



Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Is the entrepreneurial university also regionally engaged? Analysing the influence of university's structural configuration on third mission performance

Mabel Sánchez-Barrioluengo^{a,*}, Paul Benneworth^{b,c}

^a European Commission, Joint Research Centre, Unit of Human Capital and Employment, Via Fermi I-21027, Ispra, (Italy)

^b Center for Higher Education Policy Studies (CHEPS), University of Twente, 7500AE, Enschede, the Netherlands

^c NORCE, Universitetsveien 19, 4630 Kristiansand, Norway

ARTICLE INFO

Keywords:

Entrepreneurial university
Engaged university
Third mission performance
Internal structure
Region

ABSTRACT

There is an increasing interest in the analysis of how universities should maximise their specific regional contribution alongside their traditional teaching and research goals. However, due to the institutional heterogeneity it is necessary to understand the process by which universities create regional benefits, specifically through their third mission outputs. To cover this gap, this paper investigates the extent to which internal institutional configurations affect the production of these benefits on the UK Higher Education sector. It focuses on four elements of the universities' structural configuration (*steering core, administrative machinery, internal coupling and academic heartland*) in different university models: the entrepreneurial university and the (regional) engaged university model.

1. Introduction

There has been an explosion of interest on the role of universities and Higher Education Institutions (HEIs) as motor of regional development, economic growth and social change in recent years (Lawton Smith and Bagchi-Sen, 2012; Peer and Penker, 2016). It is increasingly common to claim that driving regional development represents a new 'third' mission for universities alongside the first (teaching) and second (research) missions (Perkmann et al., 2013). Universities apparently prioritise relevance and responsiveness to stakeholder needs for 'improving regional or national economic performance as well as the university's financial advantage and that of its faculty' (Etzkowitz and Leydesdorff, 2000; p.313). The 'entrepreneurial university' model has been presented then as the next logical step in the university system's natural evolution (Rothaermel et al., 2007) responding by focusing on outreach activities upon generating technology transfer and knowledge based start-ups (Audretsch, 2014), while Goddard's (2009) 'engaged university' model advocates integrating this third mission throughout all university organization activities and practices.

It has been argued (e.g. Goddard, 2012) that universities need to be more strongly managed to choose appropriate strategic priorities towards 'entrepreneurship' to contribute more systematically to knowledge based development. These discourses portray universities

strategically orchestrating core teaching and research activities to harmoniously contribute to regional growth processes (Pinheiro et al., 2012). This overlooks the tensions that non-academic engagement brings HEIs (Philpott et al., 2011; Pinheiro et al., 2012; Rip, 2002; Sánchez-Barrioluengo, 2014; Tartari and Breschi, 2012; Thompson, 1970), with universities struggling to integrate these multiple missions (including excellent research, quality education and engaged knowledge exchange) becoming 'strategically overloaded' (De Boer et al., 2007; Jongbloed et al., 2007; Benneworth et al., 2017a).

A strategic issue for entrepreneurial universities is then avoiding strategic overload, embedding entrepreneurial outcomes in these core missions. This paper seeks to contribute to the extant literature by exploring whether the entrepreneurial university can also be (regional) engaged. More specifically, we want to shed light on the understanding of how do entrepreneurial universities integrate their strategies to be more (regional) engaged institutions by exploring *the role of university internal structure* in shaping these entrepreneurial strategy-making processes. We categorize universities' internal diversity in terms of structural external commercialization and engagement configurations, such as institutional strategies, administrative machinery, support structures and academic incentives. We argue that individual university institutional configurations affect the production of specific (regional) impacts and we focus on one element of the process by which

* Corresponding author.

E-mail address: mabel.sanchez-barrioluengo@ec.europa.eu (M. Sánchez-Barrioluengo).

<https://doi.org/10.1016/j.techfore.2018.10.017>

Received 13 October 2017; Received in revised form 27 September 2018; Accepted 19 October 2018

0040-1625/ © 2018 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

universities create societal benefits, specifically on the creation of third mission outputs, and the extent to which internal institutional configuration affects the production of these benefits. This contributes to the current discussion on the key strategic challenges of entrepreneurial universities as drivers for economic growth and social change by emphasising how university internal choices regarding organizational structures plays a key role shaping third mission outputs.

Our overarching research question is then how do universities' organizational dynamics and structural configuration affect the production of third mission outputs (Larédo, 2007). We distinguish three university models based on Perkmann et al.'s (2013) categorization of collaboration activities: commercialization (intellectual property rights and spin-offs) and engagement (collaborative research, R&D contracts and technical services). We consider that the entrepreneurial university (Model 1) focus on commercialization activities as third mission outputs, while the engaged university (Model 2) combine commercialization as well as engagement activities. As engagement activities could take place at different geographical levels (local, national or international), we include an additional university model (Model 3) focus on regional collaboration activities, what we call the 'regional engaged university' (Section 2).

We develop a quantitative analytic approach using the UK's Higher Education -Business & Community Interaction (HE-BCI) survey (Section 3). The UK Higher Education System provides an interesting case because of UK universities' longstanding technology transfer structures often created or professionalised in response to specific funding streams since 1999 (Chapple et al., 2005; Decter et al., 2007). Results are presented in Section 4 and suggest that different strategic decisions regarding institutional internal structural configuration are associated with different kinds of university outputs where primarily transactional collaboration activities are associated with a central strategy, while more systematic outputs also require engagement structures and policies. In Section 5 we conclude that optimising entrepreneurial universities' regional engagement requires good internal policies, incentives systems and structures supporting academics engagement activity.

2. Literature review

To place university entrepreneurial transactions in the context of the organizational structure and the wider innovation system, we draw on two conceptual pillars. First we distinguish three university models based on a set of typical third mission outputs, following Perkmann et al. (2013): the entrepreneurial university that focus on commercialization activities (e.g. patents, licences and spin-offs), the engaged university based on 'soft activities' (like collaborative research, contract research or consulting) and the regional engaged university that emphasizes regional engagement via soft activities. Second, to understand the effects of institutional structures on interactions between universities and non-academic actors (Comunian et al., 2014), we develop Benneworth et al.'s (2017b) variant of Clark's (1998) 'entrepreneurial university' heuristic, distinguishing four elements of internal university structure, (steering core, administrative machinery, internal coupling and academic heartland).

2.1. The entrepreneurial versus the (regional) engaged university models

Universities are heterogeneous, differing in terms of size, status, specialization and focus, both within and across national systems. National higher education systems have historically included different 'types' of universities providing diversity in terms of functions, resources, networks and spatial aspirations (Teichler, 1988, 2004; Benneworth et al., 2016; Martin, 2003). These differences give universities varying capabilities/expertise for societal engagement: some institutions have always been more tightly locally integrated with local schools, firms, local authorities and communities. Conversely, more

traditional and prestigious institutions may emphasise their research, teaching and other scholarly activities' international orientation.¹ Perkmann et al. (2013) argue that effective third mission delivery by university requires better fitting the costs and benefits that third mission activities bring with the constraints and drivers of their teaching and research. This is necessary to balance universities' different objectives and activities thereby raising aggregate system effectiveness and efficiency (Hicks and Hamilton, 1999).

