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Conceptualising the entrepreneurial university: the stakeholder approach

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Abstract
This study uses the stakeholder perspective to knowledge spillover theory at university to explain how various characteristics of internal and external university stakeholders will affect its entrepreneurial outcomes. Acknowledging the heterogeneity between entrepreneurial universities, we theoretically developed and empirically tested a model for four types of stakeholders (knowledge enablers, knowledge creators, knowledge codifiers, knowledge facilitators) across three university types (Russel group, teaching-based and polytechnic universities). To test our hypotheses related to the role of stakeholders in entrepreneurial outcomes of a university we used panel data on 139 UK universities that achieved entrepreneurial outcomes during 2010 and 2016. The results demonstrate significant differences in the role that stakeholders play in knowledge spillover entrepreneurship at universities with the effects vary across three distinct university types.

Keywords Entrepreneurial university · Knowledge spillover entrepreneurship · Intellectual property revenues · Start-up · Spin-off

1 Introduction

Universities have been known to facilitate innovation and support entrepreneurship (Cunningham & Menter, 2021; Graf & Menter, 2021; Wagner et al., 2021), however how it can be achieved (Acs & Audretsch, 2010; Audretsch, 2014; Audretsch & Belitski, 2021) still remains unknown? (Audretsch, 2014; Link, 2022). In addition, the concept of

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''entrepreneurial university'' remains understudied (Bradley et al., 2013; Hayter et al. 2016; Civera et al., 2020; Audretsch & Belitski, 2021).

In this study, we draw on Guerrero et al. (2015) and Etzkowitz (2003) in defining the entrepreneurial university as any university that has the ability to innovate, recognise and create opportunities (Kirby, 2002) and which can produce and spillover knowledge (Etzkowitz, 2003). It can develop a comprehensive internal system for knowledge commercialisation including patenting and licensing, new companies creation, custom-made further-education courses, consultancy services, contract research (Chrisman et al., 1995) by providing a support structure, as a ''natural incubator'' (Etzkowitz, 2003), through different stakeholders.

Despite the variety of entrepreneurial outcomes at university the factors that determine them and the role of stakeholders across different university types remains an important research gap (Bartell, 2003; O'Kane et al., 2015; McCann, 2021). There is a call in research to study the stakeholder complexity and how the relationship between stakeholders and commercialization outcomes differ between different university types (Foss & Gibson, 2015; Abreu et al., 2016; McCann, 2021).

We draw on the knowledge spillover theory of entrepreneurship (KSTE) (Audretsch, 1995; Acs et al., 2004, 2013; Audretsch & Lehmann, 2005; Audretsch et al, 2006; Audretsch & Keilbach, 2007) to explain how knowledge created at university spills over into entrepreneurial outcomes such as starting a business (e.g., spinoffs and start-ups) and acquiring intellectual property income. Knowledge commercialization is the third mission of the university (Audretsch, 2014). Within the entrepreneurial university model (Audretsch, 1995), academics, and students are the focal point or entrepreneurs who spillover the knowledge into the ecosystem. Although the KSTE explore the new knowledge created by universities (which is reach in knowledge itself) and individuals (e.g., faculty and students within the university context) (Link & Siegel, 2005), it does not explain how the *support* provided by heterogeneous internal and external university stakeholders may a) affect the type of outcome of the entrepreneurial university and b) how these outcomes may change if different combinations of stakeholders are taken into account and across different knowledge-intensive contexts—university types. As those engaged with the development of new knowledge combine their skills and expertise with other relevant specialists to deliver new knowledge (Link & Scott, 2019). Using longitudinal data on 139 UK universities (2009–2016) collected by the Higher Education Statistics Agency (HESA), the purpose of this study is to extend the theory and explain the phenomenon by empirically testing the concept of the entrepreneurial university. It demonstrates how collaboration between a variety of stakeholders on knowledge spillovers can change university entrepreneurial outcomes across universities of different types.

This study contributes to technology transfer and knowledge spillover of entrepreneurship literature as follows.

First, we examine how knowledge spillover between universities of different types occur and how by choosing a specific combination of knowledge a university may result in the realization of entrepreneurial opportunity via specific entrepreneurial outcomes (Cunningham, 2019).

Secondly, we analyse the role that external stakeholders play at entrepreneurial universities at different levels and how stakeholders are interconnected (Cunningham et al., 2021). Finally, by merging the stakeholder perspective with the KSTE this study demonstrated the role of support provided within the multilevel context and how it changes with the type

of university (teaching, research, polytechnic) and commercialization outcomes (e.g., spin-offs, start-ups, licences income, etc.).

We do so by identifying the role stakeholders play within the entrepreneurial university and the type of support they provide to facilitate knowledge spillover (Ambos et al., 2008; Romero et al., 2021; Siegel, 2018; Wright et al., 2019a, b).

This study furthers the recent research of Cunningham et al. (2021) on the organizational architecture of entrepreneurial universities and how multi-level stakeholders may be important in explaining the variety of entrepreneurial outcomes and at different stages of entrepreneurship.

Our key findings are as follows. First, we reveal that independently of a university type (teaching or research-oriented) within the UK higher education sector, universities with teaching only oriented mission are still successful in achieving entrepreneurial outcomes having the appropriate infrastructure to promote knowledge spillover, further expanding what we know from Cunningham et al. (2021).

Second, expanding the work of Civera et al. (2020) this study shows that policy approach to stimulate entrepreneurial universities should be adjustable accordingly based on the university type even within one country (e.g., not all universities might benefit from extensive support of TTOs, while they might need a better support of business incubators based on their orientation).

The next section describes the conceptual framework and provides stakeholder classification Sect. 3 discusses the data and methodology. The results are presented in Sect. 4. Section 5 discusses the main findings and the contribution to the literature. Section 6 concludes.

2 Conceptual framework

2.1 Entrepreneurial university and knowledge spillover entrepreneurship

Knowledge creation at universities lead to knowledge spillover and create technological opportunities what have been described under the knowledge spillover theory of entrepreneurship (Acs et al., 2009).

Knowledge spillover is a flow of knowledge from one party where this knowledge is generated to another party where this knowledge is commercialized (Acs et al., 2013; Audretsch & Lehmann, 2006), and is considered as a source for entrepreneurship (Audretsch & Keilbach, 2007) which helps commercially explore university research (Agarwal et al., 2007). University spin-offs and start-ups are considered as a mechanism for knowledge spillover as they are based on university-produced knowledge (Acs et al., 2009).

Thus, the role of universities as main institutions in spilling over new knowledge and innovations has increased the attention. Universities act as connective anchors working with different stakeholders within the local environments facilitating knowledge spillover (Davies et al., 2021) and becoming one of the key actors within the knowledge spillover theory of entrepreneurship. This contributes to the creation of a university-based entrepreneurial ecosystem facilitating innovations and entrepreneurial opportunities thanks to the knowledge-sharing process among several stakeholders and their assistance of this process (Wurth et al., 2015). Within the university-based ecosystem, actors are connected by the constant flow of knowledge via different channels which enable entrepreneurial knowledge

spillover (Siegel et al., 2003). The exchange of knowledge among several stakeholders contributes to knowledge spillover (Etzkowitz & Leydesdorff, 2000; Belitski et al., 2019). That is why universities need to consider and work accordingly with actors who impact or provide support across different stages of entrepreneurship (Miller et al., 2021).

Knowledge spillover mechanisms are used by students and researchers to start business and commercialize knowledge in the market, as not all knowledge created at university will be eventually commercialized.

The stakeholder perspective is particularly useful to understand how knowledge spills over (Miller & Acs, 2017) and what type of support is provided within the process. Based on the entrepreneurial viewpoint, the factors used to determine the relevance of stakeholders are vital in a practical sense since entrepreneurs have to decide what group they need to deal with at any given stage of the new knowledge development and spillover (Bartell, 2003). It is thus vital to analyse and conceptualise a framework for applications to this task. In particular, the classification makes conceptualisation possible (Bailey, 1994).

Expanding upon the stakeholder taxonomy proposed by Yusef (2008) and aligning it with the entrepreneurial university model (Audretsch, 2014), we identified four types of entrepreneurial university stakeholders involved in the knowledge spillover:

(1) Knowledge enablers: organisations and individuals that facilitate knowledge manipulation (Klingbeil et al., 2019) (industry and government);
(2) Knowledge providers: organisations and individuals that produce and spillover knowledge within the entrepreneurial university (university students and faculty) (Boardman & Gray, 2010);
(3) Knowledge codifiers: organisations and individuals that actively seek new channels and forms of knowledge transfer, and facilitate knowledge spillovers outside the university level (technology transfer and IP offices);
(4) Knowledge facilitators: organisations that facilitate entrepreneurial incentives (Fayolle & Linan, 2014) and encourage knowledge spillovers within the university and into the ecosystem (research and science parks, business incubators, accelerators) (Amoroso et al., 2019; Wright et al., 2019a, 2019b). These stakeholders may also raise finance (e.g., venture capitalists).

Authors have explored existing case studies on entrepreneurial universities (Appendix A, Table 7) and identified that there was no research conducted to identify the role of stakeholders and effect of the support they provide on achieving university entrepreneurial outcomes at different stages of knowledge development (Cunningham & Miller, 2021; Romero et al., 2021). This research adopts a static perspective on entrepreneurial university with dynamic interactions between different stakeholders (Hayter, 2016) through various activities, including patenting and licensing, research contracts or new ventures creation (Link & Siegel, 2005).

2.2 Stakeholder classification and conceptualisation within the entrepreneurial university ecosystem

Types of university stakeholders include knowledge enablers, knowledge producers, knowledge codifiers and knowledge facilitators.

2.2.1 Knowledge enablers

2.2.1.1 Government As an external stakeholder, government facilitates the knowledge spillover process from the university. Initially, the government develop appropriate policy and political incentives for knowledge and technologies transfer. One of the most prominent examples of political instruments is the Bayh-Dole Act in the US, the Higher Education Fund in the UK (Siegel et al., 2003) or the Programme for Research in Third Level Institutions (Cunningham & Golden, 2015), Excellence Initiative in Germany (Civera et. al., 2020).

Governments' incentives also devoted to creating a flourishing entrepreneurial environment and the infrastructure needed to promote knowledge spillover and the transfer of new technologies (Cunningham et al., 2021). The government is the most common source of funding (Lee, 2021). Its explicit policy is directed at devolving responsibility to academia for ensuing research funding and its subsequent commercialisation (Guerrero et al., 2016). The government is considered as an enabling factor providing both conditions (policy, entrepreneurial incentives, infrastructure) and initial financial support to start research for both research and teaching-oriented universities. Collaborative research officially forms the relationship between two stakeholders and, unsurprisingly, is a knowledge transfer channel.

2.2.1.2 Industry Besides the government, universities engage with the industry as an initial external stakeholder. Industry market gaps and funding for research projects represent a significant input into ideas generation and development (Miller et al., 2021). The relationships between the two parties are formed through contract research, which is an effective tool and channel to spillover knowledge (Cohen et al., 2002). The existence of contracts with industry positively affects the propensity for direct commercialization of university research, but also researchers' involvement in entrepreneurial activities, and helps to create an entrepreneurial culture at the university (Powers & McDougall, 2005). Once the knowledge has been created at the universities, academia provides various services to the industry in return. Such services are also knowledge transfer channels and can be provided in the form of consultancy (Perkmann et al., 2021) or additional training. Thus, the industry is also an enabling factor for new knowledge generation via having gaps that need to be closed as well as providing financial support via research contracts and facilitating entrepreneurial culture at the university for both research- and teaching-oriented universities (Romero et al., 2021).

Summing up, both government and industry are enabling factors for new knowledge development and the following transfer. The government is a principal provider of research funding and political incentives for knowledge development and spillover in both research and teaching-led universities (e.g., Innovate UK programme). Collaboration with industry provides a base for new knowledge generation and financial support to university scientists, therefore boosting the development of R&D in research-led universities as well as facilitating knowledge spillover via its direct transfer in teaching led universities. We thus hypothesise that:

H1a: Knowledge enablers have a positive effect on university start-up activity and the licencing of technologies in research-oriented universities

H1b: Knowledge enablers have a positive effect on university start-up activity and the licencing of technologies in teaching-oriented universities

2.3 Knowledge providers

2.3.1 Researchers

Once opportunities are created and institutional conditions are established, knowledge creation for the following spillover occurs internally at the university. Within the knowledge transfer process itself, scholars represent an important group of internal stakeholders (Clauss et al., 2018) and generate new knowledge which later spillovers in both teaching- and research-oriented universities. Scientists transfer knowledge via selling IP rights as well as creating spin-offs and start-ups (Belitski & Heron, 2017) and are principal investigators and scientific entrepreneurs (Casati & Genet, 2014). Academics are the main internal nucleus that generates new knowledge, allowing both university types to operate properly (Klingbeil et al., 2019).

2.3.2 Students

Students are another group of internal stakeholders within the knowledge transfer process. Acosta et al. (2011) demonstrated that the total number of university graduates is one of the vital spillover mechanisms explaining the creation of new ventures in both teaching- and research-led universities. Within the education process, there is an interaction not only between students and professors but also between students themselves. When it comes to research activities, graduates and PhD or postdoctoral students are important participants of new knowledge creation in research projects and IP rights generation. This new knowledge can be used for academic spin-offs formation based on new knowledge in research-oriented institutions (Hayter et al., 2018) or based on identified market opportunities for teaching-led universities (Belitski & Heron, 2017).

Human capital identifies opportunities and experiments with new ideas while generating new knowledge in order to proceed to commercialisation (mostly faculty and postgraduate students within the research-oriented universities) and the creation of new ventures to address market demand (both university faculty and students within teaching- and research-led universities). This led us to hypothesise that:

H2a: Knowledge providers have a positive effect on university start-up activity and the licencing of technologies in research-oriented universities
H2b Knowledge providers have a positive effect on university start-up activity and no effect on licencing of technologies in teaching-oriented universities

Before entering the public domain and being transferred into the economy, the knowledge produced by faculty and students might follow either a traditional or formal (licensing) or alternative (non-linear) (new ventures creation, direct contracts with industry, etc.) routes to commercialisation (Bradley et al., 2013). The former process requires the invention to be codified and protected via technology transfer offices (hereafter TTOs) (or any relevant department). The latter involves knowledge facilitators stakeholder groups or science parks (hereafter SPs) and business incubators (hereafter BIs). Both stakeholder subgroups might be either internal or external to the university.

2.4 Knowledge codifiers

2.4.1 TTOs and IP offices

To ensure appropriate protection for a given invention, academia usually works with technology and intellectual property offices (Lockett et al., 2015) who are responsible for protecting intellectual property (IP) rights via codifying new knowledge and technologies, including patents, copyright, trademarks and designs (Gubitta et al., 2016). Additionally, TTOs are considered pivotal cross-level brokers within the entrepreneurial ecosystem (O'Kane et al., 2021) to seek the potential application of such codified knowledge. Patents and licences are a visible method and channel to spillover codified knowledge via the traditional route (Aksoy & Beaudry, 2021; Fisch et al., 2016), especially for research-focused universities which have more codifiable research outcomes compared to teaching-oriented universities. They facilitate the commercialisation of inventions and the creation of new ventures contributing to the university's third mission (Sengupta & Ray, 2017). They also enable start-ups (which was set up not necessarily based on research outcomes but e.g., market gaps) to raise external funding (Farre-Mensa et al., 2015), especially in teaching-led universities. Patenting is a strong, robust (not necessarily a research-based) predictor for the decision by a financial agent to invest in a firm (Stuart & Ding, 2006). Patents thus can be seen as a promising starting point for knowledge spillover and technology commercialisation (van Holm et al., 2021).

The licencing of patents is one of the channels through which new knowledge can be transferred from universities to industry. It occurs through TTO, who facilitate communication with other actors, promoting codified knowledge to industry (O'Kane et al., 2021; Perkmann et al., 2013) and formalising the knowledge transfer process (Siegel, 2018). The sale of licenses to companies is one way by which university patents can be exploited, providing an additional and often substantial income more profoundly for research-led universities (Siegel & Leih, 2018).

Summing up, TTO and IP offices are an important conduit to transfer a newly developed codified knowledge from university to industry following the traditional way of commercialisation and is a robust predictor for new ventures creation in teaching-led universities. This discussion thus led us to hypothesise that:

H3a: Knowledge codifiers have a positive effect on the licencing of technology and no effect on university start-up activities in research-oriented universities.

H3b: Knowledge codifiers have no effect on the licencing of technology while having a positive effect on university start-up activities in teaching-oriented universities.

2.5 Knowledge facilitators

2.5.1 Science parks and business incubators

In the seminal work of Link and Scott (2017) analysed the diffusion of innovations and their effects on universities, they specifically argue that Science Parks played a huge role in the spread of new knowledge. However, they also point on the following challenges of knowledge commercialization in science parks such as interaction of university faculty

with science parks divert faculty from students and curriculum towards commercial activities influencing the character of university research.

When the new knowledge created by universities is not commercialised formally through a TTO (e.g., patents, licences), it might alternatively be used for the creation of new companies. The creation of new ventures requires a supportive infrastructure and stakeholders who facilitate knowledge spillover outside the university domain, contributing to local economic development (Markman et al., 2008). Within the entrepreneurial university context, science parks and business incubators play this role of knowledge facilitation (Audretsch & Belitski, 2019; Wright et al., 2019a, 2019b).

The primary goal of SPs and BIs is to facilitate knowledge transfers from academia and research institutions and create new firms (Hayter, 2016; Ng et al., 2021). The main idea behind the establishment of SPs is to generate knowledge spillovers and develop the necessary infrastructure, provide networking opportunities (Lamperti et al., 2017; Theeranattapong et al., 2021) as well as administrative, logistic and technical help to new firms, including those which are driven by university research (e.g., creating spin-offs utilising IP right) (Lecluyse et al., 2019; Ng et al., 2021). This objective is more effective for the research-led universities (Hayter et al., 2018) as new start-ups can participate in joint R&D projects and develop innovation clusters for knowledge commercialization. Science parks facilitate the acquisition of external research funding of universities (Link & Link, 2003) as well as change university research focus to more commercial (Link & Scott, 2017).

