



The entrepreneurial university: strategies, processes, and competing goals

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Abstract

The configuration of the entrepreneurial university remains poorly understood given the complexity of the university as an organisation with multiple missions and multiple ‘products and services’, delivered by multiple and sometimes competing sub-organisations with different cultures and norms, in response to different outside pressures and demands. The outcomes of the entrepreneurial university reflect the plurality of goals, including research, teaching, knowledge commercialisation, and civic and community empowerment, but they are rarely considered within the same conceptual and empirical framework. Hence, the aim of this paper is to explore how multiple and sometimes competing strategies and associated arrangements, resources and capabilities within the entrepreneurial university affect the delivery of economic and social benefits to the external world across teaching, research, knowledge commercialisation, and civic and community empowerment missions. To achieve this aim, we elaborate the entrepreneurial university ecosystem concept so that we can systematically capture the cross-influences of the entrepreneurial university elements in their entirety rather than focussing on selected ecosystem elements and their effects in relation to one particular university mission. Our analysis is based on a novel institution-level database on university strategies, goals, policies, and support mechanisms, providing annual data for all higher education institutions in the UK over the period 2017–2020, complemented with annual administrative data on staff, finances, graduate outcomes, and infrastructure, as well as contextual data on the wider regional entrepreneurship ecosystem. Using a Seemingly Unrelated Estimation approach, we contribute with novel findings explicitly identifying synergies and tensions between different elements of the entrepreneurial university ecosystem that affect the delivery of its outcomes.

Keywords Entrepreneurial university · Ecosystems · Entrepreneurial university elements · Entrepreneurial university missions · Resources · Capabilities

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1 Introduction

The concept of the entrepreneurial university has evolved over the years to illuminate the distinctive position of the university as an institution capable of leveraging its education, research, knowledge exchange and community engagement activities to create and promote entrepreneurial thinking and actions both internally and externally. This is argued to enable the university to organisationally renew and adapt itself to the changing demands of stakeholders while maintaining its autonomy and freedoms of academic inquiry (Audretsch, 2014; Klofsten et al., 2019). Yet, the practice and outcomes of the entrepreneurial university are subject to challenges and tensions. This is largely because the university is an inherently complex organisation, pursuing multiple strategic goals delivered by both academic and non-academic units with different cultures and norms of organising teaching and learning, producing new knowledge and engaging with the external environment (Hayter et al., 2018).

The entrepreneurial university literature tends to be dominated by studies that are primarily concerned with knowledge and technology commercialisation activities (Philpott et al., 2011). In addition to creating a rather narrow interpretation of the entrepreneurial university phenomenon, these also obscure an important unresolved issue of how different strategies and collective actions within the university may align or misalign to affect the spectrum of entrepreneurial outcomes of the university across teaching, research, knowledge exchange, and civic and community empowerment missions (Audretsch & Belitski, 2022; Hayter, 2016; Thomas et al., 2023). Conversely, a relatively small but growing literature advocating a wider perspective on the entrepreneurial university outcomes rarely considers teaching, research, knowledge exchange, and civic and community empowerment within the same conceptual and/or empirical framework (Clauss et al., 2018), leaving open the question of how different entrepreneurial organisational arrangements, resources and capabilities within the university are compatible in delivering outcomes across all core missions (Centobelli et al., 2019; Guerrero & Urbano, 2012; Guerrero et al., 2015; Thomas et al., 2023).

Hence, the overarching aim of this paper is to explore how multiple strategies and associated arrangements, resources and processes within the entrepreneurial university affect the delivery of economic and social benefits to the external world across teaching, research, knowledge commercialisation, and civic and community empowerment missions. We are particularly interested in identifying synergies and tensions between different factors that may influence one or more types of entrepreneurial outcomes of the university and effectively define what economic and societal opportunities are pursued by the university. In this context, we assume that all parts of the university can potentially be *entrepreneurial*,¹ with the entrepreneurial university being a fundamental source of creative entrepreneurial thinking, actions and institutions across different university missions (Audretsch & Belitski, 2022; Holstein et al., 2018; Thomas et al., 2023). To achieve the aim of the paper, we adopt the entrepreneurial university ecosystem lens, further expanding

¹ For instance, an educator/teaching department has to be creative and innovative to ensure students and graduates are satisfied with their programmes; a researcher/research group needs to be creative and original to have a good chance to secure research funding; an academic/academic unit has to be able to transform their knowledge into the marketplace or society to generate monetary and/or empower community.

the scope of its theoretical application. Our framing represents an extension of the general entrepreneurial ecosystem model (Stam and van de Ven, 2021), informed by relevant insights drawn from relevant entrepreneurial university studies (e.g., Centobelli et al., 2019; Guerrero & Urbano, 2012; Guerrero et al., 2020; Thomas et al., 2023, among others). More specifically, our framework is applied at the level of a particular university rather than a designated geographical area. Furthermore, we elaborate the variety of outcomes of the entrepreneurial university ecosystem across teaching, research, knowledge exchange, and civic and community empowerment that directly or indirectly contribute to the societal capacity to produce additional output. As such, we fully illuminate the theoretical construct of productive entrepreneurship (Baumol, 1993) which is typically viewed as an outcome of the entrepreneurial ecosystem but often equated too restrictively to activities with direct financial returns. Finally, we elaborate the notions of the elements of the ecosystem, by distinguishing between three blocks related to institutional arrangements, resources and capabilities. This allows us to capture both synergising and conflicting cross-influences of the entrepreneurial university elements in their entirety rather than focussing on selected ecosystem elements and their effects in relation to one particular university mission (Hayter et al., 2018).

Our empirical analysis is based on a novel combination of institution-level and micro-level longitudinal data sources for the UK, including institution-level data on university commercialisation and engagement activities taken from the Higher Education—Business and Community Interaction (HE-BCI) survey, and data on finance and investments, including financial returns from commercialisation (HESA Finance data). We combine this with data on graduate employment and wellbeing outcomes taken from the Graduate Outcomes survey, which is sent directly to all UK higher education graduates every year. In our analysis that covers the period 2017–2020 we use the labour market outcomes such as graduate employment and graduate job satisfaction as a measure of teaching related outcomes of the entrepreneurial university ecosystem. Research outcomes are proxied by the research income per a full-time member of academic staff, while the number of spinoffs and social enterprises used as a measure of knowledge commercialisation, and civic and community empowerment, respectively.

Our findings reveal a number of illuminating results related to the nature, origins and implications of alignments and misalignments within the entrepreneurial university ecosystem. We find that nearly every element of the entrepreneurial university ecosystem represents a source of synergies and tensions affecting entrepreneurial outcomes pursued by the university across its core missions. Yet, none of the economic and social outcomes of the ecosystem is found to be disproportionately affected by detrimental misalignments (or synergising alignments) across the ecosystem elements.

The rest of the paper is organised as follows. The next section discusses the theoretical framing underlying our inquiry. Section 3 details the methodology. Section 4 discusses the findings before Sect. 5 concludes.

2 Theoretical framing

2.1 Complexities and ambiguities of the entrepreneurial university

The term ‘entrepreneurial university’ was initially introduced by Etzkowitz (1983) to describe the narrowing gap between scientific discovery and application, reflecting

increasingly blurry boundaries between science and commercial business. With the university increasingly viewed by businesses as a factor of production and not only as a source of training and advice, Etzkowitz (1998) described this capitalisation of knowledge as a 'second revolution' in academia. Comparing it to the first academic revolution through which research became the second mission of the university, he argued that socio-economic development became the third mission of the university, establishing the latter as an entrepreneurial university and an economic actor. Further significant developments in the conceptualisation of the entrepreneurial university are attributed to Clark (1998). By contrast to Etzkowitz, he viewed the entrepreneurial university as an organisational collective entrepreneurial response to deal with the imbalances in university relationships with the external environment (e.g., reflected in the do-more-for-less demands) and contradictory requests coming from of a growing list of stakeholders.

The perspectives of Etzkowitz and Clark have shaped the direction of subsequent developments in the conceptualisation of the entrepreneurial university (Clauss, et al., 2018). The Etzkowitz thinking has resulted in the establishment and rapid growth of the Triple Helix school of thought where the entrepreneurial university is understood to be playing an essential role in the generation, recombination and diffusion of innovation in a knowledge-based economy alongside the other two critical actors such as the industry and government (Etzkowitz & Dzisah, 2008; Etzkowitz & Leydesdorff, 2000). The Triple Helix model was subsequently transformed to the Quadruple/Quintuple Helix model to acknowledge the role of civil society and environment in innovation (Carayannis et al., 2018). Similarly, the Clark (1998) view of the university as an organisation entrepreneurially responding to external environment to be more resilient was further reinforced by Shattok (2009) and Hannon (2013). They emphasised the critical role of the entrepreneurial university in creating internal environments that embed, support and incentivise entrepreneurial mindsets and behaviour, and, as such increasing the adaptiveness of the university as an organisation.

From its very initiation, the entrepreneurial university concept faced serious critique. The shift towards the 'capitalisation of knowledge' which is at the heart of the third mission was viewed as a threat to academic freedoms and the concept of knowledge as a public good (Kleinman, 2003; Slaughter, 2020). There were concerns that the entrepreneurial university due to its apparent focus on short term commercial gains could divert resources away from basic research and undermine the pursuit of 'knowledge for its own sake' (Chubb et al., 2017; Philpott et al., 2011). While there was some evidence that the diversion effects may not be as big as feared (Thursby and Thursby (2011), on aggregate the growing body of the entrepreneurial university literature has initially done relatively little to alleviate such concerns. The literature was predominantly preoccupied with analysing technology commercialisation and spin-out activities (and effectively led to a situation where the entrepreneurial university concept was largely perceived in terms of technology transfer and associated outcomes (e.g., patents, licenses, joint ventures and spinouts) (Hayter et al., 2018; Philpott et al., 2011).

In this contentious context, Clark's wider and more inclusive interpretation of the entrepreneurial university as a 'collective entrepreneurship' and its subsequent extensions were especially relevant (Kirby, 2006; Klofsten et al., 2019). These acknowledged the variety, complexity and fragmentation of tasks, activities and structures within the university, viewing entrepreneurship as a way for different academic groups to more efficiently achieve their different objectives through developing a common culture and shared entrepreneurial identity. Extending this view, Shattock (2009) stressed that the entrepreneurial university should not be seen only in terms of the commercial exploitation of research, as it manifests in many other forms including innovative

teaching, internationalisation activities, and engagement with regional regeneration programmes. The wider perspective on the entrepreneurial university has helped to 'unhide' the contribution of basic research and of social sciences, humanities and arts to the economy and society (Abreu & Grinevich, 2014; Clauss et al., 2018). It revealed that so called 'softer' ways of knowledge exchange (e.g., consulting, conferences, and informal networking as well as graduate education) could often be more appropriate and efficient as opposed to spinouts and patent-based activities (Abreu & Grinevich, 2013; Philpott et al., 2011). It has also uncovered an important role played by teaching-focussed universities in socio-economic development (Abreu et al., 2016). Furthermore, by embracing the topics related to the university governance, leadership, culture and contextual challenges and synergies arising from both the internal and external environments, the wider perspective on the entrepreneurial university becomes critical for both upholding the autonomy of the university and its strategising as an effective societal agent (Centobelli et al., 2019; Klofsten et al., 2019; Sánchez-Barrioluengo & Benneworth, 2019). Within this perspective, the apparently competing narratives of the 'entrepreneurial university' and 'freedom of inquiry-led university' are attempted to be addressed by making an argument about the university being a fundamental and leading source of entrepreneurial ideation, behaviours and institutions (Audretsch, 2014). Correspondingly, all parts of the University can be viewed as 'entrepreneurial' either directly or indirectly through celebrating the values of academic freedom and creativity, while also raising awareness that these are also associated with noticeable societal benefits (Audretsch & Belitski, 2022; Holstein et al., 2018).

2.2 An ecosystem view on tensions and synergies at the entrepreneurial university

As shown above, the notion of the entrepreneurial university is inherent with tensions and ambiguities. These are due to the high complexity of the university as an organisation with multiple missions and multiple products and services, delivered by multiple and sometimes competing sub-organisations (e.g., teaching departments, research centres, technology transfer offices) with different cultures and norms, in response to different outside pressures and stakeholder demands (Audretsch & Belitski, 2022; Kirby, 2006). Taking a wider perspective, the outcomes of the entrepreneurial university are conceptualised to reflect the plurality of goals linked to research, teaching, knowledge exchange and community engagement activities, while outcome measures can include publications, research funding, entrepreneurial graduates, patents, licenses, spinouts, collaborative and industry commissioned projects, and contributions to regional and social development (Centobelli et al., 2019). In this regard, the entrepreneurial university is increasingly viewed as an ambidextrous organisation having to simultaneously pursue missions that may lead to overlapping or conflicting outcomes (Centobelli et al., 2019; Sangupta and Ray 2017; Thomas et al., 2023). Among some of the challenges and tensions documented by the ambidexterity literature are those related to producing commercial output as opposed to purely academic deliverables (Ambos et al., 2008; Chang et al., 2009; Sangupta and Ray 2017); developing entrepreneurial competences among both academic staff and students (Beyhan and Findik, 2018); achieving both economic and social missions; as well as accommodating regional agendas in teaching, research and knowledge transfer activities (Thomas et al., 2023).