Focusing on the third mission, governments are increasingly promoting university-industry collaboration through a range of subsidised initiatives and infrastructure supporting engagement with non-academic agents (Abreu and Grinevich, 2013; Klofsten and Jones-Evans, 2000; PACEC, 2009). Universities increasingly prioritise their relevance and responsiveness to national, regional and local needs, resulting in a progressive 'institutionalization' of such interactions (see Charles et al., 2014). Under conditions of uncertainty, organisations typically develop institutional structures, "regulative, normative, and cognitive structures and activities that provide stability and meaning for social behaviour" (Scott, 1995, p. 33). Empirical evidence suggests universities are exhibiting a large heterogeneity both in their degree and form of their entrepreneurial transformation (Huyghe and Knckaert, 2015; Jacob et al., 2003; Martinelli et al., 2008) as well as university behaviour in terms of knowledge transfer activities (Cesaroni and Piccaluga, 2015).

Scientific literature suggests different (although related) ways to categorize knowledge exchange activities. For example, Gunasekara (2006) distinguishes between: (a) transactional (generational) contributions made by universities where they codify and sell knowledge to users; and (b) developmental contributions, when they work together with their (regional) partners to improve the local absorptive capacity and systematically raise the intensity of knowledge exploitation in their immediate environment. Similarly, Perkmann's et al. (2013) systematic literature review categorizes these different channels into two distinct groups: academic commercialization and academic engagement. This corresponds with Wright et al. (2008) argument that while licensing and patenting represent the transfer of codified knowledge, the development of collaborative contract research and consultancy may be mechanisms jointly to build tacit knowledge. Taking into account these differences between third mission outputs, Trippl et al. (2015) distinguish four modes of university regional contributions, what they call the entrepreneurial university model, the regional innovation system model, the Mode 2 university model and the engaged university model. One of the criticisms attributed to the 'entrepreneurial university' literature is that it mainly focuses on particular contributions (e.g. spin-offs) thereby ignoring the wider systemic contexts which shape these transactions (Pinheiro et al., 2012).

On this basis, we distinguish between three university models, namely the entrepreneurial university, the engaged university model and its particular regional component, namely the regional engaged university. The entrepreneurial university model (Clark, 1998; Etkowitz, 1983) focuses mainly on commercialization activities (Perkmann et al., 2013), with new university structures linking academic scientists with potential research users via a supportive intermediary environment (Siegel et al., 2007) acknowledging the importance actively and strategically promoting the different pathways by which knowledge supports innovation (Uyarra, 2010). In this entrepreneurial model, universities contributions come through actively commercializing their knowledge through spin-offs, patents and licensing (Grimaldi et al., 2011; Guerrero and Urbano, 2012; Trippl et al.,

¹ But that is not to say that prestigious institutions do not have substantial local and regional impacts and benefits; this is a question of branding not substance. For example Feldman and Desrochers (2003) found evidence of the elite Johns Hopkins University creating substantial local spillover benefits even during historical periods where the university had tried to clamp down on these activities as being undesirable.

2015; Wang et al., 2016) – primarily generative contributions through knowledge transactions. A strong central management is necessary (Clark, 1998) to implement new incentive and reward structures for commercialization, create a business-friendly academic culture, and creating supportive internal structures such as technology transfer offices –TTOs– (Goldstein, 2010).

The engaged approach (Cooke, 1992; Cooke et al., 2004) acknowledges university roles in knowledge production but regards the primary contribution coming via structural improvements to the knowledge exchange environment, organization, governance and policy frameworks. Regular interactions between knowledge producers, users, intermediaries and policy makers create networks with systemic regional properties (Cooke, 2005). HEIs help optimise regional innovation system networks and their systemic innovation properties, encouraging formal R&D and consultancy transactions alongside informal knowledge transmission not involving financial compensations (Olmos-Peñuela et al., 2013; Trippel et al., 2015; Wang et al., 2016). This model distinguishes ‘soft’ activities (advisory roles, consultancy, industry training, production of highly qualified graduates), closer to the traditional academic paradigm, from ‘hard’ initiatives such as patenting, licensing and spin-off activities (Philpott et al., 2011) as part of their third mission outputs.

A final model relates to the task of universities in transferring knowledge to small and medium firms and clusters located in the region (Uyarra, 2010). We conceptualise university regional contributions being produced by “knowledge spillovers” (Benneworth and Charles, 2005; Drucker and Goldstein, 2007), allowing proximate actors to more easily access knowledge-based resources (Ponds et al., 2010) thereby facilitating two important regional processes, innovation and economic development. Many universities engage with regional partners to provide additional funding sources complementing increasingly scarce public resources. We call this the ‘regional engaged university’ model.

2.2. A model to characterize the university structural configuration

University structures matter: universities create institutional structures to allow managers to control uncertainties and manage risks (Benneworth, 2007; Comunian et al., 2014; McCormack et al., 2014). Goodall (2009) argues that strong senior academic leadership in the UK and US was associated with improved university-level research performance. McCormack et al. (2014) analysing 250 UK university departments find evidence that university management affects the provision of incentives for staff recruitment, retention and promotion. Different institutional arrangements within universities may likewise affect universities’ societal (including regional) contributions. Siegel et al. (2003) conclude that a faculty reward system and the availability of TTOs are critical organizational factors. Besley and Ghatak (2005) and Bénabou and Tirole (2006) have emphasised that sharp incentives may not be as important or effective where agents are motivated.

Each university model described above depends on a distinct institutional structure to produce its desired benefits. In the entrepreneurial model, an extended development periphery (such as TTOs that support academics in commercializing their activities) seeks to link the university as a knowledge producing sub-system to knowledge exploiters, innovating firms via transactions. In the engaged model, a more diversified set of activities stimulate and encourage academics in undertaking both formal and informal engagements with other actors, and drive other changes with policy-makers, intermediaries and other civil society organisations. Our central hypothesis here is that an entrepreneurial university that wants to be also regionally engaged must find a balance between different internal structures in order to provide the right combination of third mission outputs to increase as much as possible specific (regional) impacts.