According to Murphy and Dyrenfurth (2019), the support provided by incubators help people to conceptualise their ideas (which do not necessary based on research outputs and thus might be more effective within teaching-led universities) and launch businesses successfully facilitating knowledge spillover. Such support to new firms may include workshops, mentorship, access to investors (Abduh et al., 2007), and access to networks of entrepreneurs (Soetanto & Jack, 2013). In addition, business incubators offer support services in the form of equipment such as fax machinery, photocopiers, computers (Hatten, 2006), facilities (office space), knowledge and management support. Even though the effect of BI on new venture viability is contingent on the type of support provided (Bergek & Norrman, 2008), they do facilitate the companies' creation by providing incubation service (Lasrado et al., 2016).

2.5.2 Venture capitalists (VCs)

The availability of VCs is vital to the success of a company (Samilla & Sorenson, 2010; Powers & McDougall, 2005). Universities which can commercialize knowledge by starting new firms and acquiring property rights on the invention will be more successful in securing venture capital (Croce et al., 2014). Access to venture capital is the second-most important channel in the UK (after government support through University Challenge Funding) (Wright et al., 2006) to facilitate knowledge spillover. Additionally, to financial capital, VCs provide academic entrepreneurs with managerial and technical advice on running a business and allow access to their business networks (Hayter, 2016) as well as markets and industry (Vohora et al., 2004; Gubitta et al., 2016).

To summarise, science parks, business incubators, and VCs are mechanisms that facilitate the creation of knowledge-based spin-offs including via utilisation of IP rights (for research-oriented institutions) and university-based start-ups (for teaching-oriented institutions). We thus hypothesise that:

H4a: Knowledge facilitators have a positive effect on the licencing of technologies and university start-up activities in research-oriented universities

H4b: Knowledge facilitators have no effect on the licencing of technologies while having a positive effect on university start-up activities in teaching-oriented universities

In Fig. 1, we conceptualised how the process of collaboration between stakeholders and entrepreneurial universities occurs and to which outcomes such collaboration could potentially lead. The process accounts for both traditional and alternative routes of knowledge transfer. For both approaches, the process begins with the knowledge-enabling stakeholders, who create the opportunities to facilitate discovery (e.g., by providing funding for the research or having market gaps). These stakeholders also contribute to idea generation and exchange. Knowledge providers then use these opportunities to work on developing new knowledge via research projects and teaching (Jongbloed et al., 2008; Link & Siegel, 2005). In the next stage, newly developed ideas follow traditional or alternative routes of commercialisation and might take different paths. It might engage knowledge codifiers when the invention is disclosed to TTOs for evaluation and following promotion of the invention to the market (Siegel, 2018). Alternatively, the process can involve knowledge facilitators who enable knowledge transfer and the creation of new firms. These stakeholders provide support to ensure the successful launch of ideas on the market (Albahari et al., 2019).

In addition, newly developed knowledge might turn into services which are provided back to the industry in the form of consultancies and/or professional development courses (Perkmann et al., 2013). All stakeholders provide different support to facilitate knowledge and technology commercialisation, contributing to the third-stream income generation by the university.

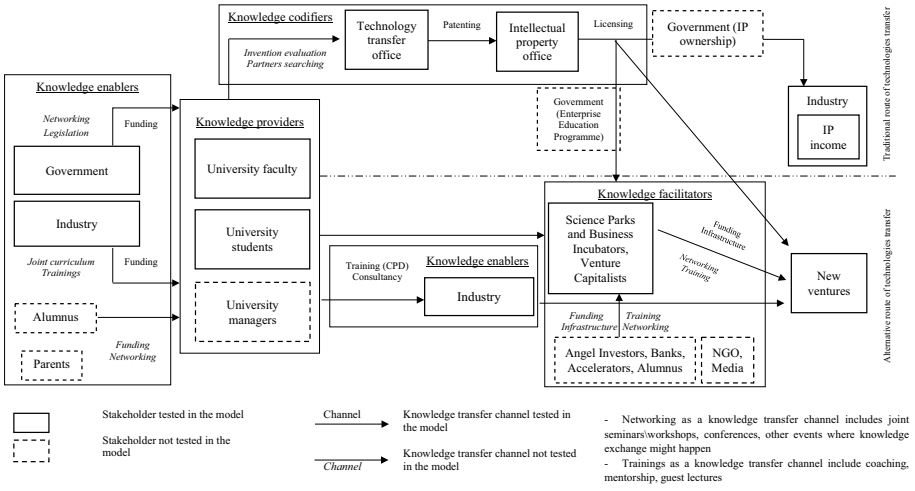

Fig. 1 Conceptualisation of the university and stakeholder collaboration process to facilitate knowledge spillover (general conceptualisation)

2.6 The context of the UK higher education system.

There is a general binary divide in the UK Higher Education sector (Guerrero et al., 2015; McCormack et al., 2014) between the older (founded before 1992), more research-oriented universities, and those which gained university status after 1992 following the introduction of the Further and Higher Education Act, and university colleges that became universities later on. These new universities are more teaching-oriented, providing vocational education and training.

Further, there is a difference between the 24 research-oriented universities (or Russell Group) and the other old research universities (the Top-5 research universities: Oxford University, Cambridge University, Manchester University, Imperial College London, University College London). In addition, there is a difference between the newer universities (or former polytechnics which offered degrees in more technical subjects) and those that previously were further education colleges (McCormack et al, 2014). Due to the heterogeneity among the Russel Group universities (Boliver, 2015) and the dominance of the top-5 universities, a fine-grained distinction exists between the two groups.

Thus, we categorise the UK universities into three main groups based on their research intensity and historical development while all of them do have a diverse infrastructure for knowledge transfer (Table 8, Appendix A). Our research-intensive universities are Russel Group universities, and we controlled for the top-five research group. The teaching domain included former polytechnics and teaching-led universities (not included in any of the groups described before). Our categorization is consistent with other research which has emphasised the institutional differences in the sector (Abreu et al., 2016).

3 Data and method

3.1 Sample

We have explored entrepreneurial outcomes of 139 UK universities for 7-year period (between 2010 and 2016) taking into consideration the contribution of different stakeholders into achieving those outcomes. The data was collected by the Higher Education Statistics Agency (HESA), specifically the university-business collaboration survey (Higher Education Business and Community Interaction Survey (HE-BCIS)). This is open-access data available at the university level. We supplemented the HE-BCIS statistics using other data from HESA (e.g., university establishment year, number of faculty and students).

We understand the entrepreneurial university outcomes drawing on Guerrero et al. (2015) who associate entrepreneurial university with the mechanism of how university activities transformed into production factors contributing to social and economic development.

Following Guerrero et al. (2015) entrepreneurial university is an institution that had entrepreneurial outcomes from teaching (staff and student start-ups), and/or research missions (contract and collaborative research, consultancy, university spin-offs, IP revenues, patents), or both. We also considered institutions that have established support structures to facilitate knowledge commercialisation and spillovers (Link & Siegel, 2005). From the teaching perspective, we considered entrepreneurial outcomes of a university such as a start-up creation (both staff and graduate) (Marzocchi et al., 2019). From the research perspective, we considered entrepreneurial outcomes as IP revenues

generation and spin-offs creation (Guerrero et al., 2015). We also considered consultancy and training activities as the main factor in the dissemination of new knowledge (entrepreneurial mission) from both teaching and research activities (Guerrero et al., 2015).

Additionally, these results should be supported by the established internal system, either for the research dimension (mostly TTOs or licensing offices) or the teaching dimension (mostly business incubators or science parks), or both (see Table 1 and Table 8, Appendix A).

From the total sample of UK higher education establishments, we excluded 29 universities that did not meet our requirements for the period covered (see Table 8, Appendix A for the sample details covered by this research).

We use a relative measure as the percentage of universities that participate in each specific activity type to visualise the differences between the three subgroups of universities (Table 8). Relative measures are applied because of the difference in university numbers in each group.

3.2 Variables

3.2.1 Dependent variable

In terms of measuring entrepreneurial capital at universities, researchers have paid more attention to two particular performance metrics, which are revenues from utilising patents (or licensing), as well as the creation of new ventures (Siegel, 2018; Siegel & Leih, 2018; Siegel & Wright, 2015). Audretsch and Keilbach's (2004) definition of university

Table 1 General features of the sample by university subgroup (% of universities in a group which perform certain commercialisation activities and have supportive infrastructures)

Indicator	University Type		
	Russel Group Universities	Polytechnic Universities	Rest Teaching Universities
Consultancy and CPD	100.00	100.00	100.00
Contract research	100.00	100.00	91.00
IP revenues	100.00	93.00	65.00
University staff start-ups	25.00	30.00	17.00
University graduates' start-ups	75.00	80.00	68.00
University spin-offs	87.00	43.00	36.00
Venture capitalists support	91.00	70.00	58.00
University Science park	37.00	16.00	14.00
External Science park	29.00	23.00	23.00
TTO exists at the University	79.00	46.00	45.00
TTO and other organisations	16.00	43.00	25.00
University Business incubator	79.00	66.00	63.00
External Business incubator	8.00	–	3.50
Number of universities in the sample	24	30	85

entrepreneurial capital consists of looking at the latter, while research conducted over the past decade has placed its emphasis on licensing revenues (Markman et al., 2005). These two metrics (IP revenues and new ventures creation) represent a certain status quo for accessing the entrepreneurial university within the framework of the profit-orientation model.

The benchmark of entrepreneurial capital is the number of new companies created by exploring university inventions (Markman et al., 2009). However, according to Siegel and Wright (2015), this measure does not capture the number of new ventures created by students, while entrepreneurial activity usually originates from student-led start-ups supplemented by programmes and classes. According to Astebro et al. (2012), there is a lack of studies within the area examining new ventures created by students. We address this gap by including the measure of students' enterprise in the research.

Thus, our dependent variables represent IP revenues generation as well as the creation of three types of entrepreneurial university ventures, which are academic spin-offs, staff and graduate start-ups. We have provided definitions of all three types of companies as well as some other variables included in the modelling in Table 9. We used natural logarithms for all the dependent variables (Siegel et al., 2003).

3.3 Independent variables

We grouped independent variables based on the outcomes of activities with four different stakeholder types (see Table 9 in Appendix A).

3.3.1 Knowledge enablers

The government is represented by the value of collaborative research contracts per staff member, or by the total funding that government (both the UK and EU) provides to universities to conduct research (Guerrero et al., 2015). Industry as a stakeholder is represented by the total value of consultancy per staff member and the training courses that universities provide for businesses (Hewitt-Dundas, 2012) (e.g., bespoke courses at business premises and courses for professional development), as well as the value of contract research.

3.3.2 Knowledge providers

Knowledge providers, as stakeholders, are represented by the total number of research staff, teaching staff and research and teaching staff together (Belitski & Heron, 2017). We have also included the number of doctoral students and those studying other higher degrees (Hayter et al., 2018). Additionally, we have considered the share of undergraduates and postgraduates taking STEM, biology, medicine and physics, business and administrative courses, as well as university employment indicators per 1,000 students (Pavone, 2019).

3.3.3 Knowledge codifiers

TTO services might be both internal and/or external to the university (Siegel et al., 2003). Along with the IPOs, as a stakeholder, which is represented by the number of patents

granted per staff member (Hewitt-Dundas, 2012) we consider IPOs and TTOs as representatives of the knowledge codifier stakeholder group.

3.3.4 Knowledge facilitators

Venture capitalists, as stakeholders, are represented by the total value of investment university spin-offs and staff and graduate start-ups receive. We measure collaboration between universities and science parks and business incubators by identifying whether universities provide such services, whether internally and/or through outsourcing.

In the final modelling, some of the variables described above have been excluded due to the multicollinearity issues. Descriptive statistics of the sample are presented in Table 10 while the correlation matrix is presented in Table 11.

To check, whether the variables chosen actually represent the stakeholder subgroup, we applied the Cronbach alpha approach. Cronbach's alpha is a measure of scale reliability and might be written as a function of tested items number, the average inter-correlation among them and the cut-off point (Wooldridge, 2010).

All new constructs have Cronbach alpha greater than 0.70, which is the reliability threshold for this analysis (Cronbach, 1951). The variables used to create Cronbach alphas are described in Table 9 (Appendix A). Control variables and their effect are presented in Appendix B.

3.4 Method

We test our hypotheses using the pooled ordinary least squares (POLS) with university and time fixed effects.

The following model was estimated:

$$y_{it} = f\left(\beta x_{it,}\theta z_{it,}\alpha_i, \lambda_t, \mu_{it}\right)\ i = 1, \ldots, \mathrm{N}; \mathrm{t} = 1, \ldots, T \tag{1}$$

where y_{it} is a set of dependent variables (represented by IP revenues as well as new ventures creation (including university spin-offs and staff and graduate start-ups)) of a university i at time t. $\hat{I}^2$ and ÆŸ are parameters to be estimated, x_{it} is a vector of independent explanatory variables lagged 1 year (four groups of stakeholders), z_{it} is a vector of exogenous control variables lagged 1 year; α_i presents time fixed effects to capture potential changes over time for all universities (e.g. research assessment exercises for UK universities in 2014); and λ_t presents university fixed effects to measure the potential changes within each university over time (e.g. university-specific characteristics such as culture, traditions, informal institutions etc.);μ_{it} is a common intercept in the Model 1 (Wooldridge, 2010).

As a robustness check, in addition to the Pooled OLS basic estimation we estimate Eq. (2) adding interactions between stakeholders (φ_{it}) :

$$y_{it} = f\left(\beta x_{it,}\psi\varphi_{it}\theta z_{it,}\alpha_i, \lambda_t, \mu_{it}\right)\mathrm{i} = 1, \ldots, \mathrm{N}; \mathrm{t} = 1, \ldots, \mathrm{T} \tag{2}$$

where y_{it} is a set of dependent variables (represented by IP revenues as well as new ventures creation (including university spin-offs and staff and graduate start-ups)) of a university i at time t. $\hat{I}^2$, ψ and ÆŸ are parameters to be estimated, x_{it} is a vector of independent

explanatory variables lagged 1 year (four groups of stakeholders), z_{it} is a vector of exogenous control variables lagged 1 year; φ_{it} is a vector of interactions between stakeholders lagged 1 year; α_i presents time fixed effects to capture potential changes over time for all universities (e.g. research assessment exercises for UK universities in 2014); and λ_t presents university fixed effects to measure the potential changes within each university over time (e.g. university-specific characteristics such as culture, traditions, informal institutions etc.); μ_{it} is a common intercept in the Model 2 (Bell & Jones, 2014).

Interaction effects were applied to check if the effect of one variable depends on the value of another variable (Bell & Jones, 2014).

To incorporate the potential non-linear relationship between the dependent and independent variables, we use logarithmic transformations of some variables. To address the concern of multicollinearity, we used a variance inflation factor (VIF) which was always less than 5 for each variable (Wooldridge, 2010).

4 Results

We start by reporting the results of Tables A 6—9, which illustrate the effect of stakeholders and their support on generation of the entrepreneurial outcomes including IP revenues and new ventures creation (university spin-offs, staff and graduate start-ups). The results are grouped by university type and include four different models of university collaboration with stakeholders. We report the main findings in this section and discuss them in the next section for all the university types.

We analysed pooled data for all three university types – Russel group, polytechnics, teaching-led university.

4.1 Russel group universities

Results for the conceptual model of the Russel group universities are reported in Table 2 (spec. 1–4).

As for the *knowledge enablers*, the financial support from the government contributes to both IP revenues and new companies' creation at university while the one from industry is only significant for new companies' creation. Table 2 (spec. 1–4) demonstrates that increase in other funding by 1% increases IP revenues generation by 0.06% ($\beta = 0.060$, $p < 0.050$) and spin-offs creation by 0.04% ($\beta = 0{,}045$, $p < 0.050$). In addition, an increase of 1% in the financial support from other government departments boosts university spin-offs creation by 0.06% ($\beta = 0.060$, $p < 0.010$).

Support of *knowledge providers* was found to be important to increase IP revenues generation and start-ups creation. However, Russel group universities with a large number of other high qualification students are less likely to increase their IP revenues compared to other Russel group universities with fewer "other students". An increase of 1% of such students reduces IP revenues by 1.24% ($\beta = -1{,}244$, $p < 0.001$). An increase in teaching capital by 1% rises IP revenues by 0.25% ($\beta = 0{,}253$, $p < 0.010$). When it comes to the university research capital, its growth by 1% increases IP revenues by 0.84% ($\beta = 0{,}836$, $p < 0.001$), university spin-offs by 0.42% ($\beta = 0{,}415$, $p < 0.010$) and graduate start-ups by 0.81% ($\beta = 0{,}809$, $p < 0.05$). Turning to the undergraduate and postgraduate students, their effect varies between the type of study and the outcome variables (see Table 2, spec. 1–4).

