48	−0.67
3. UBRP glocalization	0.59	0.37
4. Other UBRP trends	−0.41	−0.35
Goodness of fit measures		
Eigenvalue	0.61	0.19
Canonical correlation	0.62	0.40
Wilks' Lambda	0.47	0.75
Chi-square	31.4 (df = 24; sign. = 0.14)	11.8 (df = 14; sign. = 0.63)

Note: "Discriminant Analysis" tool from the "IBM SPSS Statistics 25" software package; using the "enter independents together" selection method.

researchers. We focused our attention on a selection of 48 research-intensive universities, their joint research publications with the business sector, and the dispersion of partner firms across distance-based geographical zones in the UK and abroad.

The geographical location and spatial distribution of those firms presents a new perspective on UBC patterns, and addresses an information gap in UK government statistics or university administration data on research co-operation with the local or regional business sector. In addressing these knowledge gaps and analytical challenges, the collected data from UBRP measurement approach provides some interesting new insights into aggregate-level UBC information across the UK's largest research-intensive universities.

We focused our study on two research questions, stated in subsection 1.2: (i) is the geographical distance between the university and its industry partners a meaningful parameter of a university's UBC profile? (ii) If so, how distance-dependent are the major explanatory variables describing the way research-intensive universities are engaging with R&D-active firms? Concerning the first research question, we find that the number of UBRPs has increased across all distance zones. However, long-distance "global" UBRPs has increased at a significantly higher rate than short-distance "local" UBRPs. Several universities exhibit a "glocalizing" pattern, where UBRP growth occurs across the entire range of distances. At other "globalizing" universities the growth occurs almost entirely in the long distance zones. Focusing on the subsample of universities with significant growth rates in either glocalization or globalization, we find that the glocalization rate is higher at "catching up" universities that have low levels of local UBRPs and are located in areas with relatively low levels of business sector R&D intensity.



Regarding the second question, our macro-level findings highlight a multitude of determinants that seem to be affecting UBRP patterns, where each distance zones presents a different set of determinants. Nonetheless, four common “structural” factors emerge (see subsection 5.1), which are significant in the majority of the distance zones and are like to be major drivers of UBC activity. The business sector R&D expenditure in the region represents a very significant external factor. Not surprisingly, we find evidence of spatial concentration effects in the London metropolitan area and in other R&D-intensive areas. Two of other factors—the research volume of a university and its citation impact level—reflect research-related organizational determinants such as critical mass, economies of scale, and scientific quality. The fourth factor captures the importance of the “human factor” as a UBC and UBI determinant, with empirical evidence that local UBRPs are more likely to involve boundary-spanning academic researchers. The share of these “cross-sectoral” researchers—either “university-business mobile researchers” (UBM-Rs) and/or “university-business/multiple affiliated researchers” (UB/MA-Rs)—is consistently among the most discriminating variables to explain the propensity of universities to collaborate with firms located at close distance. Given the strong positive relationships that tend to exist between social proximity, cognitive proximity and spatial proximity (Boschma, 2005), this outcome suggests that these individuals are an important driving force, if not an indispensable “success factor” for create sustainable R&D-related university-business interactions within the UK. There is still insufficient understanding of how knowledge is actually shared or transferred between individuals—either within the same local geographical area or further afield.

More in general, our UBC model critically hinges on the assumption that its three key performance indicators (UBRPs, UBM-Rs, and UB/MA-Rs) are sufficiently valid proxies of general patterns and trends as regards to university-business co-operation. The model's focus on research clearly introduces an observation bias: all three key performance indicators (KPIs) are related to research publication output, more specifically successful research (otherwise the work would not be published). Moreover, publication output quantities do not reflect essential information on inputs (such as the amount of industry funding of academic research, or highly qualified graduate students moving into industry), the effectiveness of knowledge creation processes, nor how productive interactions with the business sector actually were. For example, work by Faggian and McCann (2009) shows that the quality of UK universities, via the flows of their highest quality graduates, are found to be of limited importance for regional innovation performance in the university's local region but these graduates do have significant impacts on the innovation performance in other UK regions.