To operationalise the organizational configuration of universities, we propose to use the model described in Benneworth et al. (2017b) by which universities define missions and organise functions to deliver

core activities. We choose this model specifically because is a specification of Clark’s (1998) work, a model that has become foundational to understand how university structural elements influence entrepreneurial behaviour.² Following Clark, these authors argue that internal university structure can be described through four elements:

a) The strategic role played by the *central steering core* in articulating a shared vision and strategic platform for engagement. For regional engagement to become a more substantive task within the university, it is necessary for university leaders to change the institution. Central to this is leadership from senior managers, but also the way that institutional entrepreneurs within the university seek to actively promote change and drive regional development. The activities of the steering core will often be articulated in and complemented by strategy and policy documents, as well as statements of mission, vision and strategies and aims.

b) A supportive *administrative apparatus*, ensuring institutionalization of rules and procedures as well as support/incentive structures across the board. Universities manage their activities through decision-making apparatuses at a variety of levels from central policy to determining courses and degree outcomes, giving legitimacy and accountability to those decisions. The extent to which universities are able to engage with their regional contexts depends to a degree on how the administrative machinery responds to this challenge, and its amenability to regarding external engagement as a legitimate university activity.

c) The efforts by, and commitment of, key individuals across the *academic heartland*, while recognizing new external opportunities and directly engaging with external parties. For engagement to be effective within the university, then it requires a core group of academics who are actively engaged, who see that engagement as being scientifically legitimate. These engaged academics are also regarded as legitimate within the wider academic structures of the university, including by those academics who are not themselves engaged.

d) The *degree of internal coupling* between core and peripheral structures and activities, ensuring spill-over effects and mutually reinforcing synergies (Clark, 1998; Nedeva, 2007; Pinheiro et al., 2012). The internal validity of external engagement arises in the ways that it becomes coupled to other activities and is able to derive power legitimacy and resources within the institution. Effective external engagement depends of having mechanisms within the university that couple these external activities to ‘core’ activities in ways that legitimise them and prevent them remaining peripheral to the central academic enterprise.

Much literature regarding university technology transfer treats university structures as relatively simplistic and functional, effectively implicitly assuming that the purpose of universities is technology transfer activity. This is at odds with organizational studies of universities which point to their special status in which functional groups organise in very different ways within one HEI because of context specific conditions for their knowledge activities, producing a situation described by Reponen (1999) as ‘loose coupling’ (Becher and Trowler, 2001). Benneworth et al.’s model provides a means to specifically account for this internal complexity of universities, being derived from Clark (1998). Clark developed his model using qualitative studies of a set of universities who had actively sought to improve (and succeeding in qualitatively improving) their entrepreneurship performance but nevertheless found themselves constrained by this autonomy of academic knowledge production. We note that Benneworth et al.’s (2017b) framework was explored qualitatively using a small sample of

² Proof of the importance of Clarks work is that the paper has more than five thousands citations in Google Scholar at the time of writing. Other alternative models like Nelles and Vorley (2010) on the entrepreneurial architecture model has been less quoted in the scientific literature as evidenced by the far fewer citations (max 60) and clearly overlaps with the one proposed by Clark.

universities; in this paper we seek to extend the framework to make it suitable for deductive, quantitative research. We extend their model by operationalising it in terms of empirically testable variables, focusing upon the four dimensions along which universities internal structures might affect the delivery of third mission outputs, focusing specifically on two operational questions: Which components of universities' internal structural university affect university performance? And, do the entrepreneurial university and (regional) engaged university models differ in the relationship between their structural configuration and the performance? More specifically, we hypothesize that the four organizational structures (steering core, administrative apparatus, academic heartland and internal coupling) affect positively third mission outputs, although the particular emphasis on one or another will differ between the entrepreneurial university and the (regional) engaged university model. Through this specific research, we want to understand how university strategic decisions regarding internal configuration affect third mission performance.

3. Empirical strategy

We address these research questions in the case of UK, where universities have since 1999 in England (and later in the other UK nations) been funded to engage with business and community partners (Chapple et al., 2005). Universities sought to actively manage this process to both maximise their benefits from engagement as well as best fitting it into their other core activities. The third mission in the UK context involves interactions between HEIs and private, public, voluntary and societal organisations that support knowledge transfer and exchange (HEFCE, 2009). Policies across UK nationals have embraced commercialisation explicitly as a key target for HEIs performance influencing future government funding levels (PACEC, 2009). Commercialization activities have been further institutionalized and broadened under this agenda, representing what Uyarra (2010) described as a 'transformation'. This involved establishing novel administrative offices/structures (including TTOs and business incubators) to coordinate internally and liaise externally, increased financial resources for to technology transfer and promoting different activity mixes.

UK policy can likewise be distinguished into areas targeting entrepreneurial and engaged measures (Tripl et al., 2015). Some national policy has sought to promote entrepreneurial activities, covering Intellectual Property Rights (IPR) regulations, public subsidies for TTOs, science parks and incubators and directly funding academic spin-off processes. Other policies have focused more on encouraging universities to improve their regional environments, fostering the creation of various types of university-industry links and integrating universities within regional cluster and innovation strategies (Kitagawa, 2004).

3.1. Data & Variables

The empirical section in this paper draws on the Higher Education Business and Community Interaction Survey (HE-BCI), an annual survey³ collected and maintained by the Higher Education Statistics Agency (HESA) and administered throughout the UK since a 2001 pilot (Charles and Conway, 2002). This data is publicly available and provides information at the level of the individual university about knowledge exchange between universities and the wider world, including data on strategic direction of 'knowledge exchange' activity, their capacity and infrastructure in place to deliver this activity, as well as levels of income and activity across a range of metrics on the commercialization of knowledge. An important set of empirical studies in the scientific literature has used HE-BCI as a reliable source of information to capture third mission activities of UK universities (e.g.

Abreu and Grinevich, 2013; Clarysse et al., 2011; Geuna and Rossi, 2011; Guerrero et al., 2015; Sánchez-Barrioluengo et al., 2016; Sengupta and Ray, 2017).

The database is structured in two parts. Indicators relating to strategy and infrastructure are collected under Part A of HE-BCI; these tend to be self-assessed responses where HEIs either select from a range of options or benchmark questions which allow respondents to place themselves on a scale of development. This part of the survey provides us information about the internal structure of the university. Part B includes financial and numeric metrics collected related to commercialization and knowledge exchange activities, corresponding to the third mission outputs in our theoretical model where we distinguish between the entrepreneurial and the engaged university models. We also include a third model, where the engaged university is restricted to its regional dimension, the regional engaged university model, capturing the specifically regional component of relationships between the university and external actors.

Our analysis draws on data for the academic year 2011–12 (HEFCE, 2013), the last available information including regional outputs in Part B. All 161 publicly funded UK HEIs provided data for this survey although only 135 (83.9%) were included in the analysis⁴ due to the missing information for some of the variables used here. In terms of the geographical distribution of these HEIs, 80% are located in England, 11.9% in Scotland, 6.7% in Wales and the remainder in Northern Ireland.

Fig. 1 explains how our theoretical model was empirically implemented. It includes the four elements representing the internal structure of the universities (on the left hand side) based on Benneworth et al. (2017b) theoretical model that constitute the latent constructs (see methodology section) to be measured. The empirical model will capture how these four elements are having an effect on university third mission outputs. We measure this university performance through entrepreneurial and (regional) engaged activities (on the right hand side) following Perkmann et al. (2013). Fig. 1 also sets out how the four constructs capturing the internal organizational structural of the university will be empirically proxied.