Table 2 Results for Pooled OLS regression for the Russel group universities

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Specification	5 (1)	6—2	7—3	8—4
Independent variables	Russel group universities			
	Knowledge enablers (H1)			
Other government funding	− 0.001 (− 0.044)	0.060* (− 0.034)	0.034 (− 0.055)	0.002 (− 0.023)
Other funding	0.060** (− 0.029)	0.045** (− 0.022)	0.003 (− 0.037)	− 0.025 (− 0.015)
Bespoke courses for business	4.567 (− 755.492)	713.526 (− 582.815)	986.99 (− 952.185)	164.833 (− 391.954)
Consultancy and CPD	− 0.117 (− 0.185)	− 0.003 (− 0.142)	0.23 (− 0.233)	0.111 (− 0.096)
	Knowledge providers (H2)			
Other high qualifications	− 1.244*** (− 0.356)	− 0.397 (− 0.274)	0.527 (− 0.448)	− 0.109 (− 0.185)
Teaching capital	0.253* (− 0.135)	− 0.050 (− 0.104)	0.020 (− 0.170)	0.057 (− 0.07)
Research capital	0.836*** (− 0.288)	0.415* (− 0.222)	0.809** (− 0.363)	0.022 (− 0.149)
Teaching and research capital	0.334*** (− 0.102)	0.132* (− 0.078)	0.199 (− 0.128)	0.018 (− 0.053)
STEM UG	19.683*** (− 4.851)	1.597 (− 3.742)	− 6.577 (− 6.114)	− 0.072 (− 2.517)
STEM PG	− 8.572 (− 6.813)	− 4.928 (− 5.256)	− 7.071 (− 8.586)	1.374 (− 3.534)
Biology PG	− 0.774 (− 4.087)	3.232 (− 3.153)	3.958 (− 5.151)	− 1.567 (− 2.120)
Biology UG	− 12.309*** (− 2.775)	1.151 (− 2.141)	12.288*** (− 3.498)	2.996** (− 1.440)

Table 2 (continued)

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Business PG	− 2.809 (− 4.912)	− 1.277 (− 3.79)	− 7.789 (− 6.191)	− 2.121 (− 2.549)
Business UG	− 21.991*** (− 5.858)	− 5.812 (− 4.519)	7.598 (− 7.383)	2.288 (− 3.039)
Employment rate	− 0.071 (− 0.538)	− 0.243 (− 0.415)	− 0.887 (− 0.677)	− 0.393 (− 0.279)
	Knowledge codifiers (H3)			
Patents granted	− 81.022 (− 266.562)	− 315.645 (−205.636)	− 372.161 (− 335.961)	66.286 (− 138.294)
TTO exist at university	0.538** (− 0.219)	0.127 (− 0.169)	0.138 (− 0.276)	0.290** (− 0.113)
TTO and other organisations	0 (.)	0 (.)	0 (.)	0 (.)
	Knowledge facilitators (H4)			
External Science park	− 0.063 (− 0.302)	− 0.272 (− 0.233)	− 0.449 (− 0.380)	0.301* (− 0.157)
University Science park	0.496* (− 0.258)	0.005 (− 0.199)	0.077 (− 0.326)	0.228* (− 0.134)
University Business incubator	0.004 (− 0.285)	0.204 (− 0.219)	0.374 (− 0.359)	0.122 (− 0.148)
External Business incubator	0.889** (− 0.411)	− 0.460 (− 0.317)	1.388*** (− 0.518)	0.222 (− 0.213)
Investment in spin-offs	− 0.042 (− 0.031)	0.025 (− 0.024)	− 0.110*** (− 0.040)	0.002 (− 0.016)
Investment in staff start-ups	0.049 (− 0.037)	− 0.031 (− 0.028)	− 0.036 (− 0.046)	0.090*** (− 0.019)
Investment in graduate start-ups	− 0.067** (− 0.028)	0.003 (− 0.022)	0.113*** (− 0.036)	− 0.016 (− 0.015)

Table 2 (continued)

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
	Control variables			
Income from infrastructure	− 0.103**	− 0.076**	− 0.086	− 0.075***
	(− 0.049)	(− 0.038)	(− 0.062)	(− 0.025)
Business engagement	0.022	− 0.059	0.105	0.014
	(− 0.127)	(− 0.098)	(− 0.160)	(− 0.066)
Incentives for business engagement	0.164	0.089	0.123	0.037
	(− 0.129)	(− 0.099)	(− 0.162)	(− 0.067)
Regional strategy	0.327	− 0.131	− 0.639**	− 0.076
	(− 0.233)	(− 0.180)	(− 0.294)	(− 0.121)
Widening participation access	0.121	0.073	0.176	0.033
	(− 0.258)	(− 0.199)	(− 0.325)	(− 0.134)
Graduates' retention into the region	0.805**	− 0.736**	0.372	0.418**
	(− 0.404)	(− 0.312)	(− 0.510)	(− 0.210)
Support for community	− 0.679**	− 0.133	− 0.146	− 0.053
	(− 0.291)	(− 0.225)	(− 0.367)	(− 0.151)
Developing local partnership	0.119	− 0.057	− 0.657	0.088
	(− 0.318)	(− 0.246)	(− 0.401)	(− 0.165)
Meeting regional skills needs	− 0.164	0.933**	− 0.091	− 0.626**
	(− 0.515)	(− 0.398)	(− 0.65)	(− 0.267)
Knowledge exchange	− 0.200	− 0.211	0.561	0.040
	(–0.300)	(− 0.232)	(− 0.378)	(− 0.156)
Supporting SME	0.050	0.225	0.928**	− 0.130
	(− 0.299)	(− 0.230)	(− 0.376)	(− 0.155)
Research collaboration	− 0.634	− 0.156	0.551	0.378*
	(− 0.426)	(− 0.329)	(− 0.537)	(− 0.221)
University established year	− 0.001	− 0.001	− 0.001	− 0.001
	(− 0.001))	(− 0.001)	(− 0.001)	(− 0.001)
University fixed effects	Yes	Yes	Yes	Yes

Table 2 (continued)

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Time fixed effects	Yes	Yes	Yes	Yes
Top 5 universities	1.758*** (− 0.429)	0.836** (− 0.331)	0.370 (− 0.541)	0.378* (− 0.223)
constant	10.584*** (− 3.867)	0.606 (− 2.983)	− 8.761* (− 4.874)	0.123 (− 2.006)
R2	0.799	0.528	0.684	0.574
F	11.102	3.133	6.047	3.763
Number of observations	168	168	168	168
* p < 0.1, ** p < 0.05, *** p < 0.01				

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Agency

Standard errors are in parenthesis

As for the *knowledge codifiers*, TTO set up at the university increases IP revenues generation by 0.54% (β = 0,538, p < 0.050) and staff start-ups creation by 0.29% (β = 0,290, $p < 0.050$) (Table 2, spec. 1–4).

When it comes to *knowledge facilitators*, university collaboration with the external science parks increases the creation of staff start-ups by 0.30% (β = 0,301, $p < 0.010$) while on-campus science parks boost IP revenues generation by 0.5% (β = 0,496, $p < 0.010$) and staff start-ups creation by 0.22% (β = 0,228, $p < 0.010$). Business incubators have positive effect on IP revenues (β = 0,889, $p < 0.050$) and graduate start-ups (β = 1,388, $p < 0.001$). An increase in investment into the university spin-offs by 1% reduces graduate start-ups creation by 0.11% (β = -0,110, $p < 0.001$), which may point to the competition for resources between start-ups and spinouts at university. An increase in investment into the staff start-ups by 1% increases staff start-ups creation by 0.09% (β = 0,090, $p < 0.001$). We also noticed that an increase in the investment into graduate start-ups by 1% increases the creation of this type of new ventures by 0.11% (β = 0,113, $p < 0.001$) while reducing IP revenues generation by almost 0.07% (β = − 0,067, $p < 0.050$) (Table 2, spec. 1–4).

Interaction analysis for the Russel group universities model is illustrated in Table 3 (spec. 1–4). The following combinations of stakeholders are positive and significant for the entrepreneurial outcomes of this university type: industry with TTOs for spin-offs creation (β = 1,779, $p < 0.010$); government with TTOs for university spin-offs (β = 0,696, $p < 0.050$) and staff start-ups creation (β = 0,317, $p < 0.010$); VC investments and students for staff start-ups creation (β = 0,427, $p < 0.050$).

We also found that the following combinations of stakeholders will negatively affect the entrepreneurial outcomes of the university (Table 3, spec.1–4). First, science parks and incubators with VC investments (β = -0,670, p < 0.001) and second—government with the faculty (β = -0,602, $p < 0.010$) reduce IP revenues; third—government with VC investments reduce staff start-ups creation activity (β = -0,187, $p < 0.010$); fourth—industry with VC investments reduces IP revenues generation (β = -1,326, $p < 0.010$) and staff start-ups creation (β = -1,162, $p < 0.050$); sixth—TTOs with faculty (β = − 0,412, $p < 0.010$) and faculty with VC investments reduce staff start-ups creation (β = − 0,541, $p < 0.001$). While we find several significant negative interactions between stakeholders, this does not diminish our findings and support for our hypotheses. One can also notice that most of the negative interactions were with the VC. In the interaction analysis, we consider the joint effects of stakeholders on entrepreneurial outcomes of the university, while negative values demonstrate that these two types of stakeholders are complements. Universities as any organization pursue cost minimization strategies given time, managerial and financial constraints, and once the VC support is secured, universities may want to cut down on other forms of collaborations with external stakeholders and prioritise VCs. This led to a negative coefficient in the regression. While each stakeholder has a positive direct effect on entrepreneurial outcomes (H1a-H4a), their joint effect may be conditional on resources and decision-making on each of stakeholder for university managers and may lead to a substitution of one stakeholder with another.

4.2 Former polytechnic universities

As for the *knowledge enablers* stakeholder group (Table 4, spec. 1–4), an increase in funding from other government departments by 1% increases IP revenues by almost 0.30% (β = 0,297, $p < 0.001$), as well as graduate start-ups creation by 0.14% (β = 0,138, $p < 0.050$) whereas reduces spin-offs creation by 0.06% (β = -0,062, $p < 0.010$). Increase

Table 3 Interaction effects for the Russel Group Universities

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
University type	Russel group university			
Specification	5	6	7	8
Science park & Business Incubators # Government	− 0.047 (− 0.24)	0.267 (− 0.23)	0.230 (− 0.3)	0.035 (− 0.15)
Science park & Business Incubators # Industry	− 0.467 (− 1.13)	− 0.412 (− 1.09)	2.251 (− 1.42)	− 0.100 (− 0.71)
Science park & Business Incubators # TTOs	− 0.063 (− 0.2)	0.094 (− 0.2)	− 0.285 (− 0.25)	− 0.171 (− 0.13)
Science park & Business Incubators # University faculty	− 0.310 (− 0.32)	− 0.051 (− 0.31)	0.208 (− 0.4)	− 0.050 (− 0.2)
Science park & Business Incubators # VC investments	− 0.670*** (− 0.18)	0.071 (− 0.17)	0.227 (− 0.22)	− 0.127 (− 0.11)
Science park & Business Incubators # University students	0.065 (− 0.41)	− 0.331 (− 0.4)	0.037 (− 0.52)	0.024 (− 0.26)
Science park & Business Incubators # Total number of patents granted per staff	210.200 (− 507.9)	492.100 (− 489.62)	− 402.300 (− 640.01)	− 166.000 (− 321.29)
Government # industry collaboration	− 0.004 (− 1.02)	− 1.566 (− 0.99)	− 2.447* (− 1.29)	− 0.242 (− 0.65)
Government # TTOs	− 0.210 (− 0.3)	0.696** (− 0.29)	− 0.046 (− 0.37)	0.317* (− 0.19)
Government # University faculty	− 0.602* (− 0.32)	− 0.482 (− 0.31)	− 0.153 (− 0.4)	0.091 (− 0.2)
Government # VC investments	− 0.035 (− 0.15)	− 0.144 (− 0.15)	0.006 (− 0.19)	− 0.187* (− 0.1)
Government # University students	0.068 (− 0.36)	0.438 (− 0.35)	0.643 (− 0.46)	− 0.060 (− 0.23)
Government # Total number of patents granted per staff	322.600 (− 294.24)	50.530 (− 283.65)	− 287.700 (− 370.78)	383.900** (− 186.14)
Industry # TTOs	1.143 (− 0.96)	1.779* (− 0.93)	− 1.031 (− 1.22)	− 0.300 (− 0.61)

Table 3 (continued)

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Industry # University faculty	− 2.322 (− 1.47)	0.590 (− 1.41)	2.426 (− 1.85)	0.072 (− 0.93)
Industry # VC investments	− 1.326* (− 0.78)	0.554 (− 0.76)	1.238 (− 0.99)	− 1.162** (− 0.5)
Industry # University students	0.848 (− 1.52)	− 0.535 (− 1.47)	1.021 (− 1.92)	1.157 (− 0.96)
Industry # Total number of patents granted per staff	− 407.000 (− 1323.05)	860.800 (− 1275.44)	272.900 (− 1667.2)	849.200 (− 836.95)
TTOs # University faculty	− 0.409 (− 0.35)	− 0.214 (− 0.34)	0.203 (− 0.45)	− 0.412* (− 0.22)
TTOs # VC investments	0.196 (− 0.22)	− 0.206 (− 0.21)	− 0.109 (− 0.27)	− 0.068 (− 0.14)
TTOs # University students	− 0.014 (− 0.33)	0.060 (− 0.31)	0.612 (− 0.41)	0.062 (− 0.21)
TTOs # Total number of patents granted per staff	103.200 (− 257.22)	− 97.720 (− 247.96)	16.820 (− 324.12)	− 95.320 (− 162.71)
University faculty # VC investments	− 0.174 (− 0.25)	0.866*** (− 0.24)	0.427 (− 0.32)	− 0.541*** (− 0.16)
University faculty # University students	− 0.158 (− 0.77)	− 0.604 (− 0.74)	0.976 (− 0.97)	1.197** (− 0.49)
University faculty # Total number of patents granted per staff	234.900 (− 569.12)	− 116.300 (− 548.64)	− 2659.7*** (− 717.16)	− 78.910 (− 360.02)
VC investments # University students	0.096 (− 0.31)	− 0.048 (− 0.3)	0.145 (− 0.39)	0.427** (− 0.19)
VC investments # Total number of patents granted per staff	50.350 (− 300.24)	476.100 (− 289.44)	898.200** (− 378.34)	− 659.500*** (− 189.93)
University established year	− 0.084 (− 0.07)	− 0.109 (− 0.07)	0.246*** (− 0.09)	0.071 (− 0.04)

Table 3 (continued)

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Constant	163.500 (− 125.72)	199.100 (− 121.2)	− 446.500*** (− 158.43)	− 130.200 (− 79.53)
Number of observations	168	168	168	168
r2	0.900	0.635	0.843	0.685
F stat	14.532	2.800	8.665	3.514
* p < .10 **, p < .05, *** p < .01				

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Agency

Standard errors are in parenthesis

Table 4 Results for Pooled OLS regression for the Polytechnic universities and Rest teaching universities

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Specification	1	2	3	4	5	6	7	8
Independent variables	**Polytechnic universities**				**Rest teaching universities**			
Knowledge enablers (H1)								
Other government funding	0.297***	− 0.062*	0.138**	0.019	0.130***	0.020*	0.013	− 0.008
	(− 0.108)	(− 0.032)	(− 0.063)	(− 0.027)	(− 0.035)	(− 0.011)	(− 0.029)	(− 0.009)
Other funding	− 0.105	− 0.029	0.143***	− 0.028*	0.149***	0.009	0.068***	0.015**
	(− 0.066)	(− 0.019)	(− 0.038)	(− 0.017)	(− 0.030)	(− 0.010)	(− 0.026)	(− 0.008)
Bespoke courses for business	114.401	− 350.770*	− 715.584*	− 387.042**	6.825	1.027	− 28.008	− 10.089
	(− 635.776)	(− 188.170)	(− 368.687)	(− 160.950)	(− 31.422)	(− 9.981)	(− 26.553)	(− 7.869)
Consultancy and CPD	0.546**	0.210***	− 0.689***	− 0.033	0.136**	0.013	− 0.010	0.016
	(− 0.264)	(− 0.078)	(− 0.153)	(− 0.067)	(− 0.055)	(− 0.017)	(− 0.046)	(− 0.014)
Knowledge providers (H2)								
Other high qualifications	0.474	0.060	0.541**	− 0.314***	0.134*	0.043*	0.168**	− 0.017
	(− 0.423)	(− 0.125)	(− 0.245)	(− 0.107)	(− 0.080)	(− 0.025)	(− 0.068)	(− 0.020)
Teaching capital	− 0.178**	− 0.026	− 0.057	− 0.027	0.073*	− 0.016	0.017	0.007
	(− 0.083)	(− 0.024)	(− 0.048)	(− 0.021)	(− 0.040)	(− 0.013)	(− 0.034)	(− 0.010)
Research capital	0.278	− 0.056	0.071	− 0.058	0.212***	0.004	− 0.009	0.001
	(− 0.243)	(− 0.072)	(− 0.141)	(− 0.062)	(− 0.075)	(− 0.024)	(− 0.064)	(− 0.019)
Teaching and research capital	0.139	− 0.046	− 0.128**	0.011	0.007	0.004	− 0.260***	0.002
	(− 0.102)	(− 0.03)	(− 0.059)	(− 0.026)	(− 0.057)	(− 0.018)	(− 0.048)	(− 0.014)
STEM UG	2.962	3.723*	8.954**	3.030*	3.645**	− 0.866*	1.712	− 0.235
	(− 6.667)	(− 1.973)	(− 3.866)	(− 1.688)	(− 1.59)	(− 0.508)	(− 1.344)	(− 0.398)
STEM PG	− 5.922	− 2.040	− 9.718	0.188	0.926	0.739	− 1.640	0.317
	(− 12.973)	(− 3.840)	(− 7.523)	(− 3.284)	(− 1.729)	(− 0.549)	(− 1.461)	(− 0.433)
Biology PG	− 8.896	2.620	7.531	0.156	5.436***	− 0.445	− 1.329	− 0.590
	(− 12.606)	(− 3.731)	(− 7.310)	(− 3.191)	(− 1.709)	(− 0.542)	(− 1.444)	(− 0.428)

Table 4 (continued)