Hence, these KPIs—and the UBRPs in particular—present a limited window of analysis that tends to over-emphasize successful research co-operation and associated productive interactions in terms of researcher mobility, joint knowledge creation or exchange. Moreover, our UBC analysis does not include a clear-cut distinction by type of university, notably between “comprehensive” or “specialized,” in terms of their research activity profile. Although the variables “Publication output—medical fields” and “Publication output—STEM fields” partially capture this profile, a more explicit and fine-grained distinction deserves more attention in follow-up studies to ascertain possible effects of (changes in) research specialization on UBRP patterns and trends.

Given the growing importance of UBI and UBC as knowledge-intensive inputs into UK business sector R&D—witness the development of the Knowledge Exchange Framework (KEF) as a proposed new policy tool and information platform—more effort should be invested into developing new analytical methods and performance indicators for studying UBI, UBC and UBRP patterns and trends. One of the proposed activities, KEF Metrics, aims to provide “timely data that describes and compares institutional-level performance in knowledge exchange” (<https://re.ukri.org/knowledge-exchange/knowledge-exchange-framework/>). Between March and May 2019, 21 universities, participated in a pilot exercise to further test on how to operate KEF in England. Should KEF become operational, the three UBC performance indicators may open up new avenues for further empirical enquiry of the UK science system, especially concerning university knowledge transfer to the business section. UBI and UCB data may also be of interest in the next edition of the *Research Excellence Framework* (www.ref.ac.uk/about/what-is-the-ref/) either in terms of contributing to performance indicators, or as elements within



impact stories that academic researchers will be required to produce. UBC-related data could also supplement university-level statistical information from the Higher Education-Business and Community Interaction survey, which may help address policy-relevant information gaps, notably on the effects and effectiveness of government policies to promote UBI within the UK.

Finally, a concluding remark regarding Brexit. Although our data only run up to 2017, the large volume of UBRPs in the most recent years provides compelling information on the size of the intersection between UK academia and their corporate partners on the continent (Tijssen & Yegros, 2017). According to our data, hundreds of researchers were, and probably still are, straddling and moving between UK universities and the business sector elsewhere in Europe. This connectivity space of mutual trust relationships, common understanding and shared goals spans many personal ties and associated R&D networks. It represents several decades' worth of UK investment in valuable human capital and vulnerable social capital. Leaving the EU could seriously damage the UK's UBI infrastructures if those connections are severed.

ACKNOWLEDGEMENTS

This research project was supported by a UK government grant to the Centre for Global Higher Education (CHGE) through the Economic and Social Research Council, the Office for Students and Research England (grant reference ES/M010082/1). The authors are grateful for the helpful comments and suggestions made by this paper's reviewers.