Taking into account that this is an explorative study and that it is the first time that a study tries to empirically test the theoretical model proposed by Benneworth et al. (2017b), we sought to use a broad selection of the variables in Part A of HE-BCI survey to describe and configure the four theoretical components of the university structure. To do that, we tried to accommodate as many questions as possible from Part A of the HE-BCI questionnaire to describe each construct. However, as this is a piece of retrospective research for the survey was not based on an operationalisation of our theoretical model, we selected variables on the left hand side of Fig. 1 as producing the optimum and simplest empirical model with the highest explicative power for the objective of this research. This means that, we test empirically how the originally selected variables fulfil the empirical requirements to be part of the same construct (e.g. internal reliability). We have thus excluded questions included in part A that theoretically fit the four elements of university internal structure, but fail empirically to fulfil the requirements for effectively measuring that concept. In practical terms, this means that those variables which commonalities were not close to 0.6 were discarded from the model (Hair et al., 1998).⁵

In consequence, the *steering core*, related to the leadership and

⁴ A list of universities included in the analysis is provided in Annex I.

⁵ Initial model included three additional variables: 1) Greatest priority in your HEIs mission in RDA area (Q.06); 2) The HEI took its cue from priorities in regional strategies or the HEI identified important business clusters in its region (Q.03.2 & Q.03.4); and 3) Central placement department for student business placements (Q.30). These variables were excluded from the final model presented in this paper due to the low value of its communalities (0.101, 0.263 and 0.130 respectively).

³ The questionnaire is available at: <https://www.hesa.ac.uk/collection/c16032>

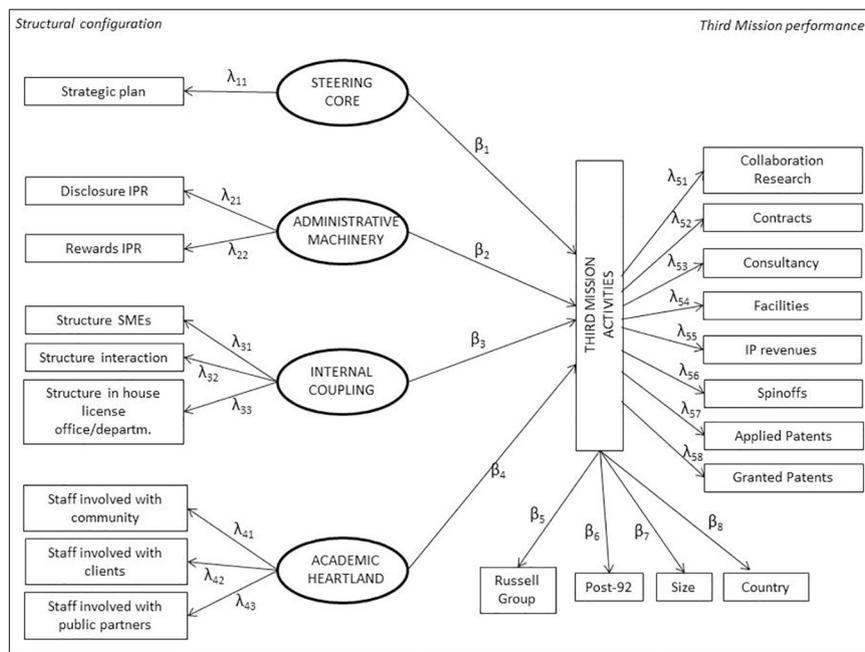


Fig. 1. Theoretical model.

strategy of each university, is measured by the availability of a strategic plan at institutional level for business support. Two variables are included to describe the *administrative machinery*, related to the rules, procedures and incentives that exist at institutional level to impulse knowledge transfer activities and social engagement at regional level: the requirement to report the creation of IPR and the existence of rewards for the IPR generated. Three main variables specify coordination and linkages that make up the *internal coupling* of the university, all of them related to the existence of internal structures or departments for specific connection mechanisms with non-academic agents: assistance to SMEs, interaction with business and community and searching for IPR opportunities. Finally, *academic heartland* covers the specificities of individual academics that engage with regional agents at different levels: with the community, with clients and/or public partners. A detailed explanation of these variables appears in Table 1. This table also includes the definition of the activities included in the analysis of third mission performance.

The theoretical model described in Fig. 1 also includes four control variables. First, we control for membership of the Russell Group; the Russell Group is a self-selecting self-styled group of elite universities seeking to differentiate themselves from other universities in the sector (Russell Group, e.g. press release dated 21st November 2014).⁶ As research-oriented universities, their third mission activities may be influenced by a positive relationship between research and third mission activities (Sánchez-Barrioluengo, 2014). We account for this by including a dummy variable to differentiate Russell Group (RG) universities from non RG-members. Second, a binary divide is often made within the UK higher education sector between the so-called ‘Old universities’, founded before 1992, which are typically more research focused, and ‘New universities’ which were granted university status after 1992 along with former University Colleges that became universities more recently. ‘New universities’ tend to be more teaching focused, and their third mission activities are assumed to be ‘locally oriented’ given their traditional focus on vocational education and training, and their relatively low engagement in basic research (Charles et al., 2014). To

control for this particular regional role, we include a dummy variable (Post-92) with the value 1 for those universities founded after 1992 and 0 otherwise. Third, it is important to take into account university size of universities given sectoral heterogeneity which we do this with a control variable for total staff working in each university (Hewitt-Dundas, 2012). Fourthly, with significant divergences in higher education policies between UK nations (England, Scotland, Wales and Northern Ireland: Scott, 2014) including third mission instruments and incentives (Huggins and Kitagawa, 2011; Kitagawa and Lightowler, 2013), the third control is a dummy variable taking the value 1 if the university is located in England and 0 otherwise. To avoid biased results given different units of measurement applying to variables, all variables were normalized except the dummy controls.⁷ Annex II includes a table with the descriptive statistics of all the variables.

3.2. Methodology

The empirical section includes two steps. First, an exploratory factor analysis, including varimax rotation and Kaiser normalization, (Hair et al., 1998) to check if the selected measures group together to describe the university’s structural configuration. Second, the theoretical model presented in Fig. 1 is empirically tackled using the structural equation modelling (SEM) as a confirmatory factor analysis method. The advantage of using SEM instead of the combination of aggregate scores from factor analysis and traditional regression models with multiple outputs is that the first a) allows for simultaneous analysis of all the variables in the model instead of separately and b) measurement error is not aggregated in a residual error term. Model estimation is based on maximum likelihood (ML)⁸ and uses the marker variable method of scaling fixing to 1 the variances of the latent variables and leave free the parameters to be estimated (Little, 2013). The evaluation

⁷ The study includes two types of variables. Measures of university’s structural configuration are dummies while third mission activities are continuous variables. The normalization process has been as follows: dummy variables are normalized by subtracting the mean of the variable; continuous variables are normalized by subtracting the means and dividing by its standard deviation.