Dependent variables		IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation		Staff s-ups creation
Biology UG	− 13.047**		− 1.406	4.005	2.302	− 2.746**	− 1.015***	− 1.024	0.019	
	(− 6.120)		(− 1.811)	(− 3.549)	(− 1.549)	(− 1.172)	(− 0.372)	(− 0.991)	(− 0.294)	
Business PG	− 5.551		− 4.642**	− 2.953	− 0.396	2.594**	− 0.593	3.786***	− 0.058	
	(− 7.842)		(− 2.321)	(− 4.548)	(− 1.985)	(− 1.162)	(− 0.369)	(− 0.982)	(− 0.291)	
Business UG	5.598		1.220	− 5.936**	− 2.840**	− 6.133***	− 0.142	− 0.100	0.691*	
	(− 4.599)		(− 1.361)	(− 2.667)	(− 1.164)	(− 1.572)	(− 0.500)	(− 1.329)	(− 0.394)	
Employment rate	1.828**		− 0.322	0.076	− 0.549**	1.157***	0.077*	0.073	0.023	
	(− 0.865)		(− 0.256)	(− 0.502)	(− 0.219)	(− 0.133)	(− 0.042)	(− 0.112)	(− 0.033)	
Knowledge codifiers (H3)										
TTO exist at university		0.721	− 0.367*	− 0.960**	0.166	− 0.002	0.085	0.696***		0.021
		(− 0.728)	(− 0.216)	(− 0.422)	(− 0.184)	(− 0.222)	(− 0.070)	(− 0.187)		(− 0.056)
TTO and other organisations		0.837	− 0.211	0.008	0.289	0.620***	− 0.099	0.174		− 0.088*
		(− 0.721)	(− 0.213)	(− 0.418)	(− 0.182)	(− 0.206)	(− 0.065)	(− 0.174)		(− 0.052)
Patents granted		360.087*	19.433	− 314.140***	− 22.320	175.246***	49.656***	− 51.517		− 5.720
		(− 187.058)	(− 55.366)	(− 108.475)	(− 47.354)	(− 55.550)	(− 17.626)	(− 46.944)		(− 13.912)
Knowledge facilitators (H4)										
External Science park		0.382	0.311***	− 0.218	− 0.034	0.170	0.043	− 0.182		− 0.008
		(− 0.393)	(− 0.116)	(− 0.228)	(− 0.100)	(− 0.205)	(− 0.065)	(− 0.173)		(− 0.051)
University Science park		0.204	0.434***	− 0.594*	0.214	− 0.043	0.241***	− 0.448**		0.253***
		(− 0.531)	(− 0.157)	(− 0.308)	(− 0.134)	(− 0.242)	(− 0.077)	(− 0.204)		(− 0.061)
University Business incubator		− 0.605*	− 0.094	1.397***	0.170*	− 0.030	0.052	0.409***		− 0.005
		(− 0.341)	(− 0.101)	(− 0.198)	(− 0.086)	(− 0.174)	(− 0.055)	(− 0.147)		(− 0.044)
External Business incubator		− 0.259	− 0.199	− 0.042	0.744**	1.394***	− 0.030	0.194		− 0.002
		(− 1.355)	(− 0.401)	(− 0.786)	(− 0.343)	(− 0.423)	(− 0.134)	(− 0.357)		(− 0.106)
Investment in spin− offs		0.086	0.048**	− 0.005	0.009	0.157***	0.019**	0.009		0.002
		(− 0.064)	(− 0.019)	(− 0.037)	(− 0.016)	(− 0.026)	(− 0.008)	(− 0.022)		(− 0.007)

Table 4 (continued)

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Investment in staff start− ups	− 0.147 (− 0.158)	0.059 (− 0.047)	− 0.185** (− 0.091)	0.170*** (− 0.040)	0.113** (− 0.048)	0.002 (− 0.015)	− 0.010 (− 0.040)	0.095*** (− 0.012)
Investment in graduate start− ups	0.009 (− 0.065)	− 0.036* (− 0.019)	0.064* (− 0.038)	− 0.046*** (− 0.016)	0.044 (− 0.035)	0.017 (− 0.011)	0.216*** (− 0.030)	0.018** (− 0.009)
Control variables								
Income from infrastructure	− 0.136* (− 0.077)	0.001 (− 0.023)	0.075* (− 0.044)	− 0.010 (− 0.019)	0.094*** (− 0.029)	− 0.002 (− 0.009)	0.011 (− 0.024)	− 0.011 (− 0.007)
Business engagement	− 0.784*** (− 0.197)	− 0.010 (− 0.058)	0.211* (− 0.114)	0.069 (− 0.05)	− 0.099 (− 0.086)	− 0.009 (− 0.027)	0.259*** (− 0.073)	0.018 (− 0.022)
Incentives for business engagement	0.554** (− 0.220)	0.103 (− 0.065)	0.022 (− 0.128)	− 0.007 (− 0.056)	− 0.352*** (− 0.103)	0.021 (− 0.033)	− 0.137 (− 0.087)	0.007 (− 0.026)
Regional strategy	− 0.985*** (− 0.320)	0.140 (− 0.095)	− 0.114 (− 0.185)	0.316*** (− 0.081)	− 0.681*** (− 0.153)	0.289*** (− 0.049)	0.224* (− 0.129)	0.152*** (− 0.038)
Widening participation access	0.773** (− 0.383)	− 0.033 (− 0.113)	− 0.708*** (− 0.222)	0.097 (− 0.097)	0.306* (− 0.168)	0.014 (− 0.053)	− 0.122 (− 0.142)	− 0.048 (− 0.042)
Graduates' retention into the region	0.785** (− 0.368)	− 0.111 (− 0.109)	1.006*** (− 0.214)	− 0.223** (− 0.093)	− 0.547*** (− 0.174)	0.015 (− 0.055)	0.036 (− 0.147)	0.002 (− 0.043)
Support for community	0.09 (− 0.467)	− 0.026 (− 0.138)	0.935*** (− 0.271)	− 0.327*** (− 0.118)	− 0.196 (− 0.196)	− 0.002 (− 0.062)	− 0.202 (− 0.166)	0.043 (− 0.049)
Developing local partnership	1.026*** (− 0.379)	− 0.123 (− 0.112)	− 0.644*** (− 0.220)	0.086 (− 0.096)	0.141 (− 0.198)	− 0.041 (− 0.063)	0.312* (− 0.168)	0.037 (− 0.050)
Meeting regional skills needs	− 0.432 (− 0.443)	0.019 (− 0.131)	0.622** (− 0.257)	0.05 (− 0.112)	− 0.336* (− 0.179)	− 0.003 (− 0.057)	0.323** (− 0.151)	0.013 (− 0.045)
Knowledge exchange	0.819* (− 0.418)	0.247** (− 0.124)	0.603** (− 0.242)	0.273** (− 0.106)	− 0.13 (− 0.224)	0.256*** (− 0.071)	0.162 (− 0.189)	0.106* (− 0.056)
Supporting SME	0.038 (− 0.411)	− 0.186 (− 0.122)	0.103 (− 0.238)	0.104 (− 0.104)	0.403** (− 0.165)	− 0.132** (− 0.052)	0.310** (− 0.140)	0.010 (− 0.041)

Table 4 (continued)

Dependent variables	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Research collaboration	− 0.047 (− 0.338)	− 0.111 (− 0.100)	0.037 (− 0.196)	0.127 (− 0.086)	0.349* (− 0.180)	0.070 (− 0.057)	− 0.019 (− 0.152)	− 0.018 (− 0.045)
University established year	0.005* (− 0.003)	0.001 (− 0.001)	0.004*** (− 0.002)	− 0.002** (− 0.001)	− 0.001 (− 0.001)	− 0.001*** (0.001)	0.001** (− 0.001)	0.001 (0.001)
University fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
constant	− 23.420*** (− 7.359)	1.359 (− 2.178)	− 4.666 (− 4.268)	7.494*** (− 1.863)	− 4.656** (− 1.813)	1.075* (− 0.576)	− 3.692** (− 1.532)	− 0.168 (− 0.454)
R^2	0.529	0.445	0.736	0.574	0.686	0.425	0.406	0.301
F	4.215	3.008	10.457	5.051	27.764	9.361	8.685	5.48
Number of observations	210	210	210	210	605	603	605	605

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Agency

Standard errors are in parenthesis

in other government funding by 1% boosts the creation of graduate start-ups by 0.14% (β = 0,143, $p < 0.001$) while reduces staff start-ups by almost 0.03% (β = -0,028, $p < 0.001$). Growth of revenues from bespoke courses does not affect university new ventures creation. Growth in revenues from consultancy and CPD courses by 1% increases IP revenues by 0.55% (β = 0,546, $p < 0.050$) and spin-offs creation by 0.21% (β = 0,210, $p < 0.001$), while reduces graduate start-up's creation by 0.69% (β = -0,689, $p < 0.001$).

With respect to *knowledge providers*, an increase in students within the other high degree by 1% boosts graduate start-ups creation by 0.54% (β = 0,541, $p < 0.050$), while reducing staff start-ups creation by 0.31% (β = -0,314, $p < 0.001$). An increase in university teaching only capital by 1% reduces IP revenues generation by 0.18% (β = -0,178, $p < 0.050$). Surprisingly, university research only capital have no effect on outcome variables for this university type. As for the mix of teaching and research capital, an increase in this human capital by 1% reduce graduate start-ups creation by 0.13% (β = -0,128, $p < 0.050$). As for the undergraduate and postgraduate students, they have different effects on outcome variables (see Table 4, spec. 1–4), however, the standard error is high enough making the influence not significant.

When it comes to *knowledge codifiers*, for this type of the university, the support provided by TTO set up at the university reduces university spin-offs creation by 0.37% (β = − 0,367, $p < 0.010$) and graduate start-ups creation by 0.96% (β = -0,960, $p < 0.050$). When it comes to patenting offices, they have an effect on outcomes variables while it is not significant due to the high standard error.

With respect to the *knowledge facilitators* (Table 4, spec. 1–4), the support of external science park causes a 0.31% rise in the creation of university spin-offs (β = 0,311, $p < 0.001$). If science park set up within the university, this might increase the creation of spin-offs by 0.43% (β = 0,434, $p < 0.001$), while the creation of graduate start-ups would decrease by 0.59% (β = -0,594, $p < 0.010$). Support from business incubators which set up at the university could lead to the decrease in IP revenues generation by 0.60% (β = − 0,605, $p < 0.010$), while increasing staff and graduate start-ups creation by 0.17% and 1.4% respectively (β = 0,170, $p < 0.010$; β = 1,397, $p < 0.001$). University collaboration with external business incubators boosts staff start-ups creation by 0.74% (β = 0,744, $p < 0.050$). When it comes to the funding, growth of investment from VCs into university spin-offs by 1% increases the creation of this type of new venture by almost 0.05% (β = 0,048, $p < 0.050$). Consequently, growth of investment into the staff start-ups by 1%, cause a rise in the creation of this type of new ventures by 0.17% (β = 0,170, $p < 0.001$), while reduce graduate start-up's creation by almost 0.19% (β = − 0,185, $p < 0.050$). Finally, an increase of the investment into graduate start-ups by 1% provides a chance of 0.06 more graduate start-ups would be created (β = − 0,064, $p < 0.010$), while 0.04% less of university spin-offs (β = − 0,036, $p < 0.010$) and 0.05% fewer of staff start-ups (β = − 0,046, $p < 0.001$) might be created.

Interaction analysis for the Polytechnics is illustrated in Table 5 (spec. 1–4). We found that a combination of science parks and business incubators with TTOs as well as government with TTOs increase IP revenues generation (β = 0,686, $p < 0.050$ and β = 0,385, $p < 0.010$ respectively). The combination of government with VC investment increases graduate start-ups creation (β = 0,491, $p < 0.010$).

We were also able to identify negative interactions between stakeholders in their effect on entrepreneurial outcomes. For example, we found negative interaction coefficients of Science Parks and Business Incubators with university students when it comes to the graduate start-ups creation (β = − 1,028, $p < 0.050$); and VC investments with students when it

Table 5 Interaction effects for Polytechnics Universities and other teaching-led universities

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
University type	Former Polytechnics				Other teaching-led universities			
Specification	1	2	3	4	5	6	7	8
Science park & Business Incubators # Government	− 0.442 (− 0.56)	0.375 (− 0.23)	− 0.319 (− 0.36)	0.072 (− 0.19)	0.005 (− 0.20)	0.150 (− 0.100)	− 0.238 (− 0.160)	0.096 (− 0.080)
Science park & Business Incubators # Industry	0.687 (− 1.85)	1.132 (− 0.76)	0.575 (− 1.19)	0.499 (− 0.62)	0.096 (− 0.33)	0.022 (− 0.17)	0.026 (− 0.26)	0.008 (− 0.13)
Science park & Business Incubators # TTOs	0.686** (− 0.26)	0.063 (− 0.11)	0.007 (− 0.17)	0.124 (− 0.09)	− 0.013 (− 0.12)	0.046 (− 0.06)	0.046 (− 0.1)	− 0.044 (− 0.05)
Science park & Business Incubators # University faculty	− 0.121 (− 0.67)	− 0.317 (− 0.28)	0.077 (− 0.43)	− 0.079 (− 0.23)	0.034 (− 0.19)	0.025 (− 0.1)	0.158 (− 0.15)	0.116 (− 0.07)
Science park & Business Incubators # VC investments	0.558 (− 0.49)	0.296 (− 0.2)	− 0.250 (− 0.32)	− 0.244 (− 0.17)	− 0.316 (− 0.25)	− 0.330** (− 0.13)	− 0.550*** (− 0.2)	− 0.143 (− 0.1)
Science park & Business Incubators # University students	0.556 (− 0.78)	0.002 (− 0.32)	− 1.028** (− 0.5)	− 0.368 (− 0.26)	− 0.083 (− 0.21)	− 0.060 (− 0.11)	0.161 (− 0.17)	− 0.071 (− 0.08)
Science park & Business Incubators # Total number of patents granted per staff	− 81.570 (− 407.46)	314.900* (− 166.61)	− 422.200 (− 262.37)	177.500 (− 137.83)	− 36.090 (− 80.17)	− 24.640 (− 40.86)	4.267 (− 64.44)	− 41.840 (− 31.58)

Table 5 (continued)

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Government # industry collaboration	− 3.308** (− 1.29)	− 0.309 − 0.53 ()	− 0.107 (−0.83)	0.674 (− 0.44)	0.026 (− 0.22)	0.050 (− 0.11)	0.045 (− 0.18)	0.027 (− 0.09)
Government # TTOs	0.385* (− 0.22)	0.136 (− 0.09)	0.168 (− 0.14)	0.014 (− 0.07)	− 0.141 (− 0.11)	− 0.088 (− 0.05)	0.130 (− 0.09)	− 0.021 (− 0.04)
Government # University faculty	0.573 (− 0.58)	− 0.166 (− 0.24)	0.292 (− 0.37)	− 0.146 (− 0.2)	0.320* (− 0.19)	0.038 (− 0.1)	0.127 (− 0.15)	0.014 (− 0.08)
Government # VC investments	− 0.301 (− 0.4)	− 0.231 (− 0.16)	0.491* (− 0.26)	− 0.073 (− 0.14)	− 0.170 (− 0.17)	0.131 (− 0.09)	− 0.147 (− 0.13)	0.142** (− 0.07)
Government # University students	− 0.411 (− 0.55)	0.083 (− 0.22)	0.122 (− 0.35)	0.060 (− 0.19)	− 0.178 (− 0.22)	− 0.111 (− 0.11)	− 0.054 (− 0.17)	0.042 (− 0.09)
Government # Total number of patents granted per staff	125.600 (− 292.21)	− 124.600 (− 119.49)	57.690 (− 188.16)	− 151.800 (− 98.85)	− 86.710 (− 57.89)	− 10.730 (− 29.51)	− 3.463 (− 46.54)	− 25.490 (− 22.81)
Industry # TTOs	0.641 (− 0.72)	0.261 (− 0.3)	0.636 (− 0.47)	0.165 (− 0.25)	− 0.156 (− 0.2)	0.134 (− 0.1)	0.184 (− 0.16)	0.075 (− 0.08)
Industry # University faculty	4.364** (− 2.12)	0.386 (− 0.87)	0.398 (− 1.36)	− 0.197 (− 0.72)	0.381 (− 0.28)	− 0.033 (− 0.14)	0.140 (− 0.22)	− 0.002 (− 0.11)
Industry # VC investments	0.758 (− 2.5)	− 0.737 (− 1.02)	1.421 (− 1.61)	− 0.559 (− 0.85)	− 0.427 (− 0.29)	0.080 (− 0.15)	− 0.408* (− 0.23)	0.016 (− 0.11)
Industry # University students	− 1.593 (− 2.43)	0.075 (− 0.99)	− 2.897* (− 1.57)	− 0.037 (− 0.82)	0.033 (− 0.3)	0.169 (− 0.15)	0.333 (− 0.24)	0.068 (− 0.12)
Industry # Total number of patents granted per staff	354.400 (− 1134)	− 301.700 (− 463.7)	373.200 (− 730.2)	736.900* (− 383.6)	209.300* (− 110.03)	61.840 (− 56.11)	76.770 (− 88.45)	41.330 (− 43.35)
TTOs # University faculty	0.112 (−0.31)	− 0.039 (− 0.13)	− 0.084 (− 0.2)	− 0.095 (− 0.1)	0.097 (− 0.15)	0.022 (− 0.07)	0.002 (− 0.12)	− 0.011 (− 0.06)

Table 5 (continued)