ORCID

Robert Tijssen  <https://orcid.org/0000-0001-5237-9583>

REFERENCES

- Abramovsky, L., Harrison, R., & Simpson, H. (2007). University research and the location of business R&D. *Economic Journal*, 117, C114–C141.
- Abreu, M., & Grinevich, V. (2013). The nature of academic entrepreneurship in the UK: Widening the focus on entrepreneurial activities. *Research Policy*, 42, 408–422.
- Acs, Z., Anselin, L., & Varga, A. (2002). Patents and innovation counts as measures of regional production of new knowledge. *Research Policy*, 31, 1069–1085.
- Adams, J., & Gurney, K. (2016). *The implications of international research: Collaboration for UK universities*. London: Digital Science.
- Ahmad, A. (2014). Globalization of science and technology through research and development. *Open Journal of Social Sciences*, 2, 283–287.
- Arundel, A., & Geuna, A. (2004). Proximity and the use of public science by innovative European firms. *Economics of Innovation and New Technology*, 13, 559–580.
- Autant-Bernard, C., Billand, P., & Massard, N. (2012). Innovation and Space—from externalities to networks. In C. Karlsson, B. Johansson, & R. Stough (Eds.), *The regional economics of knowledge and talent*. Cheltenham: Edward Elgar Publishers. 10.4337/9781781953549.00009
- Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional Studies*, 39, 61–74.
- Bozeman, B., Dietz, J., & Gaughan, M. (2001). Scientific and human capital: An alternative model for research evaluation. *International Journal of Technology Management*, 22, 716–740.
- Bozeman, B., Fay, D., & Slade, C. (2013). Research collaboration in universities and academic entrepreneurship: The state-of-the-art. *Journal of Technology Transfer*, 38, 1–67.
- Caron, E., & Van Eck, N. J. (2014). Large scale author name disambiguation using rule-based scoring and clustering. In E. Noyons (Ed.), *Proceedings of the 19th International Conference on Science and Technology Indicators* (pp. 79–86). Leiden: CWTS-Leiden University.
- Clark, B. (1998). *Creating entrepreneurial universities: Organizational pathways of transformation: Issues in higher education*. Oxford: Pergamon Press.
- Clarysse, B., Tartari, V., & Salter, A. (2011). The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. *Research Policy*, 40, 1084–1093.
- Crespi, G., Geuna, A., & Nesta, L. (2007). The mobility of university inventors in Europe. *Journal of Technology Transfer*, 32, 195–215.



- D'Este, P., & Fontana, R. (2007). What drives the emergence of entrepreneurial academics? A study on collaborative research partnerships in the UK. *Research Evaluation*, 16, 257–270.
- D'Este, P., & Iammarino, S. (2010). The spatial profile of university-business research partnerships. *Papers in Regional Science*, 89, 335–350.
- D'Este, P., & Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations. *Journal of Technology Transfer*, 36, 316–339.
- D'Este, P., Guy, F., & Iammarino, S. (2013). Shaping the formation of university-industry research collaborations: What type of proximity does really matter? *Journal of Economic Geography*, 13, 537–558.
- Dietz, J., & Bozeman, B. (2005). Academic careers, patents, and productivity: Industry experience as scientific and technical human capital. *Research Policy*, 34, 349–367.
- Faggian, A., & McCann, P. (2009). Human capital, graduate migration and innovation in British regions. *Cambridge Journal of Economics*, 33, 317–333.
- Florida, R. (2005). The world is spiky. *The Atlantic Monthly*, October 48–51.
- Friedman, T. (2005). *The world is flat: A brief history of the twenty-first century*. New York: Macmillan Press.
- Fernandez-Zubieta, A., Geuna, A., & Lawson, C. (2015). What do we know of the mobility of research scientists and of its impact on scientific production. LEI & BRICK Working Paper 08/2015.
- Franzoni, C., Scellato, G., & Stephan, P. (2012). Foreign-born scientists: Mobility patterns for 16 countries. *Nature Biotechnology*, 30, 1250–1253.
- Franzoni, C., Scellato, G., & Stephan, P. (2014). The mover's advantage: The superior performance of migrant scientists. *Economics Letters*, 122, 89–93.
- Ghemawat, P. (2011). *World 3.0: Global prosperity and how to achieve it*. Boston, MA: Harvard Business Press.
- Giuliani, E., & Arza, V. (2009). What drives the formation of "valuable" university-industry linkages? *Research Policy*, 38, 906–921.
- Guerrero, M., Cunningham, J., & Urbano, D. (2015). Economic impact of entrepreneurial universities' activities: An exploratory study of the United Kingdom. *Research Policy*, 44, 748–764.
- Gulbrandsen, M., & Smeby, J. (2005). Industry funding and university professors' research performance. *Research Policy*, 34, 932–950.
- Gulbrandsen, M., Mowery, D., & Feldman, M. (2011). Heterogeneity and university-industry relations: Introduction to the special section. *Research Policy*, 40, 1–5.
- Gulbrandsen, M., & Thune, T. (2017). The effects of non-academic work experience on external interaction and research performance. *The Journal of Technology Transfer*, 42, 795–813.
- Hewitt-Dundas, N., & Roper, S. (2011). Creating advantage in peripheral regions: The role of publicly funded R&D centres. *Research Policy*, 40, 832–841.
- Hoisl, K. (2007). Tracing mobile inventors—the causality between inventor mobility and inventor productivity. *Research Policy*, 36, 619–636.
- Hughes, A., Kitson, M., Abreu, M., Grinevich, V., Bullock, A., & Milner, I. (2010). Cambridge Centre for Business Research Survey of Knowledge Exchange Activity by United Kingdom Businesses, UK Data Archive Study No. 6464.
- Hughes, A. (2011). Open innovation, the Haldane principle and the new production of knowledge: science policy and university-industry links in the UK after the financial crisis. Centre for Business Research, University of Cambridge Working Paper 425.
- Kalapouti, K., & Varsakelis, N. (2015). Intra and inter: Regional knowledge spillovers in European Union. *The Journal of Technology Transfer*, 40, 760–781.
- Lam, A. (2007). Knowledge networks and careers: Academic scientists in the industry-university links. *Journal of Management Studies*, 44, 993–1016.
- Lam, A. (2011). University-Industry collaboration: careers and knowledge governance in hybrid organizational space. *Strategic Business Alliances*, 2, 135–145.
- Laursen, K., & Salter, A. (2004). Searching low and high: What types of firms use universities as a source of information. *Research Policy*, 33, 1201–1215.
- Laursen, K., Reichstein, T., & Salter, A. (2011). Exploring the effect of geographical proximity and university quality on university-industry collaboration in the United Kingdom. *Regional Studies*, 45, 507–523.
- Lawton Smith, H., & Waters, R. (2011). Scientific labour markets, networks and regional innovation systems. *Regional Studies*, 45, 961–978.
- Lenzi, C. (2009). Patterns and determinants of skilled workers' mobility: Evidence from a survey of Italian inventors. *Economics of Innovation and New Technology*, 18, 161–179.
- Lundberg, J., Tomson, G., Lundkvist, I., & Brommels, M. (2006). Collaboration uncovered: Exploring the adequacy of measuring university-industry collaboration through co-authorship and funding. *Scientometrics*, 69, 575–589.
- Mangematin, V., O'Reilly, P., & Cunningham, J. (2014). Pls as boundary spanners, science and market shapers. *Journal of Technology Transfer*, 39, 1–10.