One known limitation of the ambidexterity perspective on the entrepreneurial university is its binary approach. This is exceptionally well captured by Thomas et al. (2023) who are metaphorically drawing an analogy between the ambidextrous university and a person with two hands simultaneously undertaking different activities. Instead, they argue, it is more

appropriate to view the entrepreneurial university as a creature with multiple arms (e.g., similar to an ‘octopus’) moving in sometimes harmonised and sometimes awkward manner. In this context, one can consider elaborating an entrepreneurial university ecosystem perspective (Hayter et al., 2018) as a way to provide a more comprehensive and systematic view on tensions and synergies emanating from different elements of the ecosystem as they materialise across a range of entrepreneurial outcomes (rather than just focussing on two potentially conflicting missions).

While there has been an increased interest in adopting entrepreneurial ecosystem thinking in the academic entrepreneurship field (Guerrero & Urbano, 2012; Guerrero et al., 2015; Hayter et al., 2018; Wright et al., 2017), the ecosystem perspective has yet to be fully leveraged to advance our understanding of conflicts and synergies between different entrepreneurial university elements that effectively shape economic and societal opportunities pursued by the university across its different missions. The entrepreneurial university ecosystem literature remains relatively compact. It also tends to inherit many of the assumptions from other entrepreneurial university studies that have so far limited their ability to analyse potential conflicts and complementarities across what should be considered a ‘multidextrous’ ecosystem with idiosyncratic elements and competencies (Beyhan and Findik, 2018; Thomas et al., 2023). For instance, the outcomes of the entrepreneurial university ecosystem are still often equated to direct research commercialisation activities such as patenting, licensing, spin-outs, as well as university-industry partnerships (Lahikainen et al. 2019; Prokop, 2022; Padilla-Meléndez and del-Aguila-Obra, 2022; Yi & Uyerra, 2018). Morris et al. (2017) extend focus to student start-ups investigating the effects of selected ecosystem elements such as curricular and extracurricular programmes and university financial support. Noting the lack of an ecosystem framework for understanding student start-ups, Wright et al. (2017) propose to theorise it in terms of three core elements evolving over time such as within the university mechanisms (e.g. experiential teaching, accelerators, seed funding); entrepreneurs, investors and other enabling actors; and environmental elements related to both university environment and external context (e.g. research and teaching strengths, resources, rankings; policies and strategies). While adopting the entrepreneurial university approach, Guerrero et al. (2020) explore graduate career patterns by focussing on the role of selected ecosystem elements (such as incubators and entrepreneurship programmes) rather than that of a comprehensive set of elements. In contrast to most studies, Kwong et al. (2022) interprets offering social entrepreneurship education as an outcome (rather than an element) of the entrepreneurial university ecosystem, with the latter conceptualised as a combination of entrepreneurial vision, infrastructure, vibrancy, identity, behaviour and regional entrepreneurial environment.

Overall, the entrepreneurial university ecosystem literature remains to be skewed towards studies with a disproportionate focus on individual ecosystem elements at the expense of strategic ecosystem conceptualisations as observed earlier by Hayter et al. (2018) in their systematic literature review. A wider integrated perspective on the entrepreneurial university ecosystem as a set of elements and their interdependencies organised in a such way that they harmoniously enable entrepreneurial outcomes across teaching, research, knowledge exchange and community engagement remains very underdeveloped as well. One notable contribution is the work by Guerrero and Urbano (2012) and Guerrero et al. (2015). While they do not explicitly use the term ‘ecosystem’, their conceptualisation of environmental formal factors (organisational and governance structures, and entrepreneurship education), environmental informal factors (entrepreneurship role models, reward systems, entrepreneurial teaching methodologies and entrepreneurial attitudes), ‘internal’ resources (human, physical, financial and commercial) and internal capabilities

(networks, status, and localisation) represents a rather comprehensive set of elements of the entrepreneurial university ecosystem. It is also notable that their interpretation of the entrepreneurial university outcomes is not limited to conventional entrepreneurial activities but also includes teaching and research outcomes. Using this model, Guerrero and Urbano (2012) reveal that a combination of informal factors that is most critical for the development of the entrepreneurial university. The assumption of this model about a three-way configuration of the entrepreneurial university outcomes also guides Guerrero et al. (2015) in their exploratory analysis of the economic impact of these outcomes. This model, however, has not been used to systematically and explicitly explore the tensions and synergies that may emerge in the entrepreneurial university ecosystem, affecting the configuration of economic and societal opportunities pursued but the university.

Against this theoretical backdrop, this presents us with a promising opportunity to further elaborate the concept of the entrepreneurial university and enhance its analytical potential by embracing relevant observations from the entrepreneurial university ambidexterity literature and embedding them within entrepreneurial ecosystem thinking. We adopt a strategic and systematic framing of entrepreneurial ecosystems by Stam and van de Ven (2021). Building upon previous entrepreneurship literature (e.g., Feld, 2012; Isenberg, 2010; Neck et al., 2004; Spiegel, 2017; Spilling, 1996; van de Ven, 1993), it defines the entrepreneurial ecosystem as a set of interdependent elements that are organised in such a way that enable 'productive' entrepreneurship. While typically proxied by high-growth entrepreneurship, the construct of productive entrepreneurship, in its original theorising by Baumol (1993), is defined as an activity that directly or indirectly contributing to the societal capacity to produce additional output. Conceptually, this is especially meaningful in the context of the entrepreneurial university, reinforcing the case for theorising its outcomes as a multi-dimensional construct reflecting the multiplicity and evolution of university missions (Audretsch, 2014; Thomas et al., 2023). In this regard, we propose to theoretically elevate civic and community empowerment within the ecosystem framing (Fig. 1), by presenting it as a separate set of entrepreneurial university outcomes alongside those related to teaching and learning, research, and knowledge commercialisation. Keeping with our prior discussion, we propose that these outcomes should not be considered in isolation or in parallel. Some of them may overlap and be reinforced by the same elements of the ecosystem, while others may be subject to conflicting effects exposing the underlying tensions.

To be able to systematically explore synergetic and conflicting cross-influences of different elements of the entrepreneurial university ecosystem, we distinguish between institutional arrangements (e.g., codified rules and policies; non-codified norms and cultural beliefs; and guidances and expectations emanating from stakeholder networks), resources (e.g., physical infrastructure and finance) and capabilities (e.g., leadership, talent and knowledge management, intermediate and support capabilities). This largely follows the approach of Stam and van de Ven (2021), with the exception of introducing a capability construct. This is to emphasise the important role played by the entrepreneurial university's ability to make use of resources and to navigate institutional arrangements when pursuing institutional goals (Klofsten et al., 2021). This is also conceptually consistent with the Guerrero and Urbano (2012) approach. Finally, we apply our framework at the level of a given university rather than a particular geographical territory as often assumed in the entrepreneurial ecosystem literature.

The previous literature on the entrepreneurial university has provided some insights into the nature of trade-offs and complementarities one may expect to observe when it comes to achieving different university missions. For instance, Chang et al. (2009)

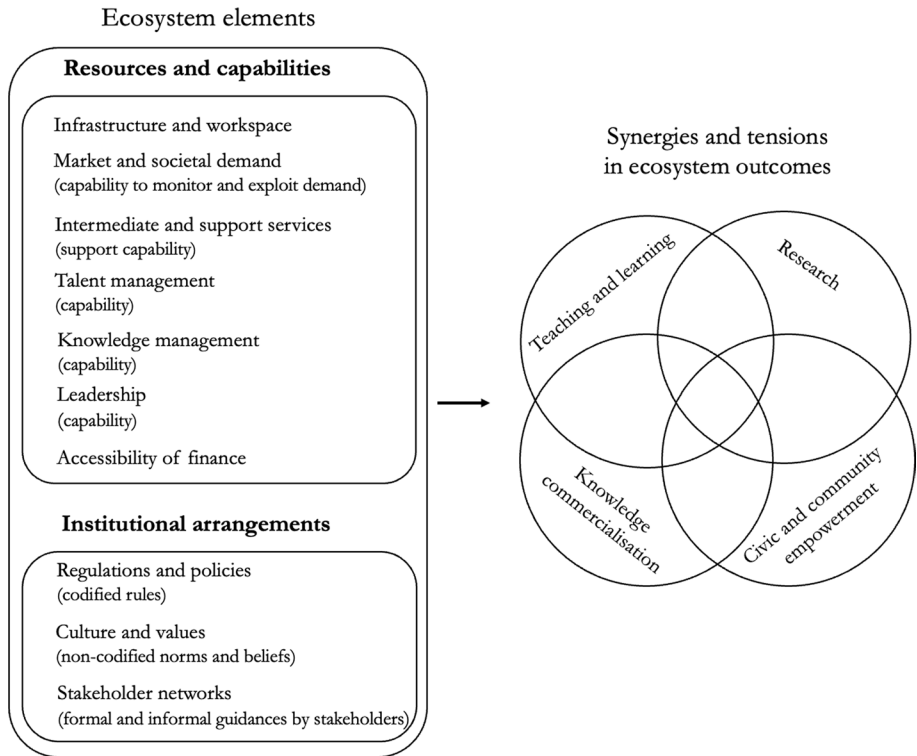


Fig. 1 Entrepreneurial university ecosystem: Elements and outcomes

find that regulatory arrangements, infrastructure (e.g., incubation facilities) and other institutional support (including intellectual property rights management and the university leadership support) can alleviate the pressures on researchers to commercialise their output. Similarly, Ambos et al. (2008) note that the establishment of so-called dual structures such as technology transfer offices can mitigate potential conflicts between research and commercialisation mission. Sangupta and Ray (2017) indicate the presence of noticeable tensions between research and knowledge exchange, which can, to some extent, be mitigated by academic engagement (e.g., contract and collaborative research and consultancies). They also find that university-industry links emerging through education and in response to the market demand (e.g. executive education) can enhance the knowledge transfer mission. The role of education and entrepreneurial culture within the university is found to be critical for students embarking on entrepreneurial careers (Beyhan and Findik, 2018; Guerrero et al., 2020). Yet, some entrepreneurial support mechanisms (including incubation facilities and access to finance) may sometimes have no or negative effect on student and graduate start-ups (Beyhan and Findik, 2018; Morris et al., 2017). Such support may be too tailored to academic entrepreneurs and spinouts, exposing the tensions between academic (staff) and student/graduate entrepreneurship. Centobelli et al. (2019) propose that entrepreneurially oriented policies and projects can have a synergising effect on the delivery of the social mission of the university, including that on a local scale. Thomas et al. (2023) observe clear tensions between the social and other missions of the

university, and provide examples of interventions to mitigate them (such as through place-based education, enhanced university project management capabilities; and mentoring programmes). Although somewhat fragmented, the above insights are extremely helpful as we proceed to empirical analysis to build and interpret an ecosystem picture of synergies and tensions that effectively shape the scope of entrepreneurial opportunities pursued by the university.

3 Data and methods

3.1 Overview of data sources and scope

Our empirical analysis is based on data provided by the Higher Education Statistics Agency (HESA), an independent quasi-governmental organisation tasked with collecting data on the UK's higher education sector. The database used in this study was compiled from multiple secondary HESA data through the linking and harmonisation of institutional data sets, survey data sets, and other tables of statistics. It includes over 300 variables covering 151 higher education institutions over the period 2015/16 to 2020/21.

We restrict our analysis to the academic years 2017/18, 2018/19, and 2019/20. This is due to a change in the survey methodology used by HESA to collect data on graduate outcomes, so that the variables for the years 2017/18 and onward are not fully comparable to those of the years prior to 2017/18. Since graduate outcomes data is collected 18 months after graduation, we are not able to include the graduation cohort of 2020/21, since the data is not yet available at the time of writing. Our analysis is therefore based on a short panel of three years and 151 institutions (out of 160); this excludes a number of smaller specialised institutions for which data on the variables of interest was unavailable.