⁸ As a more robust procedure compared to Generalized Least Squares (Olsson et al., 2000).

⁶ <http://www.russellgroup.ac.uk/russell-group-latest-news/155-2014/8585-russell-group-sign-leiden-statement-on-the-social-sciences-and-humanities/> (Accessed 21 November 2014)

Table 1
Definition of the main variables of the study.

Part A. Structural configuration		Definition (Question number in HE-BCI)	Type of variable
Group	Name		
Steering core	Strategic plan	University has a strategic plan totally developed and partially or totally implemented for business support (Q7a).	Dummy variable with value 1 if university answered values 4 or 5 and 0 otherwise.
	Disclosure IPR	There are requirements within the HEI to report or disclose (internally) the creation of IPR (inventions, software, copyright, design, trademarks, plant/animal varieties) to the disclosure company or department (Q18)	Dummy variable with value 1 if university answered 'always' in at least one of the IPR categories and 0 otherwise.
	Rewards IPR	University has rewards for staff related to the IPR that they generate (Q19)	Dummy variable with value 1 if university answered 'yes' and 0 otherwise.
Internal coupling	Structure SMEs	University has a central dedicated unit that act as an enquiry point for SMEs or assistance to SMEs in specifying their needs (Q11)	Dummy variable with value 1 if university answered 'yes' to the availability of 'An enquiry point for SMEs' or 'Assistance to SMEs in specifying their needs' in Q11 and 0 otherwise.
	Structure interaction	University has an internal department responsible for business and community interactions (Q12)	Dummy variable with value 1 if university answered 'yes, in-house capability' or 'yes, in-house capability & external agency' and 0 otherwise.
Academic heartland	Structure inhouse license office/department	University has, at least, in-house capability to seek out licensing opportunities for IPR (patents, copyrights, designs & trademarks) (Q10)	Continuous variable.
	Staff involved with community	Percentage of academic staff providing service to social community and cultural partners between 1 August 2011 & 31 July 2012 (Q15a)	Continuous variable.
	Staff involved with clients	Percentage of academic staff providing service to commercial partners/clients between 1 August 2011 & 31 July 2012 (Q15b)	Continuous variable.
	Staff involved with public partners	Percentage of academic staff providing service to public sector partners/clients between 1 August 2011 & 31 July 2012 (Q15c)	Continuous variable.
Part B. Third mission activities			
Name	Definition	University model	
		Entrepreneurial university	Engaged university
Collaboration Research	Total income from collaborative research involving public funding in current year (£000 s)		
Contracts	Total income of contract research (excluding collaborative research) in current year (£000 s)	X	X
Consultancy	Total income in consultancy contracts in current year (£000 s)	X	X
Facilities	Total income in facilities & equipment in current year (£000 s)	X	X
IP Revenues	Total income in IP revenues in current year (£000 s)	X	X
Spinoffs	Number of spin-offs with some HEI ownership in current year	X	X
Applied patents	Number of new patent applications filed in current year	X	X
Granted patents	Number of patents granted in current year	X	X

of the models is based on a set of incremental fit indices. One common rule-of-thumb for implementing SEM is that it should have a minimum threshold of 100 subjects (Williams et al., 2004); our population is above this threshold. We acknowledge that SEM as a methodology is highly sensitive to the design of the questionnaire, something which we did not control through our use of HE-BCI. Nevertheless, we have followed the approach taken by other papers in the literature dealing with similar topics and using HE-BCI as a source of information (e.g. Guerrero et al. (2015) using structural equation models or Sengupta and Ray (2017) following a simultaneous equation approach).

We run the SEM equations for three different models. Model 1 includes university activities defined according to the entrepreneurial model (IP revenues, spinoffs, applied patents and granted patents). Model 2 additionally includes collaboration research, contracts, consultancy and facilities configuring the engaged university model. Previous university outputs could take place at regional, national or international level and the broad definition of each university activity remain unclear which of these aspects are really taken place at regional level. To account for university regional contribution of universities, Model 3 places a particular emphasis in the regional component of university outputs composing the regional engaged university model.⁹ Standardized coefficients estimated are presented in the results section in order to compare results across models. The right-bottom part of Table 1 specifies the activities included in each university model.

4. Results

Results presented here are divided in two sections. The first section describes the suitability of the selected variables to measure university's structural configuration. The second section presents the main empirical results for the SEM applied to three university models described above.

4.1. Measuring university structural configuration

Table 2 includes the results from factor analysis. In this case the criterion to select the number of factors to extract is the percentage of variance explained. In our case, the model explains 68.9% of the total variance which can be considered as satisfactory in social science studies (Hair et al., 1998). The selected variables result in the optimum model^{10,11} to explain university's internal organization and corroborate their grouping as descriptors of the four dimensions of structural configuration. That is, the strategic plan is a measure of the steering core; disclosure and rewards IPR define the administrative machinery; specific structures defining SMEs, interactions and in-house license office/department compose the internal coupling; and the staff involved with community, clients and/or public partners form the academic heartland.

⁹ Unfortunately HE-BCI survey only includes regional information for contracts, consultancy, facilities and IP revenues among the selected activities.

¹⁰ The table presents the Cronbach's alpha as a measure of the reliability of each construct. The values are rather low because this coefficient is a direct function of the number of items explaining the construct (and there are at most three components considered in each item). To compensate for the weakness of this test, we have included in the next section the incremental fit indices as a complement to reliability check.

¹¹ Additionally convergent and discriminant validity were checked using the average variance extracted (AVE) for each construct: steering core (0.9), administrative machinery (0.6), internal coupling (0.3) and academic heartland (0.5). According to Huang et al. (2013) values of AVE higher than 0.4 are adequate. In addition, Fornell and Larcker (1981) said that if AVE is < 0.5, but composite reliability is higher than 0.6, the convergent validity of the construct is still adequate. Raykov's factor reliability tests (Raykov, 1997) for each construct are: steering core (0.9), administrative machinery (0.7), internal coupling (0.6) and academic heartland (0.5).

Table 2

Results of factor analysis: measures of university's structural configuration.

		Communalities	Item score
Steering core	Strategic plan	0.694	0.750
	Explained variance	9.27	
	Eigen value	0.834	
	Cronbach's alpha	–	
Administrative machinery	Disclosure IPR	0.656	0.879
	Rewards IPR	0.777	0.572
	Explained variance	13.67	
	Eigen value	1.231	
Internal coupling	Cronbach's alpha	0.473	
	Structure SMEs	0.623	0.747
	Structure interaction	0.566	0.618
	Structure in-house license office/department	0.570	0.606
Academic heartland	Explained variance	26.53	
	Eigenvalue	2.387	
	Cronbach's alpha	0.542	
	Staff involved with community	0.794	0.878
	Staff involved with clients	0.784	0.399 ^a
	Staff involved with public partners	0.734	0.827
	Explained variance	19.41	
Eigen value	1.747		
Cronbach's alpha	0.402		

Note: Total variance explained: 68.88%.