- Mansfield, E., & Lee, J. (1996). The modern university: Contributor to industrial innovation and recipient of industrial R&D support. *Research Policy*, 25, 1047–1058.
- Mejlgaard, N., & Ryan, T. (2017). Patterns of third mission engagement among scientists and engineers. *Research Evaluation*, 26, 326–336.
- Minguillo, D., Tijssen, R., & Thelwall, M. (2015). Do scienceparks promote research and technology? A scientometric analysis of the UK. *Scientometrics*, 102, 701–725.
- OECD (2010). *Measuring globalization: OECD economic globalization indicators 2010*. Paris: Organization for Economic Co-operation and Development.
- Peacock, A. (2019). Does proximity affect the impact of university-industry collaborations? Presentation at UCL, London. 6 February 2019. URL: <https://www.ucl.ac.uk/ioe/events/2019/feb/does-proximity-affect-impact-university-industry-collaborations>
- Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., ... Sobrero, M. (2013). Academic engagement and commercialization: A review of the literature on university–industry relations. *Research Policy*, 42, 423–442. <https://doi.org/10.1016/j.respol.2012.09.007>
- Ponds, R., Van Oord, F., & Frenken, K. (2010). Innovation, spillovers and university–industry collaboration: An extended knowledge production function approach. *Journal of Economic Geography*, 10, 231–255.
- Reichert, S. (2019). *The role of universities in regional innovation ecosystems*. Brussels: European University Association.
- Roach, M., & Sauermann, H. (2010). A taste for science? PhD scientists' academic orientation and self-selection into research careers in industry. *Research Policy*, 39, 422–434.
- Rosli, A., & Rossi, F. (2016). Third-mission policy goals and incentives from performance-based funding: Are they aligned? *Research Evaluation*, 25, 427–441.
- Rothaermel, F., Agung, F., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change*, 16, 691–791.
- Spiezia, V. (2003). Measuring regional economies. OECD Statistics Brief no 6. URL: www.oecd.org/sdd/15918996.pdf
- Storper, M. (2000). Globalization and knowledge flows. In J. Dunning (Ed.), *Regions, globalization, and the knowledge-based economy* (pp. 42–63). Oxford: Oxford University Press.
- Tijssen, R., Van Leeuwen, T., & Van Wijk, E. (2009). Benchmarking university-industry research co-operation worldwide: Performance measurements and indicators based on co-authorship data for the world's largest universities. *Research Evaluation*, 18, 13–24.
- Tijssen, R. (2011). Co-authored research publications and strategic analysis of public–private collaboration. *Research Evaluation*, 21, 204–215.
- Tijssen, R., Waltman, L., & Van Eck, N. (2011). Globalization of public-private research: Monitoring co-publication trends in worldwide science. Proceedings of the Atlanta Conference on Science and Innovation Policy.
- Tijssen, R., Yegros, A., & Lamers, W. (2017). UK universities interacting with industry: patterns of research collaboration and inter-sectoral mobility of academic researchers. CGHE Working Paper 14.
- Tijssen, R., & Yegros, A. (2017). UK universities and European industry. *Nature*, 544, 35.
- Tijssen, R. (2018). Anatomy of use-inspired researchers: From Pasteur's Quadrant to Pasteur's Cube model. *Research Policy*, 47, 1626–1638.
- Tripl, M. (2013). Scientific mobility and knowledge transfer at the interregional and intraregional level. *Regional Studies*, 10, 1653–1667.
- Vick, T., & Robertson, M. (2018). A systematic literature review of UK university–industry collaboration for knowledge transfer: A future research agenda. *Science and Public Policy*, 45, 579–590.
- Waltman, L., Tijssen, R., & Van Eck, N. (2011). Globalisation of science in kilometres. *Journal of Informetrics*, 5, 574–582.
- Weinstein, N., Wilsdon, J., Chubb, J., & Haddock, G. (2019). The real time REF review: A pilot study to examine the feasibility of a longitudinal evaluation of perceptions and attitudes towards REF 2021. URL: <https://re.ukri.org/news-events-publications/publications/real-time-refreview-pilot-study/>
- Yegros, A., & Tijssen, R. (2014). University-Industry interactions through scientific publications: global analysis of dual affiliates. University-Industry Interaction Conference, Barcelona (Spain), 23–25 April 2014.
- Zucker, L., Darby, M., & Torero, M. (2002). Labor mobility from academe to commerce. *Journal of Labor Economics*, 20, 629–660.