The focus of our paper is on the competing key missions of the modern university, which we argue include research, teaching and learning, knowledge commercialisation, and civic and community empowerment, and which are all outcomes of the entrepreneurial university ecosystem. The challenge lies in identifying appropriate metrics to capture both the outcomes and the elements of the ecosystem, in a way that is fully comparable across institutions and over time. We next explain how we have operationalised these variables.

3.1.1 Operationalising the outcome measures

Our preferred measure of research outcomes is the annual income from research grants and contracts awarded to an institution in a given year, divided by the total number of full-time academic staff. This figure is adjusted for inflation using the UK's GDP deflator. The research income data are taken from the HESA Finance database, which provides information on university finances, investments, buildings, etc., and the data on academic staff numbers are taken from the HESA Staff database. The GDP deflator figures are provided by the Office for National Statistics. We considered a number of alternative measures of research outcomes, including the results of the Research Excellence Framework (a national exercise intended to capture variations across institutions in the quality of research output), number of publications and citations, and number of research active staff. However, all of these measures are flawed to some extent in that they are either not fully comparable over time, are difficult to adjust for quality (especially in the case of

publications), or may not fully capture the entrepreneurial nature of the activity behind them. Income from research grants, normalised to account for differences in institutional size, arguably captures the societal benefit arising from academic research, and the data are reliable as they are provided directly by all institutions to HESA. It also captures at least some differences in research quality given the competitive nature of the funding process, and is directly comparable across institutions and over time (when adjusted for inflation).

Our preferred measure for teaching and learning outcomes is the employment rate of graduates originating from each institution, defined as the proportion of graduates who are in full-time employment. We restrict the graduate employment measure to UK domiciled students who were enrolled in a full-time undergraduate course, in order to minimise the bias resulting from lower response rates for this variable for part-time and non-UK domiciled students, and to ensure a fairly homogenous population of mostly 22–22 year old graduates.² Our data source for this variable is the Graduate Outcomes survey, which is sent to every student in the UK approximately 15 months after graduation.³ The survey is the largest and most detailed of its kind for the UK and has a response rate of 52.3% for UK domiciled full-time graduates, with lower response rates for part-time graduates (48.7%) and for international graduates (46.1% for EU, 29.4% for other countries). Our analysis is also restricted to UK domiciled students who remained in the UK following graduation in order to minimise bias resulting from differences in labour market forces across countries. As a robustness check we also use the percentage of students who say that their current activity is meaningful (a measure of graduate job satisfaction) as a second outcome variable for this mission.

Our two remaining outcome variables cover the knowledge commercialisation, and civic and community empowerment missions. Our preferred measures for these outcomes, and most of our explanatory variables, come from the annual Higher Education—Business and Community Interaction (HE-BCI) survey, which captures the aims, policies, strategies, and processes surrounding university engagement with business, civic society, and public sector partners. Part A of the survey, the qualitative component, covers both subjective assessments of the benefits of commercialisation and external engagement (e.g., “Please rank the following partners/clients in terms of benefits ultimately delivered”, “How do you rate the level of incentives for staff to engage with business and the community?”), and objective ones (e.g., “Does your institution have any subsidiary companies or distinct departments responsible for business and community interactions, and what are they?”). Part B of the survey collects quantitative administrative data, such as the number of spinoffs, the number and value of patents and licences, the number and value of collaborative research contracts, and number of attendees at externally facing events. Our preferred measures for the remaining outcome variables are the number of spinoffs registered in a given year that involve university IP (as a measure of knowledge exchange), and the number of social enterprises registered in the same year which were created by university staff, current students, or recent graduates. The intention is to choose two measures that are fairly consistent and comparable across institutions and over time, and that are also comparable to each other, one focusing on commercialisation, and the other

² Table 9 in Appendix 2 provides some descriptive statistics on the demographic characteristics of this population.

³ The surveys are sent out in quarterly waves based on the month of graduation, with those graduating in June (most common for undergraduate courses) receiving the survey in September–November of the following year, and those graduating in September (most common for taught postgraduate courses) receiving the survey in December–February of the following year. The Graduate Outcomes survey replaced the previous Destinations of Leavers from Higher Education (DLHE) survey, which was distributed around 6 months after graduation, starting with those who graduated in 2017/2018.

on community or civic empowerment through social entrepreneurship. We considered a number of alternative measures, particularly for the civic and community empowerment mission, for example the number of attendees at university cultural or scientific events, the number of visitors to university museums, or the importance given by the university to civic engagement, but an analysis of the data suggests that these measures are not captured consistently across institutions (based on institutions that are well known to us, and for which we were able to double check the figures).

3.1.2 Capturing the elements of the ecosystem

A key challenge we face is to find appropriate measures to fully capture all the elements of the university entrepreneurial ecosystem, as shown in Fig. 1, and to do this in a way that is both sufficiently detailed but also consistent across the entirety of the UK higher education sector. As discussed in Sect. 3.1, the institutional datasets collected by HESA are essentially a census of all higher education institutions in the UK, since all institutions are required to provide the information, which is then used for a variety of policy, research, and governance purposes. In translating our theoretical model into the empirical one shown in Sect. 3.2, we worked our way through the nine major HESA databases available, and looked for all the variables that were relevant measures of the elements of the ecosystem shown in Fig. 1.

The results of this exercise are shown in Table 1, indicating each element of our theoretical ecosystem, and the corresponding variables available in the data. Most of the data used to construct these variables comes from the two HE-BCI data sets described in the previous section. We also use an additional explanatory variable from the HESA Finance database: the value of the Vice-Chancellor's annual remuneration package, in £100 k.⁴ This variable is included in order to capture value placed by the institution on internationally renowned (potentially transformative) leadership, which we assume is proxied by the remuneration package.

We next provide a brief overview of the explanatory variables included in the analysis (also summarised in Table 1), with full variable descriptions provided in Appendix 1. We begin with the institutional arrangements that support or constrain the entrepreneurial university outcomes. Starting with regulations and policies, we include three variables that reflect the composition of the university's governing board in the form of the proportion of business representatives on the board, as well as civil society representatives, and public sector representatives. These are intended to capture an institutional commitment towards engaging with the business sector, civil society, and the public sector, respectively. We also include a measure of whether the institution requires its staff to use a formal contracting system for any outward-facing activities. This captures the extent to which the institution has formal or rigid policies for dealing with entrepreneurial activities. Moving on to culture and values, we include a variable that captures whether the institution offers entrepreneurship training to its staff and students. This measure is intended to indicate an institutional culture that supports innovative activities and intrapreneurship.⁵ Finally,

⁴ In the UK, the Vice-Chancellor is the most senior University officer, in charge of all academic and administrative affairs, in a role equivalent to that of President in other countries. The Chancellor has a mainly ceremonial role and is not involved in the day-to-day running of the institution.

⁵ There is a significant lack of data at the national level (covering all institutions) on this particular element, and this is one of the dimensions that future versions of the HE-BCI survey, and other HESA data collections, could helpfully expand on.

Table 1 Elements of the intrapreneurial ecosystem and corresponding variables used in the empirical analysis. Further details are provided in Appendix 1

Intrapreneurial ecosystem outputs and elements	Variables included in the analysis
Ecosystem outcomes	<p><i>Research income</i>: annual research income per member of academic staff (in £000 s, adjusted for inflation)</p> <p><i>Graduate employment</i>: undergraduates who are in full-time employment 15 months after graduation (% of cohort)</p> <p><i>Graduate job satisfaction</i>: undergraduates who report “my current activity is meaningful” 15 months after graduation (% of cohort)</p> <p><i>Student continuation</i>: full-time undergraduates in their first degree who are still in higher education one year after enrolment (% of cohort)</p> <p><i>Spinoffs</i>: registered enterprises using university IP per 1,000 academic staff</p> <p><i>Social enterprises</i>: registered social enterprises created by university staff, current students, or graduates per 1,000 academic staff</p>
Regulations and policies	<p><i>Business representatives on board</i>: business members on university’s governing board (% of board members)</p> <p><i>Civil society representatives on board</i>: civic society members on university’s governing board (% of board members)</p> <p><i>Public sector representatives on board (%)</i>: public sector members on university’s governing board (% of board members)</p> <p><i>Required contracting system</i>: whether the university has a required contracting system for all staff engagement with external partners (dummy variable)</p>
Culture and values	<p><i>Entrepreneurship training (start-ups)</i>: whether the university offers start-up support via entrepreneurship training (dummy variable)</p>
Stakeholder networks	<p><i>Benefits from business engagement</i>: benefits to the university from business engagement (scale 1–4)</p> <p><i>Priority: local area</i>: whether engagement with partners in the local area is a university priority (dummy variable)</p> <p><i>Priority: region</i>: whether engagement with partners in the region is a university priority (dummy variable)</p> <p><i>Priority: national</i>: whether engagement with partners at the national level is a university priority (dummy variable)</p> <p><i>Priority: international</i>: whether engagement with partners at the international level is a university priority (dummy variable)</p>
Infrastructure and workspace	<p><i>On-campus incubator (start-ups)</i>: whether the university offers start-up support via an on-campus incubator (dummy variable)</p> <p><i>Off-campus incubator (start-ups)</i>: whether the university offers start-up support via an off-campus incubator (dummy variable)</p> <p><i>Science-park space (start-ups)</i>: whether the university offers start-up support via science park space (dummy variable)</p>

Table 1 (continued)

Intrapreneurial ecosystem outputs and elements	Variables included in the analysis
Market and societal demand	<p><i>Business advice (start-ups)</i>: whether the university offers start-up support via business advice (dummy variable)</p> <p><i>Monitoring of labour markets</i>: extent to which university monitors skill needs and sectoral changes (scale 1–5)</p> <p><i>Employer curriculum design</i>: extent to which employers are involved in curriculum design (scale 1–5)</p> <p><i>Exploitation company (owned)</i>: whether the university has a fully-owned exploitation company (dummy variable)</p> <p><i>Exploitation company (majority)</i>: whether the university has a majority-owned exploitation company (dummy variable)</p> <p><i>Exploitation company (minority)</i>: whether the university has a minority-owned exploitation company (dummy variable)</p>
Intermediate and support services	<p><i>Internal department for engagement</i>: whether the university has a department for external engagement (dummy variable)</p> <p><i>Indemnity insurance for staff</i>: whether the university provides indemnity insurance for staff (dummy variable)</p>
Talent management	<p><i>Staff incentives for engagement</i>: extent of staff incentives to engage with external partners (scale 1–5)</p> <p><i>Staff rewards for IPR</i>: whether staff are rewarded (financially or otherwise) for IPR (dummy variable)</p> <p><i>Student placements (central)</i>: whether graduate placements are arranged centrally (dummy variable)</p> <p><i>Student placements (department)</i>: whether graduate placements are arranged by academic departments (dummy variable)</p> <p><i>Student placements (ad hoc)</i>: whether graduate placements are arranged on an ad-hoc basis (dummy variable)</p>
Knowledge management	<p><i>Files IPR in house</i>: whether the university files IPR in house (dummy variable)</p> <p><i>Requires disclosure of inventions</i>: whether the university requires staff to disclose inventions (dummy variable)</p>
Leadership	<p><i>Strategic plan (business)</i>: extent of university strategy for engagement with business (scale 1–5)</p> <p><i>Strategic plan (public and civic)</i>: extent of university strategy for engagement with public and civic sectors (scale 1–5)</p> <p><i>VC pay (in £100 k)</i>: total annual remuneration for the university's head of institution (in £100,000 s, adjusted for inflation)</p>
Accessibility of finance	<p><i>Seed corn investment (start-ups)</i>: whether the university offers start-up support via seed finance (dummy variable)</p> <p><i>Venture capital (start-ups)</i>: whether the university offers start-up support via venture capital (dummy variable)</p> <p><i>Funds for teaching (equipment)</i>: whether external engagement activities provide funds for teaching equipment (dummy variable)</p>

to capture the extent and nature of institutional stakeholder networks and associated influences, we include a variable that indicates whether the institution perceives that there are significant benefits from business engagement, and several variables to indicate the geographical extent of the university's stakeholder priorities (with national networks the

reference category in the regression models). We include the latter to capture the spatial extent of the university's entrepreneurial ecosystem.

Moving on to the resources and capabilities elements of the ecosystem, we capture infrastructure and workspace using a number of variables that indicate whether the institution provides off- or on-campus incubators and science park space for start-ups. These variables provide an indication of the value the institution places on entrepreneurship and innovation, via its support for the appropriate capital infrastructure.⁶ Our next set of variables cover the institution's knowledge of, and engagement with, its market. We define "market" broadly to include external demand for the institution's graduates, knowledge, services, civic activities, and cultural outputs. We capture this using a set of variables that include whether the university provides business advice for student and staff start-ups (indicating the extent to which it is aware of the wider market context), two measures of institutional engagement with the graduate job market (whether the university actively monitors labour markets, and whether it involves employers in curriculum design), and three variables to capture whether the university actively participates in the commercialisation of knowledge outputs (indicated by the presence of various types of exploitation company). Along the same lines, we incorporate the intermediate and support services element using variables that capture whether the university has an internal department for engagement with external partners, and whether it offers indemnity insurance for staff, both proxies for active support for innovation and entrepreneurship activities.