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
TTOs # VC investments	− 0.059 (− 0.24)	− 0.069 (− 0.1)	− 0.202 (− 0.15)	− 0.063 (− 0.08)	− 0.217* (− 0.11)	0.013 (− 0.06)	− 0.085 (− 0.09)	− 0.026 (− 0.04)
TTOs # University students	− 0.044 (− 0.32)	0.017 (− 0.13)	0.406* (− 0.21)	− 0.019 (− 0.11)	− 0.089 (− 0.18)	− 0.062 (− 0.09)	− 0.162 (− 0.14)	0.022 (− 0.07)
TTOs # Total number of patents granted per staff	− 230.200 (− 171.71)	− 81.050 (− 70.21)	169.001 (− 110.56)	− 111.300* (− 58.08)	− 37.140 (− 52.05)	− 44.410* (− 26.53)	18.910 (− 41.84)	12.590 (− 20.5)
University faculty # VC investments	− 0.357 (− 0.69)	− 0.198 (− 0.28)	0.038 (− 0.44)	− 0.111 (− 0.23)	− 0.350 (− 0.24)	− 0.061 (− 0.12)	− 0.453** (− 0.19)	− 0.116 (− 0.09)
University faculty # University students	− 1.316 (− 0.89)	− 0.252 (− 0.36)	− 0.221 (− 0.57)	0.197 (− 0.3)	0.414 (− 0.29)	− 0.089 (− 0.15)	0.329 (− 0.23)	− 0.022 (− 0.12)
University faculty # Total number of patents granted per staff	− 113.200 (− 387.31)	− 103.900 (− 158.37)	34.530 (− 249.39)	105.001 (− 131.02)	116.800 (− 128.34)	− 138.20** (− 65.42)	− 18.200 (− 103.16)	47.890 (− 50.56)
VC investments # University students	− 0.114 (− 0.8)	− 0.904*** (− 0.33)	0.327 (− 0.51)	0.068 (− 0.27)	0.336 (− 0.25)	0.063 (− 0.13)	− 0.505** (− 0.2)	− 0.063 (− 0.1)
VC investments # Total number of patents granted per staff	− 104.400 (− 373.68)	− 205.200 (− 152.8)	566.700** (− 240.62)	56.190 (− 126.4)	− 122.300* (− 71.19)	− 26.160 (− 36.3)	− 59.210 (− 57.22)	− 6.706 (− 28.04)
University established year	0.028 (− 0.02)	0.015** (− 0.01)	0.031*** (− 0.01)	0.032*** (− 0.01)	− 0.220*** (− 0.02)	− 0.003 (− 0.01)	− 0.044** (− 0.02)	0.003 (− 0.01)
Constant	− 51.860 (− 32.27)	− 29.620** (− 13.19)	− 54.830*** (− 20.78)	− 61.08*** (− 10.92)	442.500*** (− 44.08)	6.744 (− 22.47)	88.860** (− 35.43)	− 7.076 (− 17.36)

Table 5 (continued)

	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation	IP revenues	Uni spin-offs creation	Graduate s-ups creation	Staff s-ups creation
Number of observations	210	210	210	210	598	596	598	598
r2	0.846	0.654	0.893	0.751	0.916	0.601	0.855	0.546
F stat	10.936	3.759	16.708	6.011	40.829	5.624	22.176	4.502

* p < .10, ** p < .05, *** p < .01

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Agency

comes to the creation of spin-offs (β = − 0,904, $p < 0.001$). The number of negative effects is less associated with teaching type of universities than with research-led universities as they have lower opportunity costs of collaboration and are more likely to collaborate with multiple stakeholders, while research-led universities are more selective in the choice of stakeholders (Table 6).

4.3 Other teaching-led universities

When it comes to *knowledge enablers* (Table 4, spec. 5–8), an increase in financial support from other government departments by 1% enlarge IP revenues generation by 0.13% (β = 0,130, $p < 0.001$) as well as spin-offs creation by 0.02% (β = 0,020, $p < 0.010$). An increase in other funding by 1% enlarge IP revenues generation by 0.15% (β = 0,149, $p < 0.001$), graduate and staff start-ups creation by almost 0.07% and 0.02% respectively (β = 0,068, $p < 0.001$ and β = 0,015, $p < 0.050$). As for the bespoke courses university provide for industry, it has a positive effect on graduate start-ups creation while it is not significant. In addition, an increase in the income from consultancy and CPD courses for business by 1% enlarge IP revenues generation by 0.14% (β = 0,136, $p < 0.050$).

As for the *knowledge providers* (Table 4, spec. 5–8), growth in the number of other high qualification students by 1% increase IP revenues generation by 0.13% (β = 0,134, $p < 0.010$), creation of university spin-offs by 0.04% (β = 0,043, $p < 0.010$) and graduate start-ups by 0.17% (β = 0,168, $p < 0.050$). Increase in university teaching only capital by 1% increase IP revenues by 0.07% (β = 0,073, $p < 0.010$). An increase in university research only capital by 1% boosts IP revenues by 0.21% (β = 0,212, $p < 0.001$) and spin-offs creation by 0.25% (β = 0,247, $p < 0.050$). However, growth in the number of faculty who perform a mix of research and teaching activities by 1% reduces the creation of graduate start-ups by 0.26% (β = -0,260, $p < 0.001$). As for the university undergraduates and postgraduates, they have different effects on outcome variables while only several of them are significant. Thus, an increase in biology, medicine and physics undergraduates by 1% decrease university spin-offs creation by 1.01% (β = 1,015, $p < 0.001$); increase in the number of business studies postgraduates enlarge graduate start-ups creation by 3.79% (β = 3,786, $p < 0.001$); and increase in business undergraduates by 1% cause rise in staff start-ups creation by almost 0.70% (β = 0,691, $p < 0.010$).

When it comes to *knowledge codifiers* (Table 4, spec. 5–8), TTO set up at the university boosts graduate start-ups creation by 0.70% (β = 0,696, $p < 0.001$). As for the collaboration of the university with external TTO, it has a chance to increase IP revenues generation by 0.62% (β = 0,620, $p < 0.001$), while reducing staff start-ups creation by almost 0.09% (β = − 0,088, $p < 0.010$).

As for the *knowledge facilitators* (Table 4, spec. 5–8), the support provided by science parks set up around the university cause rise in the creation of spin-offs by 0.24% (β = 0,241, $p < 0.001$) and staff start-ups creation by 0.25% (β = 0,253, $p < 0.001$), while it impacts negatively graduate start-ups' creation by 0.45% (β = -0,448, $p < 0.050$). When it comes to the support provided by business incubators set up at the university, they might lead to an increase in graduate start-ups' creation by 0.41% (β = 0,409, $p < 0.001$). For this type of universities, business incubators support out of the university boundaries might facilitate IP revenues generation by 1.39% (β = 1,394, $p < 0.001$). An increase of investment into university spin-offs might cause a rise in IP revenues generation by 0.16% (β = 0,157, $p < 0.001$), in university spin-offs creation by 0.02% (β = 0,019, $p < 0.050$). An increase of investment into staff start-ups by 1% boosts IP revenues generation by 0.11% (β = 0,113,

$p < 0.050$) and staff start-ups creation by almost 0.10% (β = 0,095, $p < 0.001$). An increase of the investment into graduate start-ups by 1% causes a rise of 0.22% and 0.02% in the creation of graduate (β = 0,216, p < 0.001) and staff (β = 0,018, p < 0.050) start-ups respectively.

Interaction analysis for the other teaching universities is illustrated in Table 5 (spec. 5–8). The following combinations of stakeholders are positive and significant for the entrepreneurial outcomes for this university type: government with faculty for IP revenues generation (β = 0,320, p < 0.010); government with VC investments for staff s-ups creation (β = 0,142, p < 0.050).

There were negative associations between science parks and business incubators with VC investments for spin-offs and graduate start-ups creation (β = -0,330, $p < 0.050$ and β = − 0,550, $p < 0.001$); industry vs VC investment for graduate start-ups creation (β = -0,408, p < 0.010); TTOs vs VC investments for IP revenues generation (β = -0,217, $p < 0.010$); Faculty vs VC investments and VC investments vs students for graduate start-ups creation (β = -0,453, $p < 0.050$ and β = -0,505, $p < 0.050$ respectively).

To conclude the results section, below we provide a Table 6 with all the Hypotheses and the outcomes of the calculations together with the explanation.

Table 6 Aggregated results of hypotheses testing

No	Hypotheses	Russel Group Universities	Former Polytechnic universities	Other teaching universities
1	H1a	Supported	N/A	N/A
	H1b	N/A	Supported	Supported
2	H2a	Supported	N/A	N/A
	H2b	N/A	Partly supported	Partly supported
3	H3a	Partly supported	N/A	N/A
	H3b	N/A	Partly supported	Partly supported
4	H4a	Supported	N/A	N/A
	H4b	N/A	Partly supported	Partly supported

Russel group universities Our results support H1a that knowledge enablers (government and industry) positively affect university start-up activity and the licensing of technologies proxied by IP revenues in research-oriented universities. In addition, H2a has been supported showing that knowledge providers positively affect university start-up activity and the licencing of technologies in research-oriented universities. The H3a is partly supported as knowledge codifiers have positively affected both licencing of technology and university start-up activities in research-oriented universities.

H4a has been supported showing that knowledge facilitators have a positive effect on both the licencing of technologies and university start-up activities in research-oriented universities.

Polytechnic universities Our finding partly supports H1b as knowledge enablers increase licencing of technologies, however, the effect on new business creation is mixed, mainly supporting graduate start-ups in teaching-oriented universities. H2b have been partly supported as knowledge providers have both positive and negative effect on new ventures creation and cause a negative effect on the licencing of technologies in teaching-oriented

universities. H3b has also been partly supported as knowledge codifiers indeed do not affect IP revenues generation for this university type (teaching-oriented) while is associated negatively with new companies' creation. H4b has been supported partly as well as knowledge facilitators have mixed effect on new ventures creation and are negatively associated with the licencing of technologies in teaching-oriented universities.

Other teaching universities H1b have been fully supported as knowledge enablers have a positive effect on university start-up activity and the licencing of technologies in teaching-oriented universities. H2b have been partly supported as knowledge providers have both positive and negative effect on university start-up activity and positive effect on the licencing of technologies in teaching-oriented universities. H3b have been partly supported as well as knowledge codifiers have both positive and negative effect on university start-up activities and are positive for the licencing of technologies in teaching-oriented universities. In addition, H4b has been partly supported as knowledge facilitators have mostly a positive effect on university start-up activity (except for the negative effect of science parks on graduate start-ups) and have a positive effect on the licencing of technologies in teaching-oriented universities.

5 Discussion

By analysing the impact of support provided by different actors to an entrepreneurial university, we classify stakeholders and conceptualise the process of knowledge creation and spillover from universities of different types. Our results demonstrate that while all the four stakeholder subgroups presented (knowledge enablers, creators, codifiers and facilitators) make a substantial contribution to the final outcome, their impact varies with the type of entrepreneurial university. In this section, we describe the commonalities and differences between universities, contribution to theory as well as discuss the outcomes with respect to the literature.

5.1 Commonalities and differences in the results

Based on the results across three groups of the universities the following commonalities and differences between university types were found.

Firstly, between the *Russel group and Polytechnic Universities* we found that when it comes to *IP revenues generation*, both university types do benefit from collaborating with government (via research funding) and Industry (via providing consultancy and trainings). Interestingly, while for Russel group universities teaching only and research only capital positively contribute to the final outcome, teaching only capital cause a negative effect for Polytechnics. As for TTOs and science parks, only Russel group universities are benefiting from collaborating with this stakeholder when it comes to IP revenues generation. Furthermore, business incubators positively contribute to IP income in Russel group universities, Polytechnics get a reversed effect on collaborating with this stakeholder.

When it comes to *new ventures creation*, while collaboration with government is positive for Russel group universities, the effect is twofold (both positive and negative) when it comes to Polytechnics. The same effect has both university faculty and science parks (positive for Russel group and twofold for Polytechnics). Interestingly while university students

are not significant for Russel group universities when it comes to new companies' creation, they have a twofold effect at Polytechnics. A similar effect has collaboration with industry (consultancy and trainings for business). Collaboration with business incubators would be positive for both university types. When it comes to TTOs, while Russel group universities benefit from collaborating with this stakeholder, the effect is opposite at Polytechnics. As for the collaboration with VC, the effect is both positive and negative at both university types.

Collaboration with industry in terms of research funding seems to be not very significant for new companies' creation at Russel as well as other teaching universities, while is both positive and negative for Polytechnics.

Secondly, between the *Russel group and Teaching Universities* we found that the following stakeholders positively contribute to *IP revenues* in both university types: government (research funding), university faculty (teaching only capital and research only capital), TTOs, business incubators, industry (consultancy and trainings for business). Interestingly that while VCs are negative for Russel group universities when it comes to IP income, this stakeholder has a positive effect on rest teaching universities. Science parks are significant for Russel group universities with no effect of this stakeholder at rest teaching universities.

However, compared to other two sub-groups of universities, teaching only oriented faculty at the Polytechnics have a negative effect on IP income generation. Thus, according to Somers et al. (2018), one of the challenges facing the entrepreneurial path of teaching-led universities is related to a lack of research resources when the majority of faculty focus on teaching.

When it comes to *new companies' creation*, while the collaboration with government and business incubators are positive for both university types, the effect of other stakeholders is different. Thus, while both university faculty and TTOs have a positive effect at Russel group universities, the impact is opposite at rest teaching universities. Interestingly while university students have a twofold effect on new companies' creation at rest teaching universities, they are not significant for Russel group universities. Finally, while science parks have a positive effect on new ventures creation at Russel group universities, they are twofold at rest teaching universities. The effect is reversed when it comes to VCs, being twofold for the Russel group and positive for the rest teaching universities.

Thirdly, between the *Polytechnic and rest teaching universities* we found that while both Government and Industry positively contribute to IP income generation, the effect of other stakeholders is diverse. Thus, while teaching only capital have a negative effect at Polytechnics, this type of stakeholder together with research only capital is positive at rest teaching universities. While business incubators positively contribute to IP income at rest teaching universities, the effect is opposite at Polytechnics. Finally, university students, TTOs and VCs have a positive effect on IP revenues at rest teaching universities, they are not significant for Polytechnics when it comes to IP income.

When it comes to *new companies' creation*, both university students and science parks have twofold effect in both university types. The effect of business incubators is positive while science parks have a twofold effect at both university types. However, while the effect of government and VCs are positive for the rest teaching universities, these stakeholders have a twofold effect (both positive and negative) at Polytechnics. Collaboration with TTOs is negative for both university types. University faculty represented by those holding mix of teaching and research positions have a negative effect on new ventures creation at both university types.

5.2 Theoretical implications

Our theoretical framework and empirical tests add to the knowledge transfer and entrepreneurship literature and provide implications for scholars, policymakers, and managers.

Theoretically, we expand the KSTE by arguing that in addition to the role of the context rich in knowledge which matters for recognizing entrepreneurial opportunities at universities, it is external *support* provided at different stages of knowledge development and transfer which boosts the decision of staff and students to start a new venture and for the university to target entrepreneurship activity as the third mission of a university (Audretsch, 2014). In particular, by incorporating the stakeholders at different stages of knowledge creation and transfer and describing the support they provide, this study sheds light on the following important relationship between stakeholders and the entrepreneurial university. This study has demonstrated that *knowledge enablers* (government and industry) contribute to IP revenues generation across all university types with the government's provision of financial resources as one of the key elements to facilitate entrepreneurship activity highlighted by Fini et al. (2020) and adding to what we know from Belitski et al. (2019) and Miller et al. (2014) how government and industry enable further knowledge exchange between industry and university. We found that an important place in this process is played by industry spills overs via trainings and CPD courses additionally to consultancy across universities of all types (Kortum & Lerner, 2001). Surprisingly, research funding from industry was not proved to have a significant effect on IP revenues generation across all university types, which illustrates that universities often commercialize knowledge independently of industry or use public funding to do so. One interesting point is that consultancy and CPD courses have remained the most significant factors impacting the increase of IP income in particular at Polytechnic universities. *Knowledge providers* have remained an important conduit for IP income generation at both Russel and rest teaching universities. Our findings advance the traditional human capital view of the university, where scholars found that research capital positively influences university entrepreneurship (Pavone, 2019), and expanding Cunningham et al. (2021) who demonstrated that a professor at the university with a focus on entrepreneurship constitutes is the first step towards university entrepreneurial path, but it does not shape university organisational infrastructure.

Interestingly, internal stakeholders such as postgraduate students with other high qualifications are associated with an increase in IP income and in particular for the rest teaching universities (Meoli & Vismara, 2016) while the effect of this stakeholder is opposite at the Russel group universities. These findings are also followed the traditional human capital view (Pavone, 2019) and might demonstrate that different internal stakeholders (including postgraduate students) are more involved in research projects.

The presence of the TTO increases licencing income which was also pointed out by Siegel and Waldman (2019) and Siegel (2018). In contrast to prior research of Aldridge and Audretsch (2010) and Belitski et al. (2019), where the main stakeholder of knowledge commercialization was industry, we argue that TTO may also play an important role in knowledge commercialization and for research-led universities. This study has demonstrated that in the UK a TTO mission has expanded beyond only the protection of intellectual property rights (Cunningham et al., 2021) but to support ideas and inventions of academics, transferring them to industry and society expanding the work of Hulsbeck et al. (2013). Thus, this stakeholder is holistically involved in all stages of entrepreneurship starting from providing support for market validation and shaping and guiding patenting and licensing process (Cunningham et al., 2021).

Advancing the prior research on the role of incubators and science parks (Link & Scott, 2017; Wright et al., 2019a, 2019b; Amoroso et al., 2019; Ng et al., 2021), we demonstrated that science parks increase IP income mainly at the Russel group universities in the UK, while the effect was not significant for the rest. For business incubators, the effect was positive for all university types. This finding also advances the knowledge in the field about the role of location on- and off-campus for knowledge transfer. The differences in location of entrepreneurial outcomes were related to the support science parks provide for technology development and facilitating R&D links between universities and industry expanding Arroyo-Vazquez and van der Sijde (2008) and Link and Link (2003).