^a The variable “staff involved with clients” presents a value of 0.660 as an item score in the same component as “strategic plan”, however there is not an easy theoretical justification for this fact and for this reason we have included the variable in the group of “Academic heartland” where the variable presents the second highest item score.

The first result that emerges relates to the importance of the internal coupling construct (it captures 26.53 of the total explained variance), particularly for the regional engaged university. In this result we see echoes in the institutional literature theory that highlights the importance of formal “factors” that in reality correspond to a university's organizational units explicitly responsible for promoting technology transfer (Dill, 1995) and intensifying its focus on turning their proprietary technology into economic opportunities (Siegel et al., 2003). As Guerrero and Urbano (2012) suggested each university community is unique and its attitudes towards entrepreneurship are defined by a combination of factors, such as entrepreneurship education, teaching methodologies, role models and reward systems. Thus, our first contention is that our research corroborates the notion that internal coupling is an important structure to consider in the analysis of the internal organization of HEIs.

4.2. The effect of structural configuration on third mission performance across university models

Before starting the analysis of results we check the evaluation tests of the models (Table 3). The goodness of fit is determined mainly by the χ^2 statistic but, as in the case of Cronbach alpha, this coefficient is a direct function of the number of items used. We complement the information providing four indices to evaluate models' fit. There is not agreement in what are the best indices to identify the appropriateness of the models and, in fact, the choice of cut-off values to compare with the indices depends on model specifications, degrees of freedom, and sample size. In our particular case, we have selected three fit indices (Comparative Fit Index –CFI-, Root Mean Square Error of Approximation –RMSEA- and Standardized Root Mean Square Residual –SRMR-) that tend to reject true models when the number of observations is small (Hu and Bentler, 1999) as well as an additional index (the Tucker-Lewis index –TLI-) that is preferred to be used in case of comparison with pre-specified cut-off values (Sharma et al., 2005). Conservative guidelines for acceptable fit suggest a CFI > 0.90 (Hu and Bentler,

Table 3
SEM results for the three university models described^a.

			Entrepreneurial university	Engaged university	Regional engaged university
Components of each construct					
Steering core	λ_{11}	Strategic plan	0.997*** (0.000)	0.997*** (0.000)	0.998*** (0.000)
Administrative machinery	λ_{21}	Disclosure IPR	0.999*** (0.000)	0.998*** (0.000)	0.368*** (0.075)
	λ_{22}	Rewards IPR	0.368*** (0.075)	0.368*** (0.075)	0.997*** (0.000)
Internal coupling	λ_{31}	Structure SMEs	0.352*** (0.001)	0.352*** (0.102)	0.391*** (0.092)
	λ_{32}	Structure interaction	0.521*** (0.108)	0.520*** (0.108)	0.550*** (0.090)
	λ_{33}	Structure in-house license office/department	0.731*** (0.120)	0.733*** (0.120)	0.680*** (0.091)
Academic heartland	λ_{41}	Staff involved with community	0.561*** (0.059)	0.561*** (0.059)	0.561*** (0.059)
	λ_{42}	Staff involved with clients	0.412*** (0.071)	0.412*** (0.071)	0.412*** (0.071)
	λ_{43}	Staff involved with public partners	0.999*** (0.000)	0.999*** (0.000)	0.999*** (0.000)
University performance	λ_{51}	Collaboration Research		−0.172* (0.085)	
	λ_{52}	Contracts		−0.132 (0.086)	0.514*** (0.124)
	λ_{53}	Consultancy		−0.219*** (0.084)	0.453*** (0.119)
	λ_{54}	Facilities		−0.086 (0.087)	0.424*** (0.141)
	λ_{55}	IP Revenues	0.086 (0.087)	0.097 (0.087)	−0.2567* (0.134)
	λ_{56}	HE Spinoff	0.339*** (0.076)	0.343*** (0.076)	
	λ_{57}	Patent application	0.989*** (0.020)	0.978*** (0.018)	
	λ_{58}	Patent granted	0.862*** (0.026)	0.869*** (0.024)	
Structural configuration on third mission performance					
Steering core	β_1		0.075 (0.072)	0.079 (0.072)	0.168 (0.162)
Administrative machinery	β_2		0.014 (0.059)	0.017 (0.060)	0.435** (0.177)
Internal coupling	β_3		−0.178* (0.108)	−0.179* (0.107)	−0.288 (0.321)
Academic heartland	β_4		−0.070 (0.058)	−0.071 (0.058)	−0.046 (0.135)
Control variables					
Russell Group	β_5		−0.055	−0.066	−0.313
Post-92	β_6		−0.030	−0.031	−0.046
Size	β_7		0.882***	0.900***	−0.143
Country	β_8		−0.083	−0.080	0.238*
Model evaluation					
Chi-squared (d.f.)			179.514 (90)	306.981 (160)	155.285 (90)
p-value			p = 0.000	p = 0.000	p = 0.000
CFI			0.843	0.769	0.777
TLI			0.777	0.705	0.678
RMSEA			0.086 (0.07–0.10)	0.082 (0.07–0.09)	0.073 (0.05–0.09)
SRMR			0.090	0.102	0.079

Note.

* p-value < 0.1.

** p-value < 0.05.

*** p-value < 0.01.

^a Standardized parameters estimated are presented, standard deviation between brackets.

1995), RMSEA < 0.10 with a maximum upper bound of the 90% confidence interval of 0.10 (Browne and Cudek, 1993), SRMR < 0.10 (Bentler, 1995) and for smaller sample size and larger models, a cut-off value of < 0.90 for TLI (Sharma et al., 2005). Contrasting these cut-offs with our values, our models only fails to fulfil the CFI criteria, while all other indices are close to the values recommended for acceptable model fit. These results confirm that, although not perfect, selected indicators can be considered as good proxies for measuring university's structural configuration and third mission performance as well as the relationship between both of them.

In terms of empirical results, all the variables selected to measure the organizational settings present a positive and significant value of the coefficient (λ_{ij} where $i = 1, \dots, 4$, $j = 1, \dots, 3$), which can be interpreted as the adequacy and robustness of these items to capture the content of each internal structure element. However, results for the measurement of third mission construct present a slight difference among the entrepreneurial and the engaged models (λ_{5j}). The entrepreneurial university (Model 1) is mainly described by spinoff and patent activities, specifically the latter, and not by IP revenues. What has made it popular as a model for universities has been the explosion globally of the idea of patenting as a potential lucrative income stream for universities. The change came from America in the 1970s, and formalised by the 1980 Bayh–Dole Act in USA (Berman, 2011). As a result, the number of US universities engaging in technology transfer and licensing increased eightfold and the volume of university patents fourfold (Mowery and Shane, 2002). It is not just that universities

themselves followed the model, but there has also been a very strong policy discourse, for example around the OECD, emphasising patents' importance as a channel for universities creating economic impact.