How to cite this article: Tijssen R, van de Klippe W, Yegros A. Localization, regionalization and globalization of university-business research co-operation in the United Kingdom. *Pap Reg Sci*. 2020;99:1215–1236. <https://doi.org/10.1111/pirs.12531>



APPENDIX

TABLE A1 University-Business Co-operation statistics per university (2008–2017)

	UBRPs (% of total publication output)	UBM-Rs (% of total publication output)	UB/MA-Rs (% of total publication output)
University of Oxford	8.3	0.8	0.4
University College London	7.7	0.8	0.4
University of Cambridge	9.0	1.6	0.6
Imperial College	11.1	1.3	0.6
University of Manchester	10.0	1.1	0.4
King's College London	8.6	1.0	0.3
University of Edinburgh	8.8	0.9	0.3
University of Bristol	7.4	0.8	0.4
University of Southampton	8.0	0.6	0.3
University of Nottingham	7.6	0.7	0.4
University of Birmingham	7.2	0.7	0.4
University of Sheffield	8.9	0.8	0.4
University of Leeds	8.5	0.8	0.4
University of Glasgow	8.6	1.1	0.3
University of Liverpool	7.0	0.4	0.2
Cardiff University	6.9	0.5	0.3
University of Warwick	5.8	0.7	0.4
University of Newcastle-upon-Tyne	7.7	0.6	0.3
Queen Mary University of London	7.9	1.0	0.4
University of Durham	4.7	0.6	0.3
Queen's University Belfast	6.4	0.6	0.3
University of Exeter	4.8	0.4	0.3
University of Aberdeen	7.6	1.1	0.5
University of York	7.1	0.8	0.3
London School of Hygiene & Trop. Med.	6.1	0.6	0.2
University of Leicester	9.2	0.4	0.3
University of St Andrews	4.6	0.5	0.2
University of Lancaster	4.7	0.5	0.3
University of Sussex	3.2	0.3	0.2
University of Strathclyde	7.8	0.9	0.6
University of East Anglia	4.2	0.2	0.2
University of Bath	7.0	0.7	0.5
University of Reading	7.0	0.5	0.3
University of Surrey	8.7	1.4	0.7
Loughborough University	6.9	0.7	0.4