We contend that access to venture capital has remained a significant force for licencing income at rest teaching universities only (no Russel group neither Polytechnics). This is because of the access to funding which could help reduce time-to-market and expand the network to spillover the newly created knowledge (Cunningham et al., 2021).

Expanding the prior research on the role of university stakeholders in new venture creation (Cunningham et al., 2021) we found that the role of collaboration with the government is important for all university types as it provides funds for research activities (Belitski et al., 2019; Fini et al., 2020; Link & Scott, 2019). Interestingly the size of the effect differs between teaching and research universities, due to the extent they are active in grant applications and scholarship. This study expands our understanding of the role of students in STEM in university entrepreneurial outcomes by categorising students and doctoral students in STEM and biology, physics and medicine and examining how much their numbers raise new ventures creation at university (Meoli & Vismara, 2016; Pavone, 2019).

When it comes to *knowledge codifiers*, studies have found that within the organisational factors the role of TTOs is considered as a key for the success of university spin-offs (Siegel et al., 2003). Thus, in the UK higher education system, TTOs can be viewed as conduits for start-up activity and spinouts with the effect being highest in the Russel group universities. Our study furthers Ferguson and Olofsson (2004) who found that companies located on science parks have much higher survival rates comparing those off-park. Unlike their study and in support of (Cunningham et al., 2021; Link & Scott, 2015) we found that science parks provide support to new ventures across all stages of entrepreneurship development.

This study has demonstrated that only the rest teaching universities within the UK higher education sector do benefit a lot more from access to VC while the effect of this stakeholder group at Russel Group universities as well as the rest teaching universities is twofold or both positive and negative. We consider the negative impact of the interconnections between two stakeholders occur from the choice of commercialization route via VCs or industry (Bradley et al., 2013) and will vary with the university type.

6 Conclusion

We build on the ideas of Guerrero et al. (2015), Link and Sarala (2019), Cunningham et al. (2021) and showed the interplay of university knowledge and different stakeholders within the university entrepreneurial ecosystem. This contributes to the knowledge of the university entrepreneurial ecosystem and its organisational architecture across different stages of entrepreneurship (Cunningham et al., 2021).

From the theoretical perspective, this research advances the knowledge spillover theory of entrepreneurship by considering *support* provided to entrepreneurs (academics and students in the case of the university) at different stages of entrepreneurship (Cunningham et al., 2021) by different stakeholders mattered to achieve better entrepreneurial outcomes and contribute to university entrepreneurial mission. With the lack of support, the potential entrepreneur is not able to translate their intention into the entrepreneurial act (e.g., new venture creation or selling IP) (Henley, 2005). The definition for support for entrepreneurs could be different while Hanlon and Saunders (2007, p. 620) define support for entrepreneurship as "the act of providing an entrepreneur with access to a valued resource". Entrepreneurial support showed in this study projected in the process way of new knowledge development including stakeholders who enable the knowledge creation, then those who create knowledge and finally it includes stakeholders who codify and facilitate knowledge spillover outside of university boundaries. All these types of support provided by different stakeholders are needed for entrepreneurs (academic or student) to act on opportunities and manage the business effectively (Davies et al., 2021; Guindalini et al., 2021). The theoretical extension of KSTE provided in this study is supported by empirical evidence from the UK higher education sector over 2010–2016 period.

Secondly, this study has theoretically expanded the concept of the entrepreneurial university and provided an architectural design (Cunningham et al., 2021) of the variety of organisational units supporting entrepreneurship at different stages. It has achieved this by providing in-depth insights into the organisational structure of the entrepreneurial university and its connections with different stakeholders (Foss & Gibson, 2015). Although the literature on these universities has identified a number of their various features, there has been little theorization and empirical investigation into the actual model of university collaboration with relevant stakeholders in the context of the UK entrepreneurial university ecosystem.

Thirdly, we made a robust contribution to utilising the stakeholder perspective to describe the value creation at the entrepreneurial university. This is by applying to the technology transfer domain and education by matching four groups of entrepreneurial university stakeholders with three specific types of entrepreneurial university.

Our study is the first step in the field towards analysing the organisational structure of the entrepreneurial university and its contribution to entrepreneurial outcomes of the university. Such an approach contributes to the existing literature on entrepreneurial university architecture, which has largely been atomistic in focussing on specific stakeholders (Audretsch, 2014).

Our results demonstrated that collaboration with business incubators internally or externally increases university entrepreneurial outcomes across all university types. Therefore, on a strategic level, the university top management needs to enable conditions that will require a strategy for collaboration with business incubators and venture capitalists on campus and within a region. In addition, access to venture capitalists is another vital factor to develop entrepreneurial outcomes in teaching-based universities. An increase of VC in research-oriented universities may reduce IP revenues as most of the resources are redirected to start-ups and spinouts. The challenge for university top management involves working out how to best manage and balance stakeholders' interests in order to maximise the entrepreneurial outputs.

University managers should carefully consider the knowledge transfer mechanism and associated contextual dynamics, including the interrelationship between various groups of stakeholders in order to make the process of knowledge creation and transfer more effective and thus to facilitate entrepreneurial outcomes. In terms of enabling the process, decisions regarding resource allocation should be undertaken appropriately to continue using different knowledge transfer channels.

University top management may need to decide whether to choose IP revenue generation or the creation of new ventures or implement both strategies. The answer will depend on the university and stakeholder type.

This research is subject to certain limitations which also allow drawing directions for future research. A better analysis is needed to understand and compare disciplinary profiles between universities as academic entrepreneurship varies between disciplines.

In addition, individual-level data on the entrepreneurial outcomes of the university would complement the concept presented in this study. It also would provide a better understanding of the micro-processes of entrepreneurship at the university, as well as of how individual actors (university faculties and students) are supported (or, indeed, otherwise) in the knowledge creation and spillover processes.

However, the conceptualisation and results presented in this study are not only reliable for universities in the UK, but the methodology applied could further be duplicated in other countries as well (i.e. the USA, Germany, Switzerland, China and Spain, among others). It would be worthwhile collecting similar data from universities in these countries and applying it within a more complex analytical framework (specific to each country) at some point in the future.

We recognise that there might be different ways to conceptualise the process of knowledge commercialization at university, presenting generating questions for future research. In such a sense, future research might focus on solving data availability issues (i.e., access to data to evaluate all stakeholder contributions, integrating contextual variables per university, etc.) and building additional proxies (other measures of entrepreneurship) which could be used to measure stakeholder contributions more precisely.

Appendix A

Tables 7, 8 , 9, 10, 11

Table 7 Cases studied: Entrepreneurial university and collaboration with stakeholders

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Keast, 1995	University of Alberta, Canada	Entrepreneurship	Interviews with the vice president and director of research	Description of differences between university and business	Entrepreneurship and associated activities or initiatives is becoming increasingly important to administrators	Academic entrepreneurs, government, industry, Patenting office, TTO	Entrepreneurship and administrators
Kirby, 2006	University of Surrey	The theories of entrepreneurship and intrapreneurship development		Case study	Theory proposes the formulation of a high-level strategy that demonstrates the university's intent, makes it clear that the university encourages this form of behaviour, provides the university's staff with the knowledge and support to start their own businesses and creates an environment that reduces the risk involved	Incubation, technopark, education programmes, HEIF, research centre (pre-incubator), venture capital fund	University strategy, supportive environment
Kalar B., Antoncic B., 2015	University of Amsterdam, University of Antwerp, University of Ljubljana and the University of Oxford		1300 survey from academics in different disciplines	Descriptive analysis, cross-tabulation	Academics perceiving their university department as being highly entrepreneurially oriented are less likely to believe that engagement in technology and knowledge transfer can be harmful to academic science	Department entrepreneurial orientation and individual engagement	Academics and departmental orientation

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Banal-Estanol, A., Jofre-Bonet, M., Lawson, C., 2015	40 UK universities 24 – Russell group 16—other (engineering departments)	Individual characteristics, publications, patents, research funds	Publications in SSCI	Generalised least squares method with fixed effects estimators	The formation of links with the private sector may boost research output (provide new ideas and additional funding), but high degrees of collaboration can also damage research output (low value of research ideas, time consuming)	Patenting office, government, Academic entrepreneurs	University-industry research collaboration
Miller, K., McAdam, M., McAdam, R., 2014	1 UK university	Stakeholder theory	Multi-level semi-structured Interviews with stakeholders' representatives	Case study, observation analysis, coding of interviews (Nvivo 10)	Conflicting objectives between each of the stakeholder groups have led to the university business model evolving not as a process of co-creation but rather in a series of transitions whereby multiple stakeholders are continually shaping the university business model through strategies that are dependent upon their salience	Academic entrepreneurs, TTO, Patenting office, government	The changing university business model–stakeholder relationship

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Bramwell, A., Wolfe, D.A., 2008	University of Waterloo		96 in-depth interviews with firms, associations, and knowledge institutions	Case study	Beyond generating commercialisable knowledge and qualified research scientists, universities produce other mechanisms of knowledge transfer, such as generating and attracting talent to the local economy and collaborating with local industry by providing formal and informal technical support	Government, Patenting office, Academic entrepreneurs, TTO, Industry	Mechanisms of knowledge transfer
Guerrero, M., Cunningham J.A., Urbano, D., 2015	147 public Universities in the UK in 74 NUTS-3 regions (2005–2007)	The endogenous growth theory	Secondary data, HEBCIS (university-business -community interaction survey)	Structural equation modelling, exploratory (EFA) and confirmatory factor analysis (CFA)	The economic impact of control group (UK universities that are not part of the Russell Group) is evident on research, teaching, and entrepreneurial activities, with the highest impact associated with research and knowledge transfer	Government, Patenting office, Academic entrepreneurs, TTO, Industry	The impact of universities on economic development

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Guerrero and Urbano, 2014	Public entrepreneurial universities in Spain (academic period 2008–2009)	The knowledge spillover theory of entrepreneurship The planned behaviour theory	207 Online questionnaires with academics enrolled in business economics and engineering areas	Structural equation modelling. The confirmatory factor analysis	Partially find support for their hypotheses that academics motivational factors, subjective norms and entrepreneurial university policies have a knowledge filter effect on academics' start-up intentions	Entrepreneurial intentions and economic-growth	Knowledge spillover process by level of analysis
Hu, 2009	Feng Chia University, Taiwan		149 answers from 435 questionnaires	SEM (Structural Equation Modelling)	Industry-university links are strengthened by private and public research funding, while there was no evidence that establishing technology licensing and business incubation may reinforce those links	Academic entrepreneurs, TTO, Patenting office, incubators, industry and government	Stakeholders and university-industry collaboration
Goddard et al., 2012	North-East of England: Newcastle University (1998–2008)		In-depth interviews with key decision makers (government) and academics	Description of interviews	The relationships between regional firms and technology and innovation centres in the North-East of England to be limited due to poor matching between a strong academic research base and limited absorptive capacity	Academic entrepreneurs, government and industry	The relationships between regional firms and technology centres

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Meyer M., 2006	A small set of European countries (United Kingdom, Germany, Belgium)		Publications (SCI) and patents (US patents)	Description, categorisation	The minority of inventor-authors, that is researchers with high numbers of patents, also tends to publish and be cited over-proportionally	Patenting office and academic entrepreneurs	The relationship between scientific publication and patenting activity
Sterzi, 2013	UK universities		1376 patent applications at the European Patent Office (EPO) and invented by academic scientists in the UK	A cross-sectional analysis	We find a quality premium for academic patents owned by business companies (corporate patents) in the short and medium term (till 6 years after the patent priority year) with respect to academic patents owned by universities (university patents)	Industry, human capital, IPO	The quality of patents (academia and business)
Culkin, N. and Mallick, S., 2011	University of Hertfordshire		Analysis of university strategy and policy	Case study	Delivering employment-ready graduates ignores the demands of a radically altered world of work in the face of the government's response to the latest economic crisis	Students and industry	University graduates and changed demands

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Guerrero M., Urbano D., 2010	13 Spanish universities	Institutional theory	Spanish Entrepreneurial University Scoreboard (SEUS) (secondary information from 50 universities); e-mail questionnaires with academics	SEM (Structural Equation Modelling)	Each university community is unique and its attitudes towards entrepreneurship are defined by a combination of factors, such as entrepreneurship education, teaching methodologies, role models and reward systems	Incubators, Science Parks; human capital, government, TTO, Patenting office	Entrepreneurship education, teaching methodologies, role models and reward systems as factors that explain the attitude towards entrepreneurship at university
Bischoff K., Christine K. Volkmann Ch. K., Audretsch D. B., 2017	20 different HEIs from 19 European countries	Stakeholder theory	Interviews and validation through peer groups	An exploratory cross-case analysis of all 20 case studies was conducted on the basis of a context analysis	The findings of this study indicate that none of the examined 20 HEIs possesses an explicit, verbalized strategy for the management of its external stakeholder relations in the context of entrepreneurship education	Different levels at different universities	University strategy for collaboration with stakeholders

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Hewitt-Dundas, 2012	158 universities across the UK	Stakeholder theory	Secondary data, HEBCIS (university-business -community interaction survey)	K-means cluster analysis	Universities' approach to knowledge transfer is shaped by institutional and organisational resources, in particular their ethos and research quality, rather than the capability to undertake knowledge transfer through a Technology Transfer Office	All stakeholders included into our study	Institutional and organisational resources to support knowledge transfer

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Etzkowitz H., Germain-Alamartine E., Keel J., Kumar C., Smith K.N., Albats E., 2019	Stanford University	Triple-Helix concept	Participant observation in the Office of Technology Licensing, archival research and interviews of university-industry relations	Case study	As innovation is institutionalized in novel organizational structures, as well as linked to teaching and research, the entrepreneurial university becomes a key element in the Triple Helix of university-industry-government interaction. Stanford developed university- industry and then university-government relationships as part of an increasingly explicit university-region co-development strategy. These double helices converged into a university-industry-government coalition, Joint Venture Silicon Valley, a public brainstoming initiative "…following a venture capital winnowing approach" that generated networking start-ups in response to the 1990's recession	TTO, acceleration, incubation, coaching organisation, investors, industry, public and private funds, government and industry	University-government-industry relations and supportive stakeholders

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Luciana Lazzeretti & Ernesto Tavoletti, 2005	University of Twente	Entrepreneurialuniversity (Clark)	15 Interviews	Case study	Local economic relevance and international excellence are not incompatible objectives: they were not at the University of Twente; they can be reached even in a new-born and poor endowed university, located in a peripheral, depressed and not industrialized countryside	Incubator, Research centres (people), accelerators, Business and Science park, Government and industry	Local economic relevance and international excellence
Wong PK., Ho Y-P., Singh A., 2007	University of Singapore	Entrepreneurial university	Documents analysis	Case study	University of Singapore was shifting from being primarily a manpower provider and knowledge creator to take on a more visible role in knowledge commercialization through increased patenting, licensing to private industry and spinning-off new ventures	Venture Support unit, Incubator, patenting office, TTO, government	University changing role in knowledge creation process

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Fuster E. et. al., 2019	10 public universities in Spain	The knowledge spillover theory of entrepreneurship, Social network approach	Interviews	Social network analysis, in-depth analysis	The entrepreneurial universities influence the development of regional entrepreneurial university ecosystems through the promotion of USOs, as one of the knowledge transfer mechanisms. However, entrepreneurial universities should develop a more proactive role, through intermediaries like TTOs and UVCs, collaborating with USOs	Science parks, BI, VC, Industry and government, Patenting office, TTO	University spin-offs as knowledge transfer mechanism in the ecosystem

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Bae et al., 2018	Korea Advanced Institute of Technologies	Human capital theory and entrepreneurial self-efficacy	Publications	A comprehensive review of the literature, Meta-Analysis	There is a significant correlation between entrepreneurship education and entrepreneurial intentions. This correlation is also greater than that of business education and entrepreneurial intentions. However, after controlling for pre-education entrepreneurial intentions, the relationship between entrepreneurship education and post-education entrepreneurial intentions was not significant	Scientists, students, TTO, Incubator, research centres/ Institute for start-ups	Entrepreneurship Education and Entrepreneurial Intentions
Miller & Acs, 2017	University of Chicago	Turner's theory	Interviews, observation, document analysis, internet search/analysis	Case study	The open, innovative American frontier that closed at the end of the twentieth century has reemerged in the entrepreneurial economy on the U.S. campus	Alumnies, venture capitalists, faculty, students, angel investors, government, business incubator	Entrepreneurial university as an ecosystem

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Chrisman, et al., 1995	Alberta, Canada	Entrepreneurship	Personnel interviews	Case study, in-depth analysis	Identification of administrative role, the impact of funds reduction and different types of entrepreneurial activities	TTO, HC, government, industry, Patenting office	Administrators and their role in entrepreneurship
Bernasconi, 2005	Universidad Catholic de Chile 44,481,610	Entrepreneurial Universities (the concept of Clark, 1998)	Secondary sources	Case study	The results suggest the orientation to market as a means of survival and growth under the pressure of privatization, than a result of a Triple Helix strategy of university	Government, HC, industry	Entrepreneurship strategy of the university
De Zilwa, 2005	Australian Universities	University categories and contrast levels of independence	Secondary data from annual financial reports by Australian Higher Education	Descriptive analysis of the secondary data	Universities have used isomorphism tactics transforming themselves from being rigid bureaucracies to become more flexible network enterprises	Industry, Patenting office, government, HC, investment, TTO	University strategy on entrepreneurship
Jacob, *et al.*, 2003	Technologic f Chalmers in Sweden	Entrepreneurial Universities (Clark, 1998)	Interviews with the principal actors in the internal transformation process	Case study	One important element required for innovation is macro (vision and implementation) and micro (university organization) level flexibility and diversity	IPO, VC, Academic entrepreneurs, Incubators, seed finance	The factors for universities to become entrepreneurial