Our next set of elements cover different aspects of management and leadership. To capture the talent management element, we include two variables that measure active support and encouragement of the university towards intrapreneurial initiatives (whether the university provides staff incentives for external engagement, and whether it rewards staff for the creation of IPR). We also include several variables to capture how the institution supports student career development beyond teaching and learning activities, indicating how the university arranges student placements with external partners (whether this is done centrally, or more informally by departments or on an ad-hoc basis). To cover the knowledge management element, we include two variables to capture how formal (and potentially inflexible) the institution's approach to knowledge management is, as proxied by whether the institution files IPR in house, and whether it requires staff to disclose inventions. For the leadership element, we include a number of variables to capture whether the institution has a strategic plan for engagement with business, and for engagement with the public and civic sectors. We also include a measure of the Vice-Chancellor's pay (in £100 k) to capture the value placed by the institution on attracting highly-remunerated leadership, which we treat as a proxy for the value placed on reputation and visibility of leadership.

Our final element is accessibility of finance, and we operationalise this using three variables: the availability of seed corn investment, the availability of venture capital, and the availability of funds for additional teaching equipment as a result of external engagement activities.

⁶ This is another element of the ecosystem that could be captured more thoroughly in the HESA surveys. In particular, digital infrastructure is not captured by any available survey or administrative data instruments and is of increasing importance in a post-Covid higher education landscape.

3.2 Methods

The aim of our paper is to analyse the institutional variations in the entrepreneurial ecosystem outcomes of the modern university, while considering whether the outcomes corresponding to different missions are complementary or in competition with each other. As discussed in Sect. 2, these outcomes cannot be considered in isolation, because there are externalities that spill over from one mission to another, and there may be a conflict in terms of time and resources, resulting in an increased focus in one to the detriment of another. In addition, there are likely to be unobservable factors that affect one or more of these outcomes. Our empirical approach aims to account for both of these issues, while also allowing us to compare the relative importance of the different elements of the university's entrepreneurial ecosystem in driving the different outcomes.

We use a Seemingly Unrelated Regression (SUR) estimation model, which allows us to estimate a system of equations, with a separate equation for each of the four outcomes of interest, while also allowing the errors to be correlated across the separate equations. This accounts for any potential positive or negative spillovers across the outcomes, caused by synergies or conflicts between the university's different missions. Since we have panel data (albeit only a short panel), we make use of the time element by also allowing for unobserved heterogeneity across institutions. We do this by following the approach proposed by Bjørn (2004) for a random effects panel data SUR model, using the Stata routine developed by Nguyen and Nguyen (2010). We use standardised outcome variables, allowing us to directly compare the estimated coefficients across equations and test for equality in the coefficients. We are also able to estimate the correlation matrix in the error terms as part of the same estimation process.⁷

4 Results and discussion

Our main estimation results are shown in Table 2, for the outcome variables described in Table 1, but we also provide a set of additional results in Table 3 using our alternative measure for the teaching and learning outcome: graduate job satisfaction. In analysing our results, we consider both the effect of each component of the university's entrepreneurial ecosystem on the outcome variables (reading down the columns on Table 2), and also whether the coefficients vary significantly across university missions (reading along the rows on Table 2). The coefficients are directly comparable across equations because of our SUR approach, with all equations estimated jointly within the system, and because we have

⁷ In using a random-effects SUR approach we are making the strong assumption that the error terms are uncorrelated with the explanatory variables (or with the outcome variables) within each equation in the model. An alternative would be to use a fixed effects panel data model, which allows for correlations between the error terms and the explanatory variables, but also estimates the within effects of the coefficients of the explanatory variables, while controlling out the between effects. In contrast, the random effects model assumes that the within and between effects are comparable (Bell et al., 2019). The commonly used Hausman test (in a non-SUR setting) is also inconclusive. For the four outcome variables in our present analysis, the Hausman test (shown in Table 7) indicates that the random effects model is appropriate for the graduate employment and social enterprises equations, while the fixed effects model is more appropriate for the research and spin-off equations. Moreover, we are not able to estimate a panel data SUR model with fixed effects, and there is clearly correlation in the error terms across the outcomes (as shown in Table 8). On balance, and given strong interest in the between effects of the coefficients, we focus our analysis on the random effects SUR model as described in Sect. 3.2, but provide the non-SUR fixed and random effects estimation results for comparison purposes. These are shown in Tables 6 and 7.

standardised the outcome variables by subtracting the mean and dividing by the standard deviation.

Starting with the university's research mission, which is captured in our model using research income per member of academic staff, a few interesting results stand out. First, there seems to be a conflict between some processes and resources devoted to commercialisation, and the university's research mission. For instance, the presence of on-campus and off-campus incubators, and the existence of an internal department devoted to external engagement activities, are all negatively associated with research outcomes, as is the existence of seed corn investment. Similarly, an inflexible IPR management process that requires disclosure of inventions is negatively associated with research outcomes, as the provision of business advice for start-ups. Clearly, in this case, the presence of dual structure hardly helps to mitigate the tensions between commercialisation and research (Ambos et al., 2008). On the other hand, more subtle encouragement of academic entrepreneurship activities, such as the provision of entrepreneurship training, or an institutional culture that views business engagement positively, have a large and positive effect on research grant income. Interestingly, other forms of entrepreneurship incentives and support, such as the existence of a science park, a university-owned exploitation company, availability of venture capital, and positive rewards (financial or in terms of career progression) for academic engagement with external partners are also positively associated with research outcomes, potentially because they attract and retain successful research staff. On the leadership and reputation side, we find, unsurprisingly, that universities with an international focus, and with a highly remunerated VC, have better research outcomes, as proxied by the levels of research income they are able to attract. A final result worth noting concerns facilities aimed at student support and teaching. We find that research outcomes are negatively associated with some processes aimed improving student outcomes, such as the active monitoring of labour markets. This suggests a conflict between the university's research and teaching missions (Geschwind and Brostrom, 2015), which is particularly evident in the extent to which the university invests resources into understanding the dynamics that shape graduate employment prospects. However, we also find that ad-hoc student placements, presumably organised by individual members of academic staff using their networks, and joint curriculum design with employers, are positively associated with both research and teaching outcomes, highlighting the presence of potential synergies in the two missions that can be enabled through more 'engaged' ecosystem elements (Thomas et al., 2023).

Moving on to teaching outcomes, we will consider two sets of outcomes: graduate employment (shown in Table 2), and graduate satisfaction with current activity (shown in Table 3), where current activity is defined as employment or self-employment (for around 75% of all graduates), but also includes volunteering, further study, caring for children or other family members, developing an artistic portfolio, etc. The results are similar, but we are also able to highlight some interesting differences. In general, we find that university processes and resources aimed at supporting academic knowledge exchange are also positively associated with teaching outcomes, suggesting that both missions benefit from a strategic focus on external-facing engagement activities (Beyhan and Findik, 2018; Guerrero & Urbano, 2012). In particular, an institutional commitment to engagement with business, entrepreneurship training (for staff and students), provision of business advice, having a strategic plan for business engagement, and staff rewards for IPR, are all positively associated with graduate employment, while provision of business advice and having a strategic plan for business engagement are also positively associated with graduate job satisfaction. By contrast to graduate employment, graduate job satisfaction is positively associated with having civil society representatives on board,

Table 2 Seemingly Unrelated Regression (SUR) model with four random-effects panel data equations, reporting robust standard errors

	Research income	Graduate employment	Spinoffs	Social enterprises
<i>Regulations and policies</i>				
Business representatives on board (%)	-0.012*** (0.001)	-0.008*** (0.002)	0.036*** (0.002)	-0.004*** (0.001)
Civil society representatives on board (%)	-0.002 (0.001)	-0.012*** (0.002)	0.008*** (0.002)	0.004*** (0.001)
Public sector representatives on board (%)	-0.000 (0.001)	-0.007*** (0.001)	0.121*** (0.002)	-0.001 (0.001)
Required contracting system	0.011 (0.048)	0.033 (0.056)	-0.188** (0.078)	0.098* (0.059)
<i>Culture and values</i>				
Entrepreneurship training (start-ups)	0.132*** (0.029)	0.148*** (0.032)	-0.368*** (0.045)	-0.062** (0.030)
<i>Stakeholder networks</i>				
Benefits from business engagement	0.187*** (0.026)	0.121*** (0.031)	-0.049 (0.043)	-0.114*** (0.029)
Priority: local area	-0.074 (0.066)	-0.510*** (0.076)	-0.577*** (0.107)	0.423*** (0.084)
Priority: region	-0.007 (0.043)	-0.181*** (0.049)	-0.843*** (0.070)	-0.177*** (0.066)
Priority: international	0.191* (0.106)	0.392*** (0.123)	0.060 (0.173)	0.750*** (0.106)
<i>Infrastructure and workspace</i>				
On-campus incubator (start-ups)	-0.056*** (0.015)	-0.002 (0.018)	0.132*** (0.025)	0.094*** (0.015)
Off-campus incubator (start-ups)	-0.080*** (0.021)	0.031 (0.025)	-0.147*** (0.035)	-0.052** (0.021)
Science-park space (start-ups)	0.123*** (0.021)	0.033 (0.023)	0.163*** (0.033)	-0.065*** (0.022)
<i>Market and societal demand</i>				
Business advice (start-ups)	-0.051* (0.029)	0.070** (0.029)	0.367*** (0.041)	-0.103*** (0.022)
Monitoring of labour markets	-0.256*** (0.024)	-0.060* (0.033)	-0.033 (0.047)	-0.102*** (0.028)
Employer curriculum design	0.095** (0.038)	0.204*** (0.027)	-0.662*** (0.038)	-0.044* (0.027)
Exploitation company (owned)	0.131* (0.079)	-0.200*** (0.045)	0.167*** (0.062)	0.226*** (0.049)
Exploitation company (majority)	0.072 (0.099)	-0.057 (0.093)	-0.078 (0.130)	0.022 (0.102)
Exploitation company (minority)	-0.051* (0.029)	-0.011 (0.116)	0.861*** (0.162)	-0.212** (0.093)
<i>Intermediate and support services</i>				
Internal department for engagement	-0.189*** (0.054)	-0.190*** (0.063)	-0.305*** (0.088)	0.138** (0.067)

Table 2 (continued)

	Research income	Graduate employment	Spinoffs	Social enterprises
Indemnity insurance for staff	-0.032 (0.077)	0.128 (0.093)	-1.446*** (0.128)	0.255** (0.107)
<i>Talent management</i>				
Staff incentives for engagement	0.209*** (0.026)	-0.270*** (0.030)	0.377*** (0.043)	0.090*** (0.029)
Staff rewards for IPR	0.088 (0.068)	0.378*** (0.079)	1.408*** (0.111)	-0.285*** (0.074)
Student placements (central)	-0.014 (0.038)	-0.263*** (0.044)	-0.257*** (0.062)	-0.095** (0.039)
Student placements (department)	-0.057 (0.070)	-0.147* (0.083)	-0.644*** (0.115)	0.451*** (0.066)
Student placements (ad hoc)	0.210*** (0.043)	0.008 (0.050)	-0.070 (0.070)	0.025 (0.067)
<i>Knowledge management</i>				
Files IPR in house	0.034 (0.041)	0.029 (0.047)	0.091 (0.066)	0.207*** (0.051)
Requires disclosure of inventions	-0.295*** (0.062)	0.552*** (0.076)	-0.619*** (0.104)	0.374*** (0.082)
<i>Leadership</i>				
Strategic plan (business)	0.080*** (0.026)	0.032 (0.031)	-0.310*** (0.043)	-0.009 (0.022)
Strategic plan (public and civic)	-0.127*** (0.021)	-0.122*** (0.025)	-0.031 (0.035)	0.067*** (0.020)
VC pay (in £100 k)	0.109*** (0.026)	-0.058* (0.030)	0.191*** (0.042)	-0.184*** (0.017)
<i>Accessibility of finance</i>				
Seed corn investment (start-ups)	-0.079*** (0.018)	0.052*** (0.020)	-0.045 (0.029)	0.074*** (0.017)
Venture capital (start-ups)	0.287*** (0.030)	-0.071** (0.036)	-0.283*** (0.050)	0.201*** (0.029)
Funds for teaching (equipment)	-0.029 (0.044)	0.033 (0.049)	-0.488*** (0.070)	0.001 (0.039)
<i>N</i>	453	453	453	453

Dependent variables are standardised to allow cross-equation comparisons of coefficients. Omitted category for priority area is "Priority: national". Robust standard errors shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

and a few other measures that may support graduates in achieving their broader career plans. These include a focus on regional networks (relative to national ones), on-campus incubators and science parks (Guerrero et al., 2020), suggesting some tension between teaching outcomes aimed at graduate employment, and wider ones aimed at supporting graduates in finding a rewarding activity post-graduation. We also find, unsurprisingly, that employer involvement in curriculum design has a positive effect on teaching outcomes.