In the case of engaged university model (Model 2), results suggest that collaboration research, contracts, consultancy and facilities do not fit harmoniously with traditional commercialization activities as part of the third mission outputs. This result highlights those difficulties that universities experiencing in accommodating entrepreneurial outcomes alongside other kinds of engaged activities. Conversely contracts, consultancy and facility activities present a more regional component because they are a good proxy of university performance under the regional engaged university model (Model 3), while in this case patents are negatively related to other engagement activities, corroborating the fact that regionally-engaged universities experience difficulties in balancing these 'soft' activities with more commercial activities based on 'hard' initiatives.

Universities following the engaged model are characterized by other exchange activities that go beyond the commercialisation of research and IP protection which can be less visible, but equally or even more frequent (D'Este and Patel, 2007). The regional engaged model is more oriented towards collaborative research, contract research or consulting activities, outputs considered by some authors to be "softer" activities closer to traditional academic activities, compared to 'hard' commercial activities clearly outside the academic realm such as patenting, licensing and spin-off activities (Philpott et al., 2011).

Finally, central part of Table 3 shows the relationship between the

Table 4
Interpretative summary results for the three university models described.

	Entrepreneurial university	Engaged university	Regional engaged university
Steering core	β_1 +	+	++
Administrative machinery	β_2 +	+	+++
Internal coupling	β_3 ---	---	--
Academic heartland	β_4 --	-	-

Note. +++ Sig. positive result; ++ Non sig. positive result; + De minimis but positive; --- Sig. negative result; -- Non sig. negative result; - De minimis but negative.

four dimensions of internal university structure and the third mission performance (β_i where $i = 1, \dots, 4$). It refers to the question about how does university internal strategic structure specifically affect third mission delivery. Although this is an exploratory analysis with some limitations in terms of results' significance, it hints at which kinds of internal structures are more important for the performance of each university model.

The steering core and the administrative machinery of the university, mainly the first one, tend to have a positive influence in entrepreneurial outputs, while specific internal coupling is the dimension that presents the highest negative effect, being the unique significant result. The engaged university shares the sign of the coefficients with the entrepreneurial model although the values of these coefficients are lower. This means that the influence of internal structural configuration of the university has a lower effect on engagement outputs than on entrepreneurial ones. The regional engaged university shows that its administrative machinery is the main structure affecting regional performance, although also the steering core presents a positive but non-significant coefficient.

Table 4 summarizes the results and suggests that both steering core and administrative machinery relates positively with both the entrepreneurial and the engaged models, being the latest specifically relevant at regional level because it presents the unique significant and positive result.

This suggests that this approach sees universities magnifying the benefits of proximity (Wallsten, 2001); the easiest way of researchers to obtain rewards under such circumstances being involved in engagement activities with the closest agents. In this respect, authors like Hewitt-Dundas (2012) found that in the UK, the type and intensity of knowledge transfer is determined by university research quality (see also Laursen et al., 2011), but interactions also differ across partner types, namely small and medium sized firms (SMEs), large firms or non-commercial organisations. Whereas large companies tend to be more attracted to work with a university because of its research reputation in a particular area of interest, small firms may demand more routine services and consultancy, which as less specialised services are more easily found in their local university whatever its overall research profile (Pinto et al., 2013; Siegel et al., 2007).

Lastly, our results also suggest that increasing numbers of researchers ('academic heartland') involved in academic engagement does not necessarily correspond to increments in raising regional performance under either the entrepreneurial or the (regional) engaged models. This appears counterintuitive as more people active in an area should lead to more outputs, but this assumption would on this occasion not be borne out by the empirical results. Our interpretation here is that engagement activities have become a policy category, and so numbers increase then more people recognise what they do as engagement, and see it as a less dangerous category to be active in. But if there is no change in engagement behaviour and only a change in reporting behaviours then this would not correspond to an increasing importance of engagement to the core university knowledge processes.

This corresponds with results elsewhere that highlight that there is no simple trade-off between technology transfer and traditional academic activities (Rafferty, 2008; Uyarra, 2010).

5. University structure as a determinate of external engagement

This paper has focused on analysing the role played by the internal university structure as shaper of university performance through third mission activities. Our overarching finding is that university entrepreneurial engagement converge around two distinct models. Universities orient themselves either towards particularly focused knowledge transfer outcomes or towards more general contributions to regional economic development activity. This suggests that there are difficulties in integrating and combining these 'hard' activities (supporting firm innovation via knowledge exchange transactions) and 'soft' activities (improving the wider regional economy) into a single coherent third mission. Our study is exploratory and *ex post*, and lacking strongly significant relationships; with that caveat structure appears to matter in influencing how universities produce regional benefit, and secondly, university internal institutional structure associates with the mechanisms by which universities have regional impacts. These two models are not ideal types but emergent composites that typologize clearly distinct ways that UK universities are choosing to make their regional contribution, and the associated structural arrangements necessary to deliver those contributions. The logical next step in this process is to analyse the output side and explore how these structural configurations are associated with the production of more of these entrepreneurial or regional outputs, along with the potential different ways that structural elements operate in these two university types.

Secondly, this paper corroborates earlier findings that technology transfer offices (linking mechanisms) do not have a strong added value for delivering entrepreneurial activities (Hülsbeck et al., 2013). This does not imply that TTOs themselves are of no value, rather that effective TTOs fit with individual institutional goals and strategies as well as overall universities governance (Schoen et al., 2014). Other authors have argued that good TTOs also have experienced staff whose tacit knowledge of commercialisation is critical to producing effective commercialisation outcomes (Lockett et al., 2003). This research suggests that there is a trade-off in TTO activities between being 'entrepreneurial' and being 'managerial' (bureaucratic), and this finding clearly warrants further analysis.

The significance of internal coupling (e.g. TTO) is for the regional engaged university, helping academics to take their technology to regional partners. To date, whilst geographical proximity has indeed been found to influence the likelihood of university-industry interaction (Laursen et al., 2011), the spatial dimension of these relations is far from simple and uniform (D'Este and Iammarino, 2010). Pace Landry et al. (2010), who found a complementary effect between consulting activities and other commercialization outputs (e.g. patents, spin-offs), this research does not validate a positive relationship between these activities without the consideration of the geographical level. Future analysis should develop specific surveys to analyse if this complementarity between 'hard' and 'soft' activities exists and the difference between the entrepreneurial and the engaged university models at the regional level within other higher education systems.