Table 7 (continued)

Author(-s), Publication year	Unit of Analysis	Theoretical framework	Data	Methodology	Findings	Stakeholders covered	Research focus
Zhao, 2004	Australian Universities	Academic Entrepreneurship	Extensive interviews with academic entrepreneurs and commercialization managers, survey	A comprehensive review of the literature on research commercialization; in-depth analysis	Identified and discussed the key issues in the study and proposed a series of recommendations to enhance the overall performance of university research commercialization	Academic entrepreneurs and commercialization managers	Issues related to research commercialisation
Schmoch, 1999	Germanyand USA	Knowledge transfers	Description about the interaction	Comprehensive literature review	Identification of similes and differences related with the formalization	Patenting office, industry, government	University-industry relations formalisation
Klofsten M. and Jones-Evans D., 2000	Ireland and Sweden Universities	Academic Entrepreneurhip	10 case studies 1857 structured questionnaire to all academics	Case study	Impact of previous entrepreneurial experiences among academics in both countries and their practical application in activities as consultancy and contract research	Industry, government, Patenting office, TTO, Academic entrepreneurs	Practical experience of academics
Ryu, 1998	Yonsei University of Korea	Entrepreneurial Scholarship	Semi-structured interviews with male full professors	Case study, in-depth analysis	Identification of strategic planning and the development of the academic services	Government, Academic entrepreneurs, industry, science/technology park	Role of strategy in entrepreneurship

Table 8 The general information of the sample (entrepreneurial outcomes and entrepreneurial infrastructure)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Anglia Ruskin University	1	0	0	+	+	−	−	−	−	−	−	−	−	−	+	−	−	−
Bournemouth University	1	0	0	+	+	+	−	+	−	+	+	+	−	−	+	−	+	−
The University of Brighton	1	0	0	+	+	+	+	+	−	−	+	+	−	−	+	−	−	−
Birmingham City University	1	0	0	+	+	+	−	+	+	−	−	−	−	−	−	+	−	−
The University of Central Lancashire	1	0	0	+	+	+	−	+	−	+	+	+	−	−	−	+	+	−
Coventry University	1	0	0	+	+	+	+	+	+	+	+	+	+	−	+	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of East London	1	0	0	+	+	−	−	+	−	+	+	+	−	−	−	−	+	−
The University of Greenwich	1	0	0	+	+	+	−	−	−	+	+	+	−	−	+	−	+	−
The University of Lincoln	1	0	0	+	+	+	−	+	−	+	+	+	−	+	+	−	+	−
Kingston University	1	0	0	+	+	+	−	+	−	+	+	−	−	−	−	+	+	−
Leeds Beckett University	1	0	0	+	+	+	−	+	+	+	−	+	−	−	−	+	+	−
Liverpool John Moores University	1	0	0	+	+	+	−	+	−	−	+	+	+	−	−	+	−	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The Manchester Metropolitan University	1	0	0	+	+	+	−	+	+	+	+	+	−	+	−	−	+	−
Middlesex University	1	0	0	+	+	+	−	−	+	−	−	+	−	−	−	+	−	−
De Montfort University	1	0	0	+	+	+	−	+	+	+	+	+	−	−	−	+	+	−
University of Northumbria at Newcastle	1	0	0	+	+	+	−	+	−	−	+	+	−	−	−	−	−	−
The Nottingham Trent University	1	0	0	+	+	+	−	+	+	+	+	+	−	+	+	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Oxford Brookes University	1	0	0	+	+	+	−	−	+	−	+	+	−	+	+	−	−	−
University of Plymouth	1	0	0	+	+	+	+	+	+	+	+	+	+	−	−	+	+	−
The University of Portsmouth	1	0	0	+	+	+	+	+	+	+	+	+	−	+	+	−	+	−
Sheffield Hallam University	1	0	0	+	+	+	−	+	−	−	+	−	−	−	+	−	−	−
London South Bank University	1	0	0	+	+	+	+	+	−	+	+	+	−	+	+	−	+	−
Staffordshire University	1	0	0	+	+	+	+	+	−	+	+	−	−	−	−	+	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Sunderland	1	0	0	+	+	+	−	+	−	+	+	+	+	−	−	+	+	−
Teesside University	1	0	0	+	+	+	+	+	+	+	+	+	−	−	−	+	+	−
The University of West London	1	0	0	+	+	−	−	−	−	−	+	−	−	−	+	+	−	−
University of the West of England, Bristol	1	0	0	+	+	+	+	+	+	+	+	−	−	+	+	−	+	−
The University of Westminster	1	0	0	+	+	+	−	−	−	−	−	−	−	−	+	−	−	−
The University of Wolverhampton	1	0	0	+	+	+	+	+	+	+	+	+	+	−	−	+	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
London Metropolitan University	1	0	0	+	+	+	−	+	−	+	+	−	−	−	−	−	+	−
The University of Birmingham	0	1	0	+	+	+	−	+	+	+	−	+	+	−	+	−	−	−
The University of Bristol	0	1	0	+	+	+	+	+	−	+	+	+	−	+	+	−	+	−
The University of Cambridge	0	1	0	+	+	+	+	+	+	+	+	+	−	+	+	−	+	−
University of Durham	0	1	0	+	+	+	+	+	+	−	+	−	−	+	+	−	−	−
The University of Exeter	0	1	0	+	+	+	−	+	+	+	−	+	−	−	−	+	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Leeds	0	1	0	+	+	+	−	+	+	+	−	+	−	−	+	−	−	+
The University of Liverpool	0	1	0	+	+	+	−	+	+	+	+	+	−	+	−	+	+	−
Imperial College of Science, Technology and Medicine	0	1	0	+	+	+	−	+	+	+	+	+	+	−	−	−	+	−
King's College London	0	1	0	+	+	+	−	+	+	+	−	+	−	−	+	−	+	−
London School of Economics and Political Science	0	1	0	+	+	+	−	−	−	−	−	−	−	−	+	−	−	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Queen Mary University of London	0	1	0	+	+	+	−	−	+	+	+	+	−	−	+	−	+	−
University College London	0	1	0	+	+	+	−	−	+	+	+	+	−	−	+	−	+	−
Newcastle University	0	1	0	+	+	+	−	+	+	+	+	+	−	+	+	−	+	−
University of Nottingham	0	1	0	+	+	+	−	+	+	+	+	+	−	−	+	−	+	−
The University of Oxford	0	1	0	+	+	+	−	+	+	+	+	+	+	−	+	−	+	−
The University of Sheffield	0	1	0	+	+	+	−	+	+	+	+	+	+	−	−	+	+	−
The University of Southampton	0	1	0	+	+	+	+	+	−	+	+	+	+	−	+	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Warwick	0	1	0	+	+	+	−	−	+	+	+	+	+	−	+	−	+	−
The University of York	0	1	0	+	+	+	−	−	+	+	−	+	+	−	−	+	+	−
The University of Edinburgh	0	1	0	+	+	+	+	+	+	+	−	+	+	−	+	−	+	−
The University of Glasgow	0	1	0	+	+	+	−	+	+	+	+	+	−	+	+	−	+	−
Cardiff University	0	1	0	+	+	+	−	+	+	+	+	+	−	−	+	−	−	+
The Queen's University of Belfast	0	1	0	+	+	+	−	−	+	+	+	+	+	−	+	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Manchester	0	1	0	+	+	+	+	+	+	+	+	+	−	+	+	−	+	−
The Open University	0	0	1	+	+	+	−	+	−	+	+	−	−	−	−	+	+	+
Cranfield University	0	0	1	+	+	+	−	−	+	+	+	+	+	+	−	+	+	−
Royal College of Art	0	0	1	+	+	+	−	+	+	+	+	−	−	−	+	−	+	−
Buckinghamshire New University	0	0	1	+	+	−	+	+	−	+	−	+	−	−	−	−	+	−
University of Chester	0	0	1	+	+	+	−	+	−	+	+	−	+	−	−	−	−	−
York St John University	0	0	1	+	+	−	−	+	−	+	+	+	−	+	−	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
University of St Mark and St John	0	0	1	+	+	−	−	+	−	−	+	−	−	+	−	−	−	−
Falmouth University	0	0	1	+	+	−	+	+	−	+	+	−	−	−	+	−	+	−
The University of Winchester	0	0	1	+	+	−	+	+	−	+	+	−	−	−	+	−	+	−
Liverpool Hope University	0	0	1	+	+	−	+	+	−	+	−	−	−	−	−	+	−	−
University of the Arts, London	0	0	1	+	+	+	+	+	−	+	+	+	−	−	+	−	+	−
University of Bedfordshire	0	0	1	+	+	−	−	+	−	+	+	+	−	+	+	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Northampton	0	0	1	+	+	+	+	+	−	+	+	+	−	−	−	+	+	−
Ravensbourne	0	0	1	+	−	−	−	+	−	+	+	−	−	−	−	−	+	−
Rose Bruford College	0	0	1	+	−	−	−	+	−	+	−	−	−	−	−	−	+	−
Royal Academy of Music	0	0	1	+	−	+	−	−	−	−	−	−	−	−	−	+	−	−
Royal College of Music	0	0	1	+	−	−	−	+	−	−	−	−	−	−	+	−	−	−
Southampton Solent University	0	0	1	+	+	+	−	+	−	−	−	+	−	−	−	+	−	−
University of Cumbria	0	0	1	+	+	+	−	+	−	+	−	−	−	−	−	−	−	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Trinity Laban Conservatoire of Music and Dance	0	0	1	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−
University of Worcester	0	0	1	+	+	−	−	+	−	−	−	−	−	−	−	−	−	−
Bath Spa University	0	0	1	+	+	−	−	+	−	−	−	−	−	−	−	−	−	−
The University of Bolton	0	0	1	+	+	+	−	−	−	−	+	−	−	−	−	+	−	−
University of Gloucestershire	0	0	1	+	+	−	+	+	−	+	+	+	−	−	−	−	+	−
University of Derby	0	0	1	+	+	+	−	+	−	+	+	+	−	−	−	+	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
University of Hertfordshire	0	0	1	+	+	+	+	+	+	+	+	+	+	−	+	−	+	−
The University of Huddersfield	0	0	1	+	+	+	−	+	−	+	−	+	−	−	−	+	+	−
The University of Chichester	0	0	1	+	+	−	−	−	−	+	+	+	−	−	−	−	+	−
The University of Wales, Newport	0	0	1	+	+	+	−	+	−	−	+	+	−	−	+	−	−	−
Glyndŵr University	0	0	1	+	+	−	−	+	−	+	+	−	−	−	−	−	+	−
Cardiff Metropolitan University	0	0	1	+	+	−	+	+	+	+	+	−	−	−	−	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
University of South Wales	0	0	1	+	+	+	−	+	+	−	+	+	−	−	+	−	−	−
Swansea Metropolitan University	0	0	1	+	−	−	−	+	−	+	+	+	−	+	−	−	+	−
Trinity University College	0	0	1	+	−	−	−	−	−	+	+	−	−	+	−	−	+	−
University of Abertay Dundee	0	0	1	+	+	+	−	−	−	+	+	−	−	−	+	−	+	−
Glasgow School of Art	0	0	1	+	+	−	−	−	−	−	−	−	−	−	−	+	−	−
Queen Margaret University, Edinburgh	0	0	1	+	+	+	−	−	−	+	−	+	−	−	−	+	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The Robert Gordon University	0	0	1	+	+	+	−	−	+	−	−	+	−	−	+	−	−	−
The University of the West of Scotland	0	0	1	+	+	−	−	−	+	+	+	−	−	+	+	−	+	−
Glasgow Caledonian University	0	0	1	+	+	−	−	+	+	+	+	+	−	+	+	−	+	−
Edinburgh Napier University	0	0	1	+	+	+	−	+	+	+	+	−	−	−	+	−	+	−
Aston University	0	0	1	+	+	+	−	+	+	+	+	+	−	+	−	+	+	−
The University of Bath	0	0	1	+	+	+	−	+	−	−	+	+	−	+	+	−	−	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Bradford	0	0	1	+	+	+	−	+	+	+	−	+	−	+	−	+	+	−
Brunel University London	0	0	1	+	+	+	−	−	+	−	+	+	+	−	−	+	−	−
The City University	0	0	1	+	+	+	−	+	+	+	+	+	−	−	−	−	+	−
The University of East Anglia	0	0	1	+	+	+	+	+	−	+	+	+	−	+	+	−	+	−
The University of Essex	0	0	1	+	+	+	−	−	+	+	−	+	−	−	+	−	+	−
The University of Hull	0	0	1	+	+	+	−	+	−	+	+	+	+	−	+	−	+	−
The University of Keele	0	0	1	+	+	+	+	+	−	+	+	+	+	−	−	+	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
The University of Kent	0	0	1	+	+	+	+	+	−	+	−	+	+	−	+	−	+	−
The University of Lancaster	0	0	1	+	+	+	−	+	+	+	+	+	−	+	+	−	+	−
The University of Leicester	0	0	1	+	+	+	−	+	+	+	+	+	−	+	−	+	+	−
Birkbeck College	0	0	1	+	+	+	−	−	+	+	−	−	−	−	−	−	−	−
Goldsmiths College	0	0	1	+	+	−	−	−	+	+	−	+	−	−	−	+	−	−
Institute of Education	0	0	1	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−
London Business School	0	0	1	+	+	+	−	+	−	+	−	+	−	−	−	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
London School of Hygiene and Tropical Medicine	0	0	1	+	+	+	−	−	−	−	−	−	−	−	+	−	−	−
Royal Holloway and Bedford New College	0	0	1	+	+	+	−	+	−	+	+	+	−	−	+	−	+	−
The Royal Veterinary College	0	0	1	+	+	+	−	−	+	+	+	−	−	−	+	−	+	−
St George's Hospital Medical School	0	0	1	+	+	+	−	−	+	−	−	−	−	−	+	−	−	−
The School of Pharmacy	0	0	1	+	+	+	−	−	+	+	+	+	−	−	+	−	+	−
University of London	0	0	1	+	−	+	−	−	−	−	+	−	−	−	−	−	−	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Loughborough University	0	0	1	+	+	+	−	+	−	+	+	+	−	−	+	−	+	−
The University of Reading	0	0	1	+	+	+	−	−	+	+	+	+	+	−	+	−	+	−
The University of Salford	0	0	1	+	+	+	−	+	+	+	+	−	−	+	+	−	+	−
The University of Surrey	0	0	1	+	+	+	−	+	+	+	+	+	+	−	+	−	+	−
The University of Sussex	0	0	1	+	+	+	−	+	+	+	−	+	+	−	+	−	+	−
The University of Strathclyde	0	0	1	+	+	+	+	+	+	+	+	+	−	+	+	−	+	−
The University of Aberdeen	0	0	1	+	+	+	−	+	+	+	−	+	−	+	+	−	+	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Heriot–Watt University	0	0	1	+	+	+	+	+	+	−	+	+	+	−	+	−	−	−
The University of Dundee	0	0	1	+	+	+	−	+	−	+	+	+	−	−	−	+	+	−
The University of St Andrews	0	0	1	+	+	+	−	−	+	+	+	−	−	−	+	−	−	+
The University of Stirling	0	0	1	+	+	−	−	+	−	+	+	−	−	+	+	−	+	−
University of Wales Trinity Saint David	0	0	1	+	+	−	−	+	−	+	+	+	−	−	−	−	+	−
Aberystwyth University	0	0	1	+	+	+	−	+	−	+	+	+	−	−	+	−	−	+

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
Bangor University	0	0	1	+	+	+	−	+	+	+	+	+	−	−	+	−	+	−
Swansea University	0	0	1	+	+	+	+	+	+	+	+	+	+	−	+	−	+	−
University of Ulster	0	0	1	+	+	+	−	−	−	−	+	+	−	+	−	+	−	−
The Institute of Cancer Research	0	0	1	+	+	+	−	−	−	−	+	+	−	−	+	−	−	−
Norwich University of the Arts	0	0	1	+	+	−	−	+	−	−	+	−	−	−	−	+	−	−
Royal Agricultural University	0	0	1	+	+	−	−	+	−	−	−	−	−	−	−	−	−	−

Table 8 (continued)

Institution	Polytechnic University	Russel Group University	Rest Teaching-oriented university	Consultancy and CPD	Contract research	IP revenues	Staff start-ups	Graduate start-ups	University spin-offs	University Business incubator	External Business incubator	Venture capitalists support	University Science park	External Science park	TTO exist at university	TTO and other organisations	University Business incubator	External Business incubator
University of the Highlands and Islands	0	0	1	+	+	−	−	−	−	+	+	+	−	+	−	+	+	−
The University of Buckingham	0	0	1	+	+	−	−	−	−	+	−	−	−	−	−	−	+	−
University for the Creative Arts	0	0	1	+	−	−	−	+	−	−	+	+	−	−	−	+	−	−