Table 3 Seemingly Unrelated Regression (SUR) model with four random-effects panel data equations, reporting robust standard errors

	Research income	Graduate job satisfaction	Spinoffs	Social enterprises
<i>Regulations and policies</i>				
Business representatives on board (%)	-0.011*** (0.002)	-0.018*** (0.002)	0.004* (0.002)	-0.004*** (0.001)
Civil society representatives on board (%)	-0.001 (0.002)	0.007*** (0.002)	-0.007*** (0.002)	0.005*** (0.001)
Public sector representatives on board (%)	-0.000 (0.001)	-0.004*** (0.001)	0.005*** (0.002)	0.001 (0.001)
Required contracting system	0.063 (0.056)	-0.091 (0.055)	-0.152* (0.079)	0.096 (0.058)
<i>Culture and values</i>				
Entrepreneurship training (start-ups)	0.096*** (0.033)	-0.161*** (0.031)	-0.107** (0.046)	-0.066** (0.030)
<i>Stakeholder networks</i>				
Benefits from business engagement	0.180*** (0.031)	-0.200*** (0.031)	0.055 (0.043)	-0.110*** (0.029)
Priority: local area	-0.024 (0.076)	-0.166** (0.076)	0.309*** (0.108)	0.410*** (0.083)
Priority: region	-0.054 (0.050)	0.084* (0.049)	0.004 (0.070)	-0.216*** (0.066)
Priority: international	0.130 (0.123)	-0.102 (0.123)	-0.034 (0.173)	0.785*** (0.105)
<i>Infrastructure and workspace</i>				
On-campus incubator (start-ups)	-0.033* (0.018)	0.061*** (0.018)	0.045* (0.025)	0.090*** (0.015)
Off-campus incubator (start-ups)	-0.125*** (0.025)	-0.024 (0.025)	-0.069** (0.035)	-0.070*** (0.020)
Science-park space (start-ups)	0.156*** (0.024)	0.116*** (0.023)	-0.026 (0.033)	-0.068*** (0.022)
<i>Market and societal demand</i>				
Business advice (start-ups)	-0.047 (0.029)	0.149*** (0.029)	-0.003 (0.041)	-0.103*** (0.022)
Monitoring of labour markets	-0.052 (0.033)	-0.106*** (0.033)	0.070 (0.047)	-0.102*** (0.028)
Employer curriculum design	-0.272*** (0.027)	0.176*** (0.027)	-0.032 (0.038)	-0.046* (0.026)
Exploitation company (owned)	0.100** (0.044)	0.088* (0.045)	0.089 (0.062)	0.232*** (0.049)
Exploitation company (majority)	0.241*** (0.092)	-0.269*** (0.093)	-0.147 (0.130)	0.072 (0.101)
Exploitation company (minority)	-0.130 (0.115)	-0.048 (0.116)	-0.150 (0.162)	-0.249*** (0.092)

Table 3 (continued)

	Research income	Graduate job satisfaction	Spinoffs	Social enterprises
<i>Intermediate and support services</i>				
Internal department for engagement	-0.171*** (0.062)	0.091 (0.062)	-0.068 (0.088)	0.148** (0.066)
Indemnity insurance for staff	-0.007 (0.089)	0.070 (0.092)	0.109 (0.128)	0.279*** (0.106)
<i>Talent management</i>				
Staff incentives for engagement	0.234*** (0.030)	-0.031 (0.030)	0.009 (0.043)	0.097*** (0.029)
Staff rewards for IPR	0.028 (0.079)	-0.087 (0.079)	0.042 (0.111)	-0.278*** (0.074)
Student placements (central)	-0.021 (0.044)	-0.082* (0.044)	0.038 (0.062)	-0.083** (0.039)
Student placements (department)	0.035 (0.081)	0.049 (0.083)	-0.133 (0.115)	0.422*** (0.065)
Student placements (ad hoc)	0.223*** (0.050)	-0.281*** (0.050)	-0.012 (0.070)	0.025 (0.067)
<i>Knowledge management</i>				
Files IPR in house	0.065 (0.047)	0.133*** (0.047)	-0.089 (0.066)	0.204*** (0.051)
Requires disclosure of inventions	-0.263*** (0.072)	0.540*** (0.076)	-0.035 (0.104)	0.333*** (0.082)
<i>Leadership</i>				
Strategic plan (business)	0.014 (0.030)	0.165*** (0.031)	-0.114*** (0.043)	0.002 (0.022)
Strategic plan (public and civic)	-0.109*** (0.024)	0.001 (0.025)	0.100*** (0.035)	0.062*** (0.020)
VC pay (in £100 k)	0.141*** (0.030)	-0.056* (0.030)	0.024 (0.042)	-0.185*** (0.017)
<i>Accessibility of finance</i>				
Seed corn investment (start-ups)	-0.096*** (0.020)	-0.016 (0.020)	-0.036 (0.029)	0.081*** (0.017)
Venture capital (start-ups)	0.308*** (0.035)	0.084** (0.036)	0.022 (0.050)	0.185*** (0.028)
Funds for teaching (equipment)	-0.093* (0.050)	-0.217*** (0.049)	0.080 (0.070)	-0.009 (0.039)
<i>N</i>	453	453	453	453

Dependent variables are standardised to allow cross-equation comparisons of coefficients. Omitted category for priority area is "Priority: national". Robust standard errors shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Other activities such as the centrally organised student placements, and (more marginally) university monitoring of graduate labour markets, are negatively associated with teaching

and learning outcomes, perhaps suggesting that these are being organised as a response to otherwise poor employment outcomes for the university's students.

We next consider the determinants of spinoff activity involving university IPR, a proxy for knowledge exchange outcomes. Interestingly, while there are some synergies with the research mission, we find that spinoff activity is much more reliant on processes and resources aimed at supporting institutional infrastructure (such as on-campus incubators, science park space, and fully-owned exploitation companies) as well as networks concentrating on the national scale, rather than the international networks which are so important for the university's research and teaching missions. A university priority to involve business, public sector, and civic society representatives in the strategic direction of the university (proxied by a set of variables capturing the percentage of external representatives on the university's governing body), is positively associated with spinoff activity, but negatively associated with both research and teaching outcomes. This result would be consistent with the positive effects of campus-based entrepreneurship support infrastructure, since university links with business, civic society, and public sector representatives are likely to involve stakeholder engagement in proximity to the university. In other results, we find that talent management capabilities (such as the provision of staff incentives for external engagement and rewards for IPR), university leadership as well as business advice and market monitoring capabilities in the form an exploitation company have positive effect on spinoff activity. Yet, several other ecosystem elements aimed at supporting academic entrepreneurship through university channels have a negative effect on spinoff activity, including having a strategic plan for business engagement, providing entrepreneurship education, availability of finance, and off-campus incubators. These results might suggest that spinoff activity is more reliant, in the aggregate, on a combination of support mechanisms that are providing relatively risk-free market entry and direct access to external stakeholder expertise (Belitski & Aginskaya, 2018).

Finally, we consider the effects of our university entrepreneurial ecosystem variables on social enterprises created by university staff, current students, and recent graduates, which we use as a proxy for progress on the university's civic and community empowerment mission. It is useful to consider both Tables 2 and 3 in this case, since Table 3 uses a broader measure of teaching and learning outcomes (graduate job satisfaction), which is closer in spirit to the university's civic mission. Taking both sets of results together, we find that the creation of social enterprises is positively associated with seed corn investment and other university entrepreneurship support mechanisms such as staff indemnity insurance and staff incentives for external engagement. The presence of a fully-owned exploitation company is also beneficial, with similar sized coefficients to those found for the spinoffs outcome, indicating that both the commercial and not-for-profit forms of academic entrepreneurship benefit from this form of institutional support. We also find, not surprisingly, that there is a positive association between greater civic society representation on the university board and the registration of social enterprises. A university commitment to building both local and international networks is also of key importance, highlighting the role of networks within the civic mission of the university to deal with community development and social issues at the doorstep of the university as well as global socio-economic challenges and injustices (Hoefler and Silva, 2016; Mdleleni, 2021). In contrast, there is a strong negative association between VC remuneration and the creation of social enterprises, suggesting that prestige and leadership profile in the form of an internationally-renowned VC brings little benefit in terms of the university's civic and community empowerment mission, in contrast to the positive benefits it seems to convey on research and teaching outcomes.

5 Conclusions

This study is motivated by a combination of theoretical and practical considerations which define its contribution to the field. From a theoretical point of view there is a clear demand for a better understanding of how alignments and misalignments between entrepreneurial university structures, processes and capabilities may create positive and negative spillovers across different entrepreneurial university outcomes. The relevant theorising of these multiple and simultaneous alignments and misalignments and their implications for the socio-economic opportunities pursued by the entrepreneurial university is still at a relatively early stage (Audretsch & Belitski, 2022). There are increasing and explicit calls in the literature to move away from a binary mode of conceptualising conflicts and complementarities in achieving the different missions of the entrepreneurial university (Thomas et al., 2023). We, therefore, contribute by making a theoretical case for elaborating the entrepreneurial university ecosystem perspective to systematically explore tensions and synergies created by different elements of the ecosystem in relation to the delivery of socio-economic benefits associated with various university missions. While there has been growing interest in embracing entrepreneurial ecosystem thinking in the context of the entrepreneurial university (Guerrero & Urbano, 2012; Guerrero et al., 2015; Hayter et al., 2018; Wright et al., 2017), it has not been fully utilised to analyse tensions and synergies within the ecosystem. As such, we further enhance the theoretical relevance of the entrepreneurial university ecosystem framing and further untap its theoretical potential.

Due to its wide scope and systematic nature, our exploratory study, as expected reveals, an extremely rich picture of an ambiguous environment that all four university missions face in the entrepreneurial university ecosystem. Taking a strategic view on the detailed findings presented in the preceding section, it is worth mentioning a few most contributing observations. Firstly, while nearly every element of the entrepreneurial university ecosystem represents a source of synergies and tensions for achieving entrepreneurial outcomes related to research, teaching and learning, knowledge commercialisation and civic and community empowerment, we can conclude that none of these distinct outcomes is disproportionately affected by the amount of detrimental misalignments (or synergising alignments). Besides reinforcing our theoretical position about the multiplicity of the entrepreneurial university ecosystem outcomes, this finding is significant as it provides a strong indication of the entrepreneurial ecosystem that enables the university to generate new knowledge and capture value from it in a relatively 'balanced' way to realise socio-economic opportunities (Audretsch and Belitski, 2022; Guerrero & Urbano, 2012; Clauss et al., 2018). Secondly, we find that more 'subtle' and relational elements of the ecosystem can be more instrumental in alleviating the tensions between certain missions (e.g. between research and knowledge commercialisation; and between teaching and research) than the elements associated with rigid 'dual' type structures (Ambos et al., 2008). Thirdly, the findings related to the community and social empowerment mission as well as knowledge commercialisation may indicate the emergence of the 'engaged university' ecosystem in the sense of providing leadership in dealing with place-based and socially responsible agendas (Audretsch, 2014; Audretsch and Belitski, 2022; Thomas et al., 2023).

Our study furthers the critical discussion championed by this journal on the entrepreneurial university as a catalyst of societal and economic advancements (Cerver Romero et al., 2021; Rådberg & Löfsten, 2024). It supports and reinforces the case for theorising the creation of social value as an essential outcome of the entrepreneurial university, and explicitly responds to the calls for advancing our understanding of whether existing

entrepreneurial university mechanisms are aligned to strive for both economic and social value (Menter, 2024). Our study also resonates with and extends recent research on the role of stakeholders in the entrepreneurial university (Radko et al., 2023). It provides new evidence on how different stakeholder networks and different stakeholder representations on the university board can be significant factors, contributing to both synergies and tensions across the outcomes of the entrepreneurial university ecosystem. Furthermore, echoing Gianiodis and Meek (2020), our study encourages to have a nuanced discussion on how entrepreneurial training and entrepreneurial culture can play a synergetic role in shaping diverse outcomes of the entrepreneurial university.