Thirdly, the two different mission orientations do not correlate with the relative research intensity of the institution (our dummy variables Russell Group vs Post-1992 Universities). From this we infer no vertical segmentation of these two types of university (entrepreneurial and regional engaged) with one being more prestigious than the other. This fits with findings elsewhere that universities orient their engagement to their particular strengths in core missions and variants of engagement (e.g. Sánchez-Barrioluengo (2014) identifies three core processes, teaching, research and knowledge exchange that lie behind three engagement missions). In line with Benneworth et al. (2016), it is clear that there is no one-size-fits all for managing university engagement.

The majority of academic research to date has focused upon systematic analyses of entrepreneurial universities (Perkmann et al., 2013) in parallel with more exploratory (anecdotal) analyses of universities' regional impacts through knowledge processes (beyond aggregate effects of universities as businesses through the supply chain, cf. Hermannsson et al., 2013). There is therefore a need to fill these two gaps, firstly relating to a more precise characterisation of the different missions and their relationships to core university knowledge processes, and secondly, for more analytic research on universities wider regional (non-commercial) knowledge impacts (the developmental impacts, cf. Gunasekara, 2006).

Given that generating impact seems to be an increasingly urgent policy pressure, such as the UK Minister for Universities recent announcement of a Knowledge Exchange Framework to measure university knowledge exchange activity (Morgan, 2017), we highlight three policy implications from our work, methodological, substantive and operational. Firstly, further development of these models of engagement is dependent on more robust structural indicators in higher education datasets beyond the UK HEBICIS survey. There are a number of international survey instruments, such as the European Tertiary Education Register (ETER) or U-Multirank into which structural and entrepreneurship variables are already partially present and could relatively easily be inserted. The second policy recommendation is to propose that policy need recognise that there are different, equally valid approaches to creating societal contribution, and there is no one-size-fits-all model to be proposed. The risk of rewarding knowledge exchange metrics is in incentivising all universities to pursue one of the two orientations, even where the other orientation would better fit with their core activities. By developing knowledge exchange metrics (third recommendation) that better reflect the different missions and the different underlying knowledge processes it is possible to create policy frameworks that steer universities towards the most contextually-suitable orientation.

We should recognise here the three main limitations of this work. First, this is an exploratory study linking university internal structure of

universities with institutional outputs repurposing an existing database (the HE-BCI survey) to operationalise our model; that operationalisation was restricted to the available questions and a survey developed specifically for this purposes would allow extending this exploratory work. Second, operationalising the steering core variable was restricted by the dataset, and did not adequately capture the way universities implement strategic management by reducing individual control. This is a complex variable requiring further reflection for its operationalisation in any third-mission survey for universities. Third the HE-BCI survey itself measures a limited range of KE activities (Rossi and Rosli, 2014), neglecting other outputs such as joint workshops and meetings which are informal and tacit in nature but nevertheless significant for firms' innovation (Howells et al., 2012). The majority of studies to date used part B of the survey (quantitative university performance information), while the qualitative information about strategies in part A is extremely limited (Rossi and Rosli, 2014 is an exception) and the data is not usable beyond an initial exploratory study. A specific recommendation for any statistical agency undertaking a university third mission survey would therefore be either to omit structural information or go beyond binary dummy variables to use richer categories of different kinds of university structure affecting third mission behaviour.

Acknowledgments

A preliminary version of the manuscript was presented at the Regional Studies Association Annual Conference (Piacenza, 2015) and EU-SPRI Annual Conference (Helsinki, 2015). Thanks are due to conference delegates for the valuable comments and suggestions provided as well as those provided by two anonymous reviewers and the guest editors of the Special Issue. Part of this research was done under the EU-SPRI PhD Circulation Award. The views expressed here are those of the authors and in no circumstance should be regarded as representing the official position of the European Commission.

Appendix A

Annex I

List of universities included in the analysis.

Aberystwyth University	Sheffield Hallam University	The University of Newcastle-upon-Tyne
Anglia Ruskin University	Southampton Solent University	The University of Northampton
Aston University	St Mary's University College	The University of Northumbria at Newcastle
Bangor University	St Mary's University College, Twickenham	The University of Nottingham
Bath Spa University	Staffordshire University	The University of Oxford
Birkbeck College	Swansea Metropolitan University	The University of Plymouth
Birmingham City University	Swansea University	The University of Portsmouth
Bishop Grosseteste University	Teesside University	The University of Reading
Bournemouth University	The Arts University Bournemouth	The University of Salford
Brunel University	The City University	The University of Sheffield
Buckinghamshire New University	The Manchester Metropolitan University	The University of Southampton
Canterbury Christ Church University	The Nottingham Trent University	The University of St Andrews
Cardiff Metropolitan University	The Open University	The University of Stirling
Cardiff University	The Queen's University of Belfast	The University of Strathclyde
Coventry University	The Robert Gordon University	The University of Sunderland
Cranfield University	The School of Oriental and African Studies	The University of Surrey
De Montfort University	The University of Aberdeen	The University of Sussex
Edge Hill University	The University of Bath	The University of the West of Scotland
Edinburgh Napier University	The University of Birmingham	The University of Wales, Newport
Falmouth University	The University of Bolton	The University of Warwick
Glasgow Caledonian University	The University of Bradford	The University of West London

(continued on next page)

Annex I (continued)

Glyndwr University	The University of Brighton	The University of Westminster
Goldsmiths College	The University of Bristol	The University of Winchester
Harper Adams University	The University of Buckingham	The University of Wolverhampton
Heriot-Watt University	The University of Cambridge	The University of Worcester
Heythrop College	The University of Central Lancashire	The University of York
Imperial College of Science, Technology and Medicine	The University of Chichester	University College Birmingham
Institute of Education	The University of Dundee	University College London
King's College London	The University of East Anglia	University for the Creative Arts
Kingston University	The University of East London	University of Abertay Dundee
Leeds Metropolitan University	The University of Edinburgh	University of Bedfordshire
Leeds Trinity University	The University of Essex	University of Chester
Liverpool Hope University	The University of Exeter	University of Cumbria
Liverpool John Moores University	The University of Glasgow	University of Derby
London Business School	The University of Greenwich	University of Durham
London Metropolitan University	The University of Huddersfield	University of Gloucestershire
London School of Economics and Political Science	The University of Hull	University of Hertfordshire
London School of Hygiene and Tropical Medicine	The University of Keele	University of South Wales
London South Bank University	The University of Kent	University of St Mark and St John (Prior to 2012/ 13)
Loughborough University	The University of Lancaster	University of the Arts, London
Middlesex University	The University of Leeds	University of the Highlands and Islands
Oxford Brookes University	The University of Leicester	University of the West of England, Bristol
Queen Margaret University, Edinburgh	The University of Lincoln	University of Ulster
Queen Mary University of London	The University of Liverpool	University of Wales Trinity Saint David
Roehampton University	The University of Manchester	York St John University

Annex II
Descriptive statistics.

Qualitative variables

Strategic plan	85.9%
Disclosure IPR	88.9%
Rewards IPR	81.5%
Structure SMEs	