(Continues)



TABLE A1 (Continued)

	UBRPs (% of total publication output)	UBM-Rs (% of total publication output)	UB/MA-Rs (% of total publication output)
University of Dundee	9.2	1.1	0.5
Swansea University	6.8	0.4	0.2
Brunel University London	5.9	1.3	0.6
London School of Econ. and Pol. Sci.	2.1	0.4	0.2
University of Kent	3.8	0.5	0.3
Heriot-Watt University	7.2	0.8	0.7
University of Plymouth	5.9	0.9	0.3
Open University	5.0	0.3	0.1
University of Hull	6.1	0.8	0.4
Bangor University	4.8	0.4	0.2
Cranfield University	11.3	0.9	0.6
University of Ulster	4.5	0.3	0.3
City University London	4.4	0.8	0.4

Note:

*Universities sorted by decreasing 2008–2017 research publication output in the Web of Science.



Resumen. Este estudio empírico analiza la cooperación universidad-empresa (CUE) desde la perspectiva de la distancia. El estudio se centra en las 48 universidades más importantes del Reino Unido en cuanto a investigación, y recopila datos de las direcciones de los autores afiliados en las publicaciones de investigación en colaboraciones universidad-empresa (PIUE) entre 2008 y 2017. La proximidad espacial entre la universidad y sus socios de colaboración de las empresas que figuran en estas publicaciones de investigación se enmarca en tres tipos de distancia principalmente: "local" (0–99 km); "regional" (100–499 km); "mundial" (500 km o más). Las tendencias anuales de las PIUE revelan una tendencia a la globalización de la CUE. Varias universidades muestran signos de "glocalización" de la CUE, para las que el número de sus PIUE mundiales ha aumentado más rápidamente que el de las PIUE locales. Cuatro factores comunes determinan en gran medida el número de PIUE, independientemente de la distancia: la intensidad de la I+D del sector empresarial en la zona geográfica local de la universidad; el tamaño de la investigación que realiza la universidad; el impacto de las citas internacionales de alto nivel de la universidad; y la presencia de investigadores universitarios con experiencia laboral en el sector empresarial.

抄録: 本稿の実証的研究では産学連携(university - business cooperation:UBC)を、距離をベースとした観点から分析する。英国における48の大規模な研究大学に焦点を当て、2008~2017年の産学連携研究出版物(university - business research publications:UBRP)の著者所属施設の連絡先からデータを収集した。これらの共著論文に記載されている大学とビジネスパートナーとの空間的近接性は、「local(0~99km)」「regional(100~499km)」、「global(500km以上)」という、主に3つの距離に分類される。UBRPの年間の動向から、UBCのグローバル化的傾向が明らかにされている。いくつかの大学はUBCのグローバル化の兆候を示しており、globalに分類されるUBRPの数はlocalのUBRPよりも急速に増加している。この分類に関係なく、UBRPの数を決定する共通する4つの大きな要因がある。すなわち、大学の立地する地域における企業の研究開発部門の集中度、大学の研究の規模、国際的に高い大学のインパクトファクター、産業セクターでの実務経験を有する大学研究者の存在である。