From a practitioner's point of view, we contribute by elaborating a framework and a method that can easily be utilised to create an invaluable diagnostics tool for institutional managers and policy makers. This tool could enable them to systematically evaluate the effectiveness of different parts and functions of the entrepreneurial university in relation to the range of expected outcomes, to consider them holistically rather than in a binary manner, and to identify areas for an urgent action, as well as medium and long-term strategies. For instance, we can see from our results that having an off-campus incubator as part of the ecosystem infrastructure is one of the most problematic and detrimental factors for most of the ecosystem outcomes, implying that the university has to carefully consider this element. Any institution using our tool would be expected to urgently 'rethink' this and other elements with similarly problematic effects, and take an urgent corrective action. It is assumed in our study that any part of the university could potentially be considered entrepreneurial, either directly or indirectly (Audretsch & Belitski, 2022; Holstein et al., 2018). As such, it is implied that any university could be seen as entrepreneurial to a certain degree. In this context, university managers from universities in the UK (or elsewhere) that may be deemed 'non-entrepreneurial' due to, for instance, a certain knowledge commercialisation metric, can especially benefit from our framework and its empirical insights. The application of the framework would enable the managers to systematically draw conclusions on the underlying constraining factors for the metric of interest, ensuring they do not overlook any essential positive effects of the same factors elsewhere within the ecosystem when initiating a corrective action.

Finally, as any large-scale secondary data study, our scope and analysis are affected by data availability. Our study is limited both in terms of the number of time periods (only three so far for detailed graduate outcomes data) and the factors covered. As we stressed earlier, obtaining more high-quality administrative data on e-learning, IT infrastructure and institutional culture would be essential for advancing analyses like ours. Furthermore, the responses to the surveys we use may be influenced by the identity of the respondent within a given institution (e.g., who can speak for all of learning and teaching, research, commercialisation, and civic mission outcomes). The study offers opportunities for several extensions. Due to its accessible methodology, it could be replicated in alternative national contexts where similar data is available to enable international comparisons and contextualisation. Complementing and extending our study through a series of qualitative analyses would also be highly desirable. This could enrich the interpretation of the results by delving deeper into, for instance, how the elements of the ecosystem may function or malfunction, producing unintended consequences. Conducting studies from an entrepreneurial university ecosystem perspective is data demanding. Researchers interested in extending this type of analysis in higher education contexts with limited access to data should not feel demotivated, though. There are several methodological approaches that could be explored under such circumstances. For instance, in the absence of structured large scale secondary data, one can consider using relevant unstructured data that can be analysed using text analytics techniques (Prüfer and Prüfer, 2020). One can also

consider using a Delphi study that may involve collecting both quantitative and qualitative information to arrive at accessible measurements of elements and outputs of the ecosystem (Cobben et al., 2023). Alternatively, a Delphi study could serve as a precursor for developing a purpose-built survey to systematically collect primary data on the university entrepreneurial ecosystem (Abreu & Grinevich, 2013). Furthermore, where feasible, motivated researchers should reach out to Higher Education Statistics authorities to explore opportunities for amending the scope of the existing data collection exercises to fully capture the elements of the university entrepreneurial ecosystem and an inclusive multi-mission perspective on its outcomes.

Appendix 1: Detailed descriptions for all the variables included in the analysis

Data sources

All of the variables used in the study were constructed from data provided by the UK's Higher Education Statistics Agency (HESA). The data sources are (a) Graduate Outcomes survey, which is sent to all UK graduates 15 months after graduation, (b) HE-BIC survey, which is completed annually by all public higher education institutions (Part A for qualitative responses, Part B for quantitative responses), and (c) Staff and Finance databases, which contain administrative data submitted annually by all higher education institutions to HESA

Outcome variables

Research income per academic staff (in £000 s): annual income from all research grants and contracts in thousands of pounds, divided by the institution's full time academic staff, and adjusted for inflation using the GDP deflator with base year 2015 (Staff, Finance)

Graduate employment (%): percentage of an institution's undergraduate student cohort in a given year of graduation, who are in full-time employment 15 months after graduation (Graduate Outcomes)

Graduate job satisfaction (%): percentage of an institution's student cohort in a given year of graduation, who strongly agree with the statement "My current activity is meaningful" (Graduate Outcomes)

Spinoffs: number of registered companies set-up to exploit IP that has originated from within the institution, where the institution continues to have some ownership, divided by the number of full-time academic staff (and rescaled by a thousand so the measure is per 1,000 staff). (HE-BIC Part B)

Social enterprises: number of social enterprises registered by staff, students, or graduates, divided by the number of full-time academic staff (and rescaled by a thousand so the measure is per 1,000 staff). (HE-BIC Part B)

Explanatory variables

Business representatives on board (%): percentage of members on the institution's governing body who are representatives of commercial business (HE-BCI Part A)

Civil society representatives on board (%): percentage of members on the institution's governing body who are representatives of social, community, or cultural groups (HE-BCI Part A)

Public sector representatives on board (%): percentage of members on the institution's governing body who are representatives of public sector organisations (HE-BCI Part A)

Required contracting system: whether the institution has a required contracting system for all staff business and community interaction activities (HE-BCI Part A)

Entrepreneurship training (start-ups): whether the institution offers start-up support via entrepreneurship training (HE-BCI Part A)

Benefits from business engagement: the benefits ultimately delivered with respect to the institution's knowledge exchange priorities, resulting from engagement with commercial private business, on a scale of 1–4 (HE-BCI Part A)

Priority: local area: whether the local area is a priority for the institution in terms of knowledge-exchange activities (HE-BCI Part A)

Priority: region: whether the region or nation (for Scotland, Wales, and Northern Ireland) is a priority for the institution in terms of knowledge-exchange activities (HE-BCI Part A)

Priority: national: whether national collaborations are a priority for the institution in terms of knowledge-exchange activities (HE-BCI Part A)

Priority: international: whether international collaborations are a priority for the institution in terms of knowledge-exchange activities (HE-BCI Part A)

On campus incubator (start-ups): whether the institution offers start-up support via this mechanism (HE-BCI Part A)

Off-campus incubator (start-ups): whether the institution offers start-up support via this mechanism (HE-BCI Part A)

Science-park space (start-ups): whether the institution offers start-up support via this mechanism (HE-BCI Part A)

Business advice (start-ups): whether the institution offers start-up support via this mechanism (HE-BCI Part A)

Monitoring of labour markets: the extent to which the institution monitors skills needs and sectoral changes through local labour market intelligence, on a scale of 1–5 (HE-BCI Part A)

Employer curriculum design: the extent to which employers are actively involved in the development of content and regular reviewing of the institution's curriculum, on a scale of 1–5 (HE-BCI Part A)

Exploitation company (owned): whether the institution has this subsidiary company or department to manage business and community interactions (HE-BCI Part A)

Exploitation company (majority): whether the institution has this subsidiary company or department to manage business and community interactions (HE-BCI Part A)

Exploitation company (minority): whether the institution has this subsidiary company or department to manage business and community interactions (HE-BCI Part A)

Internal department for engagement: whether the institution has this subsidiary company or department to manage business and community interactions (HE-BCI Part A)

Indemnity insurance for staff: whether the institution provides indemnity insurance for staff to cover external engagement activities (HE-BCI Part A)

Staff incentives for engagement: the level of incentives provided for staff to engage with business and community partners, on a scale of 1–5 (HE-BCI Part A)

Staff rewards for IPR: whether staff are rewarded (financially or otherwise) for the intellectual property they generate (HE-BCI Part A)

Student placements (central): whether graduate business placements are arranged centrally (HE-BCI Part A)

Student placements (department): whether graduate business placements are arranged via individual schools or departments (HE-BCI Part A)

Student placements (ad hoc): whether graduate business placements are arranged in an ad-hoc way between students and businesses (HE-BCI Part A)

Files IPR in house: whether the institution exerts ownership over intellectual property by filing IPR in house (HE-BCI Part A)

Requires disclosure of inventions: whether the institution requires staff to report or disclose inventions (HE-BCI Part A)

Strategic plan (business): the extent to which the university has developed a strategic plan for business engagement, on a scale of 1–5 (HE-BCI Part A)

Strategic plan (public and civic): the extent to which the university has developed a strategic plan for public and community engagement, on a scale of 1–5 (HE-BCI Part A)

VC pay (in £100 k): the total annual remuneration package for the institution's Vice Chancellor or equivalent head of institution (HESA Finance database)

Seed corn investment (start-ups): whether the institution offers start-up support via this mechanism (HE-BCI Part A)

Venture capital (start-ups): whether the institution offers start-up support via this mechanism (HE-BCI Part A)

Funds for teaching (equipment): whether the institution's external engagement activities (linked to local-area regeneration) have provided funds for additional teaching equipment (HE-BCI Part A)

Appendix 2: Additional tables

See Tables 4, 5, 6, 7, 8, 9, and 10.

Table 4 Descriptive statistics for the variables included in the analysis

Variable	Obs	Mean	Std. dev	Min	Max
Grant income per academic staff (in £000 s)	453	21.10	28.80	0	289.61
Graduate employment	453	53.11	9.24	17	79.00
Graduate job satisfaction	453	42.65	5.97	24	69.00
Student continuation	451	6.72	3.70	0	23.8
Spinoffs	453	0.98	7.32	0	116.67
Social enterprises	453	1.12	3.93	0	53.97
Business representatives on board (%)	453	37.21	13.87	0	82.35
Civil society representatives on board (%)	453	11.96	11.74	0	56.25
Public sector representatives on board (%)	453	29.31	17.71	0	83.33
Required contracting system	453	0.73	0.44	0	1.00
Entrepreneurship training (start-ups)	453	3.34	0.85	1	4.00
Benefits from business engagement	453	3.34	0.84	1	4.00
Priority: local area	453	0.11	0.31	0	1.00
Priority: region	453	0.35	0.48	0	1.00
Priority: international	453	0.04	0.18	0	1.00
On-campus incubator (start-ups)	453	3.04	1.31	1	4.00
Off-campus incubator (start-ups)	453	1.93	0.96	1	4.00
Science-park space (start-ups)	453	1.73	1.06	1	4.00
Business advice (start-ups)	453	3.17	0.80	1	4.00
Monitoring of labour markets	453	3.75	0.83	1	5.00
Employer curriculum design	453	4.17	0.93	1	5.00
Exploitation company (owned)	453	0.44	0.50	0	1.00
Exploitation company (majority)	453	0.06	0.23	0	1.00
Exploitation company (minority)	453	0.04	0.18	0	1.00
Internal department for engagement	453	0.83	0.37	0	1.00
Indemnity insurance for staff	453	0.90	0.31	0	1.00
Staff incentives for engagement	453	3.73	0.79	1	5.00
Staff rewards for IPR	453	0.83	0.37	0	1.00
Student placements (central)	453	0.61	0.49	0	1.00
Student placements (department)	453	0.93	0.26	0	1.00
Student placements (ad hoc)	453	0.74	0.44	0	1.00
Files IPR in house	453	0.37	0.48	0	1.00
Requires disclosure of inventions	453	0.89	0.31	0	1.00
Strategic plan (business)	453	4.15	0.86	2	5.00
Strategic plan (public and civic)	453	3.90	0.96	1	5.00
VC pay (in £100 k)	453	2.95	0.84	0.9	6.16
Seed corn investment (start-ups)	453	2.44	1.16	1	4.00
Venture capital (start-ups)	453	1.61	0.74	1	4.00
Funds for teaching (equipment)	453	0.36	0.48	0	1.00
Russell Group	453	0.16	0.37	0	1.00
ITL 1 region	453	6.75	3.08	1	12