Source: Higher Education Business and Community Interaction Survey

Table 9 Sources and definition of all variables used in this study

Name	Description	Source
Dependent variable		
IP revenues	The gross income to the HEP, including the sale of shares in spin−offs, before disbursements to investors and other interested parties. As such this total differs from that recorded in the HESA Finance Statistics Return	HE−BCIS
University spin−offs	The number of new spin -off companies for the reporting period	HE-BCIS
Staff start-ups	The number of new staff start-up companies for the reporting period	HE-BCIS
Graduate start-ups	The number of new graduate start-up companies for the reporting period	HE-BCIS
Independent variables		
Knowledge enablers		
CPD courses	This includes revenue generated by Continuing Professional Development (CPD) courses, defined as a range of short and longtraining programmes for learners already in work who are undertaking the course for purposes of professional development, upskilling or workforce development	HE-BCIS
Bespoke courses	Does university provide bespoke courses at business premises or not	HE-BCIS
Contract research	This includes contract numbers and income identifiable by the HE provider as meeting the specific research needs of external partners, excluding any already returned in collaborative research involving public funding and excluding basic research council grants	HE-BCIS
Consultancy	This includes contract numbers and income associated with consultancy, that is advice and work crucially dependent on a high degree of intellectual input from the HE provider to the client (commercial or non-commercial) without the creation of new knowledge. May be carried out either by academic staff or by members of staff who are not on academic contracts	HE-BCIS
UK funding	includes income from other UK government departments and includes income from Knowledge Transfer Partnerships	HE-BCIS
Other funding	includes charities, public and not-for-profit organisations as well as commercial businesses	HE-BCIS
Knowledge providers		
Employment rate	An employment rate at the university per 1000 students	HESA
Doctoral students	Number of doctoral students	HESA
Other higher degree	Number of students with other higher degree	HESA
Teaching capital	Number of faculty representing teaching capital	HESA
Research capital	Number of faculty representing research capital	HESA
Teaching and research capital	Number of faculty representing teaching and research capital	HESA
STEM UG	Share of stem undergraduates	HESA
STEM PG	Share of stem postgraduates	HESA
Biology PG	Share of biology physics and medicine postgraduates	HESA

Table 9 (continued)

Name	Description	Source
Biology UG	Share of biology physics and medicine undergraduates	HESA
Business PG	Share of business & administrative studies postgraduates	HESA
Business UG	Share of business & administrative studies undergraduates	HESA
Other degree	Number of students studying on other higher degree	HESA
Knowledge codifiers		
Patents granted	Includes all individual patents and any individual national patents	HE-BCIS
TTO exists at university	There is a technology transfer office at the university to support knowledge transfer	HE-BCIS
TTO and other organisations	university works with technology transfer office and other organisations to support knowledge transfer	HE-BCIS
Knowledge facilitators		
External Science park	Science park support do not exist at the university, but university work with it as partnership	HE-BCIS
University Science park	Science park support exists at the university	HE-BCIS
University Business incubator	University provide business incubation support at the university	HE-BCIS
External Business incubator	University provide business incubation support at the university and involving external agencies	HE-BCIS
Investment in spin-offs	Total investment received to support university spin-offs (venture capital or VC)	HE-BCIS
Investment in staff start-ups	Total investment received to support staff start-ups (venture capital or VC)	HE-BCIS
Investment in graduate start-ups	Total investment received to support graduate start-ups (venture capital or VC)	HE-BCIS
External investment**	Estimated external investment received (£000 s) to support new ventures	HE-BCIS
Control variables		
Income from infrastructure	This includes the use and income associated with the use of the HE provider's physical academic resources byexternal parties and captures provision which can be uniquely provided by a HE provider. It does not include simple trading activities such as commercial hire of conference facilities or academic conferences	HE-BCIS
Business engagement	University has a strategic plan for business engagement	HE-BCIS
Incentives for business engagement	University has incentives for faculty to engage with business and community	HE-BCIS
Regional strategy	University has a strategy to engage with business	HE-BCIS
Widening participation access	University provides contribution to economic development of the region through widening participation access	HE-BCIS
Graduates' retention into the region	University provides contribution to economic development of the region through the programme for graduates' retention into the region	HE-BCIS
Support for community	University provides contribution to economic development of the region through support provided to community	HE-BCIS

Table 9 (continued)

Name	Description	Source
Developing local partnership	University provides contribution to economic development of the region through developing partnerships with local business and community	HE-BCIS
Meeting regional skills needs	University provides contribution to economic development of the region through meeting regional need	HE-BCIS
Knowledge exchange	University provides contribution to economic development of the region through knowledge exchange	HE-BCIS
Supporting SME	University provides contribution to economic development of the region through supporting SMEs	HE-BCIS
Research collaboration	University provides contribution to economic development of the region through research collaboration	HE-BCIS
University established year	Year, when the university was established	website

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Agency

** estimates for estimated external investment received (£000 s) (from external partners but excluding investment from HEFCE (now OfS)/ BEIS) third stream funds) are provided by HE providers where possible

Table 10 Descriptive statistics

Variable	Entrepreneurial University			Russel Group Universities			Polytechnic Universities			Rest Teaching Universities		
	Obs	Mean	S.D	Obs	Mean	S.D	Obs	Mean	S.D	Obs	Mean	S.D
Specification	1	2	3	4	5	6	7	8	9	10	11	12
IP revenues	953	3.56	2.85	168	6.99	1.47	210	2.78	2.09	567	2.88	2.66
University spin-offs	951	0.49	0.68	168	0.97	0.74	210	0.36	0.57	565	0.40	0.64
Graduate start-ups	953	2.03	1.66	168	1.95	1.48	210	2.79	1.62	567	1.76	1.65
Staff start-ups	953	0.23	0.50	168	0.27	0.53	210	0.25	0.56	567	0.21	0.46
Income from infrastructure	953	4.85	2.84	168	6.94	2.42	210	5.18	2.06	567	4.09	2.88
Business engagement	953	4.22	0.80	168	4.29	0.76	210	4.28	0.78	567	4.17	0.82
Incentives business engagement	953	3.74	0.83	168	4.04	0.77	210	3.54	0.89	567	3.71	0.79
Regional strategy	953	0.33	0.47	168	0.20	0.40	210	0.37	0.48	567	0.34	0.47
Widening participation access	953	0.68	0.47	168	0.62	0.49	210	0.80	0.40	567	0.67	0.47
Graduates' retention into the region	953	0.42	0.49	168	0.33	0.47	210	0.54	0.50	567	0.40	0.49
Support for community	953	0.34	0.47	168	0.32	0.47	210	0.31	0.46	567	0.35	0.48
Developing local partnership	953	0.48	0.50	168	0.44	0.50	210	0.51	0.50	567	0.47	0.50
Meeting regional skills needs	953	0.48	0.50	168	0.33	0.47	210	0.64	0.48	567	0.47	0.50
Knowledge exchange	953	0.57	0.50	168	0.81	0.39	210	0.54	0.50	567	0.51	0.50
Supporting SME	953	0.59	0.49	168	0.45	0.50	210	0.67	0.47	567	0.61	0.49
Research collaboration	953	0.63	0.48	168	0.93	0.25	210	0.51	0.50	567	0.60	0.49
External Science park	953	0.23	0.42	168	0.30	0.46	210	0.24	0.43	567	0.20	0.40
University Science park	953	0.21	0.41	168	0.39	0.49	210	0.18	0.39	567	0.17	0.38
University Business incubator	953	0.66	0.47	168	0.81	0.39	210	0.64	0.48	567	0.63	0.48
External Business incubator	953	0.04	0.19	168	0.08	0.28	210	0.01	0.12	567	0.03	0.17
Patents granted	953	0.00	0.00	168	0.00	0.00	210	0.00	0.00	567	0.00	0.00
UK funding	952	5.38	2.95	168	7.71	2.19	210	5.66	1.98	566	4.67	3.04
Consultancy and CPD	950	8.14	1.65	168	9.46	0.69	210	8.75	0.68	565	7.55	1.79
Contract research	953	7.10	2.66	168	10.17	0.78	210	7.08	0.88	567	6.29	2.69

Table 10 (continued)

Variable	Entrepreneurial University			Russel Group Universities			Polytechnic Universities			Rest Teaching Universities		
	Obs	Mean	S.D	Obs	Mean	S.D	Obs	Mean	S.D	Obs	Mean	S.D
TTO exist at university	953	0.54	0.50	168	0.79	0.41	210	0.50	0.50	567	0.48	0.50
TTO and other organisations	953	0.31	0.46	168	0.21	0.41	210	0.44	0.50	567	0.29	0.45
Employment rate	953	4.35	0.66	168	4.81	0.36	210	3.97	0.25	567	4.34	0.72
Doctoral students	953	4.03	1.66	168	6.19	0.46	210	3.92	0.66	567	3.48	1.60
Teaching capital	953	4.79	2.11	168	5.90	0.91	210	4.95	2.07	567	4.42	2.24
Research capital	953	5.62	1.62	168	6.73	0.67	210	6.08	1.43	567	5.15	1.65
Teaching and research capital	953	2.89	1.86	168	4.65	1.66	210	2.91	1.58	567	2.40	1.69
Investment in spin-offs	953	3.13	3.97	168	7.84	3.63	210	1.29	2.52	567	2.47	3.45
Investment in staff start-ups	953	0.59	1.80	168	1.17	2.75	210	0.33	1.26	567	0.51	1.58
Investment in graduate start-ups	953	1.64	2.61	168	2.67	3.58	210	1.71	2.42	567	1.28	2.23
STEM UG	953	0.07	0.06	168	0.10	0.04	210	0.08	0.03	567	0.06	0.06
STEM PG	953	0.03	0.04	168	0.05	0.04	210	0.02	0.03	567	0.02	0.05
Biology PG	953	0.03	0.07	168	0.07	0.05	210	0.02	0.03	567	0.03	0.08
Biology UG	953	0.10	0.07	168	0.17	0.05	210	0.08	0.03	567	0.08	0.07
Business PG	953	0.04	0.06	168	0.04	0.02	210	0.04	0.04	567	0.04	0.07
Business UG	953	0.07	0.05	168	0.04	0.02	210	0.11	0.04	567	0.07	0.06
Other degree	953	6.56	1.25	168	7.81	0.40	210	6.94	0.49	567	6.07	1.29
University established year	953	1857.01	132.19	168	1741.54	216.62	210	1867.96	65.96	567	1887.67	93.54

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Agency

Table 11 Pearson correlation matrix for the main variables

IP revenues	1.000										
University spin-offs	0.463*	1.000									
Graduate start-ups	0.134*	0.170*	1.000								
Staff start-ups	0.162*	0.284*	0.223*	1.000							
External Science park	0.152*	0.133*	0.104*	0.056	1.000						
University Science park	0.319*	0.295*	0.113*	0.237*	-0.231*	1.000					
University Business incubator	0.249*	0.268*	0.347*	0.21*	0.235*	0.273*	1.000				
External Business incubator	0.156*	0.031	0.052	-0.018	-0.024	-0.057	-0.209*	1.000			
UK funding	0.440*	0.345*	0.258*	0.135*	0.176*	0.263*	0.303*	0.058	1.000		
Consultancy and CPD	0.488*	0.309*	0.278*	0.189*	0.157*	0.242*	0.342*	0.066*	0.377*	1.000	
Bespoke courses for business	-0.263*	-0.183*	-0.157*	-0.103*	-0.072*	-0.129*	-0.168*	-0.047	-0.225*	-0.238*	1.000

Table 11 (continued)

IP revenues	1.000																						
TTO exist at university	0.435*	0.304*	0.186*	0.152*	0.158*	0.174*	0.283*	0.069*	0.284*	0.338*	-0.260*	1.000											
TTO and other organisations	-0.014	-0.041	0.090*	-0.016	-0.022	0.034	-0.014	0.001	0.014	0.066*	-0.036	-0.584*	1.000										
Employment rate	0.340*	0.146*	-0.138*	-0.029	-0.048	0.058*	-0.094*	-0.014	0.043	-0.076*	-0.094*	0.154*	-0.154*	1.000									
Other high degree	0.456*	0.401*	0.342*	0.180*	0.160*	0.295*	0.356*	0.067*	0.393*	0.673*	-0.316*	0.418*	0.064*	-0.028	1.000								
Teaching capital	0.297*	0.144*	0.159*	0.099*	0.046	0.202*	0.150*	0.074*	0.229*	0.285*	-0.266*	0.225*	0.002	0.113*	0.406*	1.000							
Research capital	0.442*	0.321*	0.255*	0.167*	0.128*	0.222*	0.264*	0.082*	0.331*	0.514*	-0.361*	0.363*	-0.006	-0.069*	0.660*	0.111*	1.000						
Teaching and research capital	0.533*	0.372*	0.089*	0.159*	0.129*	0.246*	0.254*	0.121*	0.356*	0.486*	-0.283*	0.391*	-0.032	0.123*	0.575*	0.314*	0.575*	1.000					
STEM UG	0.435*	0.337*	0.271*	0.206*	0.232*	0.346*	0.336*	0.041	0.346*	0.380*	-0.250*	0.340*	0.056	-0.062*	0.482*	0.336*	0.359*	0.366*	1.000				
STEM PG	0.347*	0.283*	0.034	0.104*	0.147*	0.251*	0.216*	0.002	0.141*	0.265*	-0.117*	0.172*	0.010	0.083*	0.343*	0.095*	0.265*	0.323*	0.422*	1.000			
Biology PG	0.278*	0.158*	-0.048	0.022	0.023	0.100*	0.087*	0.035	0.196*	0.128*	-0.124*	0.187*	-0.045	0.363*	0.143*	-0.013	0.170*	0.238*	0.107*	0.315*	1.000		
Biology UG	0.392*	0.275*	0.119*	0.142*	0.169*	0.247*	0.292*	0.126*	0.365*	0.352*	-0.222*	0.297*	-0.058	0.031	0.371*	0.334*	0.346*	0.398*	0.432*	0.181*	0.244*	1.000	
Business PG	0.091*	0.015	0.136*	-0.008	0.034	0.061*	0.118*	-0.004	-0.017	0.221*	0.064*	0.047	-0.039	-0.066*	0.262*	0.007	0.143*	0.052	0.100*	0.267*	0.104*	0.011	1.000
Business UG	-0.066*	-0.019	0.207*	0.029	0.135*	0.044	0.219*	-0.041	0.064*	0.200*	-0.076*	0.063*	0.100*	-0.334*	0.307*	0.209*	0.212*	0.084*	0.300*	-0.017	-0.132*	0.113*	0.209*	1.000

Table 11 (continued)

IP revenues	1.000																							
Investment into spin-offs	0.461*	0.515*	0.133*	0.192*	0.164*	0.290*	0.272*	0.132*	0.383*	0.387*	-0.234*	0.430*	-0.109*	0.233*	0.475*	0.275*	0.366*	0.454*	0.424*	0.303*	0.203*	0.451*	0.027	-0.079*	1.000
Investment into staff start-ups	0.256*	0.210*	0.083*	0.397*	0.119*	0.122*	0.180*	0.005	0.202*	0.184*	-0.104*	0.219*	-0.101*	0.087*	0.194*	0.126*	0.155*	0.159*	0.172*	0.109*	0.066*	0.138*	-0.001	-0.022	0.350*	1.000
Investment into graduate start-ups	0.242*	0.230*	0.381*	0.169*	0.072*	0.099*	0.249*	0.021	0.231*	0.211*	-0.104*	0.202*	-0.023	0.083*	0.259*	0.179*	0.155*	0.161*	0.215*	0.082*	0.026	0.100*	-0.005	0.074*	0.275*	0.338*	1.000

Source: Higher Education Business and Community Interaction Survey, Higher Education Statistic Age

Appendix B

Control variables used in the research

With respect to the entrepreneurial university and its social responsibilities, and in specific reference to the UK context (Marzocchi et al., 2019), we included control variables as predictors of university entrepreneurial outcomes. Such variables account for university-specific features which were included in a model with a one-year lag to enforce a causality.

For university characteristics, we considered the following variables as controls: total value from renting facilities, a strategic plan for business engagement, incentives for the university staff to engage with business, and whether the university was amongst the top five group or otherwise. We also included university age as a proxy for university maturity.

As for facilities, academia can use its buildings and equipment and rent them to businesses, encouraging entrepreneurial behaviour and generating third-stream income (Etzkowitz, 2003) (contributing to the entrepreneurial mission). Table 10 (Appendix A) provides descriptive statistics for all variables used in our estimation for the overall sample of 139 UK universities, as well as descriptive statistics for each subgroup of the entrepreneurial university. Means and standard deviations across the four samples allow us to compare the university-level characteristics for each group in the population. In addition, we provide a Pearson-type correlation matrix in Table 11 Appendix A. This provides a statistical adjustment to the correlations among the variables applied in the model using multiple regression (Wooldridge, 2010).

Results of the effect of control variables

When it comes to the *control variables*, there are some patterns between the university groups on the impact of variables included in the final calculations. Below, we have provided general information, while details can be found in Tables A 6 – 9.

Interestingly, renting university facilities is not exactly beneficial for universities in general and only teaching universities might benefit significantly out of that when it comes to IP revenues generation. Having a plan for engagement with business has a negative effect on IP revenues generation for Polytechnics, while is positive for the graduate start-up's creation for these university type as well as rest teaching universities. This factor together with the partnership development indicator as well as the one on contributing to knowledge development is not significant for the strategy of Russel group universities. As for the incentives for engagement with business, this priority in the university strategy has a positive effect on IP revenues generation for Polytechnics while is negative for other teaching universities. The contribution of the university to regional strategy is negative for the IP revenues generation for teaching universities, while is positive for the start-ups and spin-offs creation. This factor is not significant for the Russel group universities.

The contribution of the university to economic development through widening participation/access, have a positive effect on IP revenues generation for teaching universities. The contribution of universities to graduates retention to the region has different effects on IP revenues generation with being positive for Polytechnics and Russel group universities, while is negative for teaching universities. In addition, this factor has a positive effect on graduate start-ups creation. The contribution of the university to the community has a positive effect on graduate start-ups creation for the Polytechnics. The contribution of the

university to the economic development of the region through partnerships development has a positive effect on IP revenues generation in general but vary when it comes to the new ventures' creation.

University's contribution to the regional skills development has a positive effect on graduate start-ups creation for Polytechnic and other teaching universities. Contribution of universities to knowledge sharing has a positive effect on IP revenues generation as well as the creation of new ventures. This factor is not statistically significant for the Russel group universities.

Contribution of the university to SMEs development has a positive effect on IP revenues generation and graduate start-ups creation. Contribution of universities through research collaboration with industry has a positive effect on IP revenues generation for teaching universities.

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