Table 5 Correlation matrix for all variables included in the analysis

	Grant income	Graduate employment	Graduate job satisfaction	Student continuation	Spinoffs	Social enterprises	Business representatives	Civil society representatives	Public sector representatives	Required contracting system	Entrepreneurship training	Benefits from business engagement
Grant income	1.000											
Graduate employment	-0.029	1.000										
Graduate job satisfaction	0.087	0.411	1.000									
Student continuation	-0.369	-0.030	0.000	1.000								
Spinoffs	0.027	-0.006	-0.108	-0.022	1.000							
Social enterprises	-0.107	0.035	-0.025	0.158	-0.024	1.000						
Business representatives	-0.190	-0.058	-0.298	0.063	0.078	0.070	1.000					
Civil society representatives	-0.128	-0.191	0.057	0.067	-0.095	-0.055	-0.219	1.000				
Public sector representatives	-0.112	-0.010	-0.008	0.228	0.025	0.001	-0.167	-0.034	1.000			
Required contracting system	0.074	0.147	-0.007	-0.004	-0.074	0.069	0.148	-0.109	0.054	1.000		
Entrepreneurship training	0.070	0.136	-0.114	0.164	-0.010	0.054	0.122	-0.154	-0.015	0.163	1.000	
Benefits from business engagement	0.316	0.208	-0.102	-0.157	0.092	0.064	0.078	-0.277	-0.052	0.253	0.068	1.000
Priority: local area	-0.143	-0.128	-0.115	0.109	0.142	-0.065	0.139	0.040	-0.054	-0.253	0.137	-0.206
Priority: region	-0.041	0.000	0.035	0.150	-0.050	0.120	-0.064	0.033	0.202	-0.027	0.052	0.043
Priority: international	0.150	-0.005	-0.034	-0.094	-0.007	-0.051	0.021	0.002	-0.139	-0.054	-0.118	-0.103
On-campus incubator (start-ups)	0.177	0.169	0.088	0.089	0.063	0.103	-0.012	-0.113	-0.105	0.271	0.297	0.240
Off-campus incubator (start-ups)	0.137	0.133	-0.041	-0.023	-0.042	0.143	-0.072	-0.129	0.000	0.216	0.130	0.401
Science-park space (start-ups)	0.321	0.127	0.074	-0.199	0.002	-0.004	-0.058	-0.206	-0.103	0.143	0.083	0.342
Business advice (start-ups)	-0.074	0.128	0.074	0.156	-0.008	0.024	0.021	-0.063	-0.060	0.000	0.460	0.067

Table 5 (continued)

	Grant income	Graduate employment	Graduate job satisfaction	Student continuation	Spinoffs	Social enterprises	Business representatives	Civil society representatives	Public sector representatives	Required contracting system	Entrepreneurship training	Benefits from business engagement
Monitoring of labour markets	-0.020	0.051	-0.073	0.080	0.107	0.182	0.151	-0.156	0.134	0.266	0.214	0.252
Employer curriculum design	-0.313	0.147	0.100	0.198	0.049	0.104	0.170	-0.078	0.273	0.106	0.048	-0.049
Exploitation company (owned)	0.192	0.036	0.011	0.012	0.086	0.033	0.036	-0.246	-0.009	0.076	0.144	0.256
Exploitation company (majority)	0.011	-0.083	-0.019	-0.083	-0.013	0.010	0.039	-0.024	-0.081	-0.005	-0.132	0.019
Exploitation company (minority)	-0.034	-0.022	-0.034	0.061	-0.005	0.026	0.102	-0.029	-0.061	0.063	0.022	0.095
Internal department for engagement	0.126	0.033	-0.059	0.077	-0.105	0.054	0.035	-0.146	-0.045	0.331	0.159	0.191
Indemnity insurance for staff	0.227	0.255	0.032	0.067	0.051	0.028	-0.002	-0.127	0.034	0.429	0.188	0.377
Staff incentives for engagement	0.232	-0.030	-0.021	-0.231	0.074	0.085	0.005	-0.212	-0.105	0.164	0.141	0.300
Staff rewards for IPR	0.246	0.261	-0.013	0.041	0.063	0.071	-0.024	-0.193	-0.093	0.393	0.223	0.439
Student placements (central)	-0.126	-0.089	-0.015	0.258	0.010	0.027	0.069	0.042	0.086	0.017	0.122	-0.075
Student placements (department)	0.119	0.096	-0.023	-0.027	0.034	0.064	-0.098	-0.127	0.031	0.162	-0.011	0.099
Student placements (ad hoc)	0.198	0.091	-0.120	-0.103	0.062	0.079	-0.054	-0.186	0.089	-0.013	0.062	0.074
Files IPR in house	0.208	0.089	0.053	-0.129	-0.006	-0.025	0.037	-0.224	-0.101	0.131	0.083	0.206
Requires disclosure of inventions	0.158	0.326	0.173	0.072	0.048	0.009	-0.038	-0.279	0.070	0.278	0.042	0.241
Strategic plan (business)	0.077	0.087	0.048	-0.084	0.022	0.102	0.139	-0.207	0.038	0.296	0.169	0.305

Table 5 (continued)

	Grant income	Graduate employment	Graduate job satisfaction	Student continuation	Spinoffs	Social enterprises	Business representatives	Civil society representatives	Public sector representatives	Required contracting system	Entrepreneurship training	Benefits from business engagement
Strategic plan (public and civic)	-0.002	-0.103	-0.005	-0.147	0.078	0.091	0.136	-0.062	-0.053	0.129	-0.013	0.088
VC pay (in £100 k)	0.383	0.156	-0.007	-0.200	0.036	-0.085	-0.015	-0.247	-0.184	0.185	0.221	0.203
Seed com investment (start-ups)	0.053	0.133	0.013	-0.087	-0.054	0.117	0.105	-0.100	-0.017	0.145	0.212	0.230
Venture capital (start-ups)	0.334	0.096	0.049	-0.124	0.011	0.103	-0.067	-0.184	0.032	0.225	0.133	0.355
Funds for teaching (equipment)	0.022	0.076	-0.098	0.093	0.079	0.052	-0.011	-0.041	0.108	0.146	0.181	0.021
Priority: local area	Priority: region	Priority: international	On-campus incubator (start-ups)	Off-campus incubator (start-ups)	Science park space (start-ups)	Business advice (start-ups)	Monitoring of labour markets	Employer curriculum design	Exploitation company (majority)	Exploitation company (owned)	Exploitation company (minority)	Exploitation company (minority)
Priority: local area	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Priority: region	-0.255	1.000										
Priority: international	-0.065	-0.136	1.000									
On-campus incubator (start-ups)	-0.060	-0.108	-0.062	1.000								

Table 5 (continued)

	Priority: local area	Priority: region	Priority: international	On-campus incubator (start-ups)	Off-campus incubator (start-ups)	Science-park space (start-ups)	Business advice (start-ups)	Monitoring of labour markets	Employer curriculum design	Exploitation company (owned)	Exploitation company (majority)	Exploitation company (minority)
Off-campus incubator (start-ups)	-0.179	-0.079	-0.040	0.185	1.000							
Science-park space (start-ups)	-0.181	-0.075	0.046	0.266	0.317	1.000						
Business advice (start-ups)	0.097	-0.004	-0.161	0.152	0.074	0.025	1.000					
Monitoring of labour markets	-0.229	0.060	-0.108	0.220	0.137	0.198	0.116	1.000				
Employer curriculum design	-0.076	0.197	-0.297	-0.105	-0.101	-0.100	0.171	0.371	1.000			
Exploitation company (owned)	-0.079	-0.093	0.060	0.216	0.057	0.188	0.086	0.173	-0.058	1.000		

Table 5 (continued)

	Priority: local area	Priority: region	Priority: international	On-campus incubator (start-ups)	Off-campus incubator (start-ups)	Science- park space (start-ups)	Business advice (start-ups)	Monitoring of labour markets	Employer curriculum design	Exploi- tation company (owned)	Exploi- tation company (majority)	Exploitation company (minority)
Exploitation company (majority)	0.009	0.047	-0.045	0.015	-0.076	0.088	0.023	-0.020	-0.001	0.118	1.000	
Exploitation company (minority)	0.049	0.011	0.031	0.141	-0.025	-0.008	0.050	0.117	0.108	0.217	0.216	1.000
Internal department engagement	-0.112	-0.086	0.050	0.155	0.139	0.179	0.084	0.137	-0.114	-0.037	0.108	0.086
Indemnity insurance for staff	-0.207	-0.071	0.063	0.349	0.183	0.201	0.097	0.133	-0.096	0.243	-0.013	0.065
Staff incentives for engagement	-0.178	-0.056	0.064	0.099	0.183	0.215	0.126	0.340	0.141	0.133	0.083	0.066
Staff rewards for IPR	-0.109	-0.081	-0.016	0.372	0.281	0.283	0.040	0.206	-0.106	0.279	0.031	0.086

Table 5 (continued)

	Priority: local area	Priority: region	Priority: international	On-campus incubator (start-ups)	Off-campus incubator (start-ups)	Science-park space (start-ups)	Business advice (start-ups)	Monitoring of labour markets	Employer curriculum design	Exploitation company (owned)	Exploitation company (majority)	Exploitation company (minority)
Student placements (central)	-0.029	-0.077	-0.030	0.035	0.024	0.028	0.145	0.098	0.070	0.053	0.074	0.054
Student placements (department)	-0.070	-0.161	0.051	0.207	0.090	0.150	-0.073	0.124	-0.072	0.158	0.067	0.053
Student placements (ad hoc)	0.008	-0.117	0.052	0.080	0.084	0.112	-0.032	0.129	-0.024	0.128	0.008	0.030
Files IPR in house	-0.035	-0.056	-0.016	0.110	0.069	0.254	-0.038	0.043	-0.095	0.127	0.033	-0.149
Requires disclosure of inventions	-0.240	0.051	0.066	0.243	0.154	0.204	-0.095	0.191	0.023	0.213	-0.007	0.068
Strategic plan (business)	-0.159	-0.146	-0.118	0.232	0.219	0.181	0.132	0.517	0.172	0.099	-0.041	0.037
Strategic plan (public and civic)	-0.149	-0.132	0.006	0.049	0.157	0.169	0.027	0.258	0.048	-0.015	0.146	-0.042

Table 5 (continued)

	Priority: local area	Priority: region	Priority: international	On-campus incubator (start-ups)	Off-campus incubator (start-ups)	Science-park space (start-ups)	Business advice (start-ups)	Monitoring of labour markets	Employer curriculum design	Exploitation company (owned)	Exploitation company (majority)	Exploitation company (minority)	
VC pay (in £100 k)	-0.123	-0.159	0.195	0.253	0.155	0.297	0.004	0.062	-0.206	0.233	0.000	0.087	
Seed corn investment (start-ups)	0.030	-0.063	-0.026	0.140	0.167	0.175	0.227	0.012	0.059	0.150	0.019	0.053	
Venture capital (start-ups)	-0.221	-0.009	-0.002	0.289	0.410	0.363	-0.004	0.231	-0.021	0.254	0.024	0.135	
Funds for teaching (equipment)	-0.040	-0.007	-0.140	0.199	0.088	0.227	-0.022	0.285	0.072	0.106	-0.122	0.030	
Internal department for engagement				Staff incentives for engagement	Staff rewards for IPR	Student placements (central)	Student placements (department)	Student placements (ad hoc)	Files IPR in house	Requires disclosure of inventions	Strategic plan (business)	Strategic plan (public and civic)	VC pay (in £100 k)
Internal department for engagement	1.000												

Table 5 (continued)

	Internal department for engagement	Indemnity insurance for staff	Staff incentives for engagement	Staff rewards for IPR	Student placements (central)	Student placements (department)	Student placements (ad hoc)	Files IPR in house	Requires disclosure of inventions	Strategic plan (business)	Strategic plan (public and civic)	VC pay (in £100 k)
Indemnity insurance for staff	0.296	1.000										
Staff incentives for engagement	0.164	0.214	1.000									
Staff rewards for IPR	0.356	0.603	0.198	1.000								
Student placements (central)	0.121	0.071	-0.025	0.079	1.000							
Student placements (department)	0.155	0.245	0.037	0.199	-0.167	1.000						
Student placements (ad hoc)	0.135	0.150	0.051	0.158	0.067	0.354	1.000					
Files IPR in house	0.112	0.204	0.172	0.263	-0.042	0.089	0.096	1.000				

Table 5 (continued)

	Internal department for engagement	Indemnity insurance for staff	Staff incentives for engagement	Staff rewards for IPR	Student placements (central)	Student placements (department)	Student placements (ad hoc)	Files IPR in house	Requires disclosure of inventions	Strategic plan (business)	Strategic plan (public and civic)	VC pay (in £100 k)
Requires disclosure of inventions	0.146	0.457	0.112	0.407	0.067	0.150	0.150	0.244	1.000			
Strategic plan (business)	0.215	0.126	0.369	0.208	0.014	0.097	0.094	0.188	0.134	1.000		
Strategic plan (public and civic)	0.133	-0.005	0.288	0.107	0.092	0.097	0.050	0.171	-0.081	0.487	1.000	
VC pay (in £100 k)	0.253	0.334	0.258	0.450	0.024	0.085	0.159	0.307	0.361	0.168	0.099	1.000
Seed corn investment	0.032	0.209	0.091	0.168	0.056	0.088	0.121	0.152	0.107	0.120	0.150	0.133
Venture capital	0.118	0.233	0.238	0.324	-0.029	0.088	0.151	0.239	0.234	0.270	0.158	0.372
Funds for teaching	0.076	0.106	0.036	0.203	0.088	0.172	0.239	-0.029	0.089	0.114	-0.061	0.045
					Seed corn investment			Venture capital			Funds for teaching	
Seed corn investment (start-ups)					1.000							
Venture capital (start-ups)					0.372			1.000				
Funds for teaching (equipment)					-0.021			0.031				1.000

Table 6 Fixed effects panel data estimation of university entrepreneurial ecosystem outputs (without SUR)

	Research income	Graduate employment	Spinoffs	Social enterprises
<i>Regulations and policies</i>				
Business representatives on board (%)	-0.001 (0.001)	0.008 (0.005)	0.007 (0.006)	0.002 (0.005)
Civil society representatives on board (%)	-0.001 (0.002)	0.008 (0.005)	-0.000 (0.002)	0.013* (0.008)
Public sector representatives on board (%)	-0.001 (0.001)	0.001 (0.003)	-0.003 (0.004)	0.007 (0.008)
Required contracting system	-0.033 (0.029)	-0.374* (0.204)	-0.078 (0.119)	-0.153 (0.153)
<i>Culture and values</i>				
Entrepreneurship training (start-ups)	-0.043 (0.045)	0.012 (0.111)	-0.101 (0.083)	-0.051 (0.065)
<i>Stakeholder networks</i>				
Benefits from business engagement	0.029 (0.022)	0.095 (0.112)	0.040 (0.091)	-0.351*** (0.128)
Priority: local area	-0.105 (0.071)	-0.224 (0.427)	0.437 (0.447)	0.341 (0.567)
Priority: region	-0.169*** (0.050)	-0.446 (0.438)	0.056 (0.121)	-0.945** (0.478)
Priority: international	-0.030 (0.064)	0.143 (0.494)	-0.282 (0.286)	0.707 (0.435)
<i>Infrastructure and workspace</i>				
On-campus incubator (start-ups)	-0.014 (0.013)	0.035 (0.029)	0.022 (0.053)	0.042 (0.034)
Off-campus incubator (start-ups)	0.016 (0.026)	0.022 (0.073)	0.013 (0.046)	-0.010 (0.053)
Science – park space (start-ups)	0.045 (0.028)	0.024 (0.050)	0.040 (0.079)	-0.006 (0.070)
<i>Market and societal demand</i>				
Business advice (start-ups)	-0.013 (0.022)	0.003 (0.047)	-0.060 (0.078)	-0.004 (0.032)
Monitoring of labour markets	-0.041** (0.021)	-0.095 (0.110)	-0.034 (0.121)	-0.060 (0.066)
Employer curriculum design	0.015 (0.026)	-0.135 (0.104)	-0.141 (0.135)	-0.042 (0.109)
Exploitation company (owned)	-0.078** (0.040)	-0.082 (0.162)	0.246 (0.242)	0.197 (0.145)
Exploitation company (majority)	-0.057 (0.122)	-0.459*** (0.143)	-0.332 (0.531)	0.125 (0.264)
Exploitation company (minority)	0.011 (0.096)	0.063 (0.219)	-0.187 (0.338)	-0.369 (0.463)
<i>Intermediate and support services</i>				
Internal department for engagement	-0.061** (0.023)	0.153 (0.123)	0.211 (0.214)	-0.174 (0.196)

Table 6 (continued)

	Research income	Graduate employment	Spinoffs	Social enterprises
Indemnity insurance for staff	-0.089 (0.092)	0.148 (0.248)	-0.795 (0.837)	0.593 (0.421)
<i>Talent management</i>				
Staff incentives for engagement	0.049 (0.030)	-0.043 (0.103)	-0.056 (0.076)	0.426** (0.200)
Staff rewards for IPR	0.017 (0.040)	-0.397*** (0.120)	0.358 (0.353)	-0.324** (0.145)
Student placements (central)	-0.034 (0.028)	-0.224* (0.115)	1.062 (0.979)	0.075 (0.168)
Student placements (department)	-0.010 (0.043)	-0.250 (0.198)	0.325 (0.368)	0.297 (0.196)
Student placements (ad hoc)	0.015 (0.072)	-0.116 (0.391)	-0.958 (0.893)	1.195** (0.578)
<i>Knowledge management</i>				
Files IPR in house	-0.098 (0.063)	0.108 (0.117)	0.164 (0.153)	0.466 (0.441)
Requires disclosure of inventions	0.096 (0.068)	0.591*** (0.185)	0.239 (0.339)	-0.141 (0.306)
<i>Leadership</i>				
Strategic plan (business)	-0.072 (0.063)	-0.159* (0.092)	-0.024 (0.090)	-0.013 (0.075)
Strategic plan (public and civic)	0.002 (0.025)	0.043 (0.056)	0.241 (0.257)	0.030 (0.081)
VC pay (in £100 k)	0.004 (0.017)	0.023 (0.070)	-0.023 (0.031)	-0.103 (0.086)
<i>Accessibility of finance</i>				
Seed corn investment (start-ups)	-0.002 (0.015)	0.057 (0.068)	0.011 (0.033)	0.068 (0.045)
Venture capital (start-ups)	0.017 (0.024)	0.002 (0.089)	-0.028 (0.071)	0.033 (0.112)
Funds for teaching (equipment)	0.020 (0.031)	-0.047 (0.115)	0.093 (0.089)	-0.028 (0.110)
Constant	0.470* (0.283)	0.871 (0.834)	-0.158 (0.836)	-1.424 (1.355)
R-squared (within)	0.060	0.124	0.114	0.083
R-squared (between)	0.019	0.001	0.003	0.004
R-squared (overall)	0.020	0.000	0.000	0.000
Correlation (within errors, regressors)	-0.012	-0.418	-0.635	-0.784
F statistic (33, 151)	1.67	7.99	0.23	9.95
Prob > F	0.021	0.000	1.000	0.000
N	453	453	453	453

Dependent variables are standardised to allow cross-equation comparisons of coefficients. Omitted category for priority area is "Priority: national". Robust standard errors shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 7 Random effects panel data estimation of university entrepreneurial ecosystem outputs (without SUR)

	Research income	Graduate employment	Spinoffs	Social enterprises
<i>Regulations and policies</i>				
Business representatives on board (%)	-0.003*** (0.001)	0.004 (0.004)	0.005 (0.004)	0.004 (0.003)
Civil society representatives on board (%)	-0.002 (0.002)	0.001 (0.004)	0.002 (0.003)	0.002 (0.004)
Public sector representatives on board (%)	-0.002 (0.001)	0.000 (0.003)	0.001 (0.003)	-0.001 (0.005)
Required contracting system	-0.037 (0.063)	-0.138 (0.143)	-0.105 (0.112)	-0.031 (0.104)
<i>Culture and values</i>				
Entrepreneurship training (start-ups)	0.003 (0.038)	0.088 (0.083)	0.015 (0.085)	-0.019 (0.059)
<i>Stakeholder networks</i>				
Benefits from business engagement	0.074** (0.029)	0.129 (0.081)	0.243 (0.159)	-0.062 (0.098)
Priority: local area	-0.145* (0.079)	-0.414** (0.190)	0.579 (0.409)	0.142 (0.251)
Priority: region	-0.134* (0.078)	-0.173 (0.159)	-0.030 (0.144)	0.275 (0.175)
Priority: international	0.127 (0.121)	-0.193 (0.473)	1.387 (1.258)	0.385 (0.389)
<i>Infrastructure and workspace</i>				
On-campus incubator (start-ups)	-0.004 (0.014)	0.033 (0.033)	0.053 (0.046)	0.080** (0.034)
Off-campus incubator (start-ups)	-0.006 (0.028)	0.061 (0.058)	-0.142 (0.098)	0.087 (0.075)
Science-park space (start-ups)	0.080*** (0.028)	0.022 (0.041)	-0.064 (0.055)	-0.085 (0.070)
<i>Market and societal demand</i>				
Business advice (start-ups)	-0.016 (0.021)	0.068 (0.062)	0.035 (0.052)	-0.035 (0.060)
Monitoring of labour markets	-0.035 (0.028)	-0.094 (0.089)	-0.049 (0.076)	0.087 (0.089)
Employer curriculum design	-0.065** (0.026)	0.096 (0.080)	0.104 (0.107)	0.060 (0.063)
Exploitation company (owned)	-0.064 (0.043)	-0.085 (0.109)	-0.114 (0.171)	0.060 (0.117)
Exploitation company (majority)	0.007 (0.076)	-0.292* (0.168)	-0.139 (0.245)	-0.033 (0.289)
Exploitation company (minority)	0.009 (0.108)	-0.002 (0.222)	-0.354 (0.278)	-0.238 (0.324)
<i>Intermediate and support services</i>				
Internal department for engagement	0.011 (0.057)	0.051 (0.146)	-0.116 (0.162)	0.144 (0.128)

Table 7 (continued)

	Research income	Graduate employment	Spinoffs	Social enterprises
Indemnity insurance for staff	0.157 (0.137)	0.244 (0.286)	-0.103 (0.158)	-0.145 (0.189)
<i>Talent management</i>				
Staff incentives for engagement	0.076** (0.032)	-0.159** (0.071)	0.070 (0.059)	0.101 (0.071)
Staff rewards for IPR	0.044 (0.053)	-0.045 (0.198)	0.118 (0.104)	0.166 (0.108)
Student placements (central)	-0.068** (0.034)	-0.282*** (0.092)	0.381 (0.480)	0.015 (0.119)
Student placements (department)	-0.010 (0.055)	-0.114 (0.201)	0.322 (0.214)	0.255** (0.122)
Student placements (ad hoc)	0.132* (0.072)	0.109 (0.179)	-0.378 (0.272)	0.122 (0.117)
<i>Knowledge management</i>				
Files IPR in house	-0.024 (0.063)	0.112 (0.105)	-0.170 (0.157)	-0.058 (0.132)
Requires disclosure of inventions	0.106* (0.054)	0.805*** (0.233)	0.253 (0.213)	-0.020 (0.183)
<i>Leadership</i>				
Strategic plan (business)	-0.066 (0.055)	-0.091 (0.079)	-0.024 (0.069)	0.019 (0.059)
Strategic plan (public and civic)	0.007 (0.022)	-0.022 (0.056)	0.180 (0.155)	0.043 (0.059)
VC pay (in £100 k)	0.029* (0.017)	0.019 (0.054)	-0.027 (0.033)	-0.177*** (0.069)
<i>Accessibility of finance</i>				
Seed corn investment (start-ups)	-0.019 (0.014)	0.044 (0.053)	-0.043 (0.037)	0.083 (0.053)
Venture capital (start-ups)	0.079** (0.032)	-0.077 (0.086)	0.267 (0.211)	0.137 (0.094)
Funds for teaching (equipment)	-0.006 (0.035)	0.059 (0.086)	0.129 (0.081)	0.008 (0.136)
Constant	-0.145 (0.249)	-0.926 (0.794)	-2.617 (1.600)	-1.663*** (0.587)
R-squared (within)	0.032	0.067	0.031	0.017
R-squared (between)	0.308	0.223	0.282	0.218
R-squared (overall)	0.298	0.201	0.121	0.118
Wald Chi-squared (33)	134.56	83.98	10.05	30.65
Prob > Chi-squared	0.000	0.000	1.000	0.585
N	453	453	453	453

Dependent variables are standardised to allow cross-equation comparisons of coefficients. Omitted category for priority area is "Priority: national". Robust standard errors shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 8 Hausmann tests for fixed vs. random effects panel data models (without SUR)

Dependent variable	Chi-squared (33)	<i>P</i> -value	Appropriate model?
Research income	51.15	0.023	FE
Graduate employment	39.34	0.207	RE
Spinoffs	52.57	0.017	FE
Social enterprises	26.72	0.772	RE

Table 9 Cross-equation correlations and Breusch–Pagan test of independence for SUR model (pooled data)

	Research income	Graduate employment	Spinoffs	Social enterprises
Research income	1.000			
Graduate employment	-0.154	1.000		
Spinoffs	0.035	-0.181	1.000	
Social enterprises	-0.090	-0.009	0.109	1.000

Breusch–Pagan test of independence: Chi-squared(6) = 35.204, Prob = 0.000

Table 10 Demographic characteristics of UK-domiciled first-year full-time undergraduate students

Category	2017/18 (%)	2018/19 (%)	2019/20 (%)
<i>Sex</i>			
Female	56	57	57
Male	44	43	43
Other	0	0	0
<i>Age group</i>			
20 and under	75	74	72
21–24 years	10	10	11
25–29 years	5	5	6
30 years and over	10	11	11
<i>Disability status</i>			
Known disability	14	16	16
No known disability	86	84	84
<i>Ethnicity</i>			
White	71	71	69
Black	10	9	10
Asian	13	13	14
Mixed	5	5	5
Other	2	2	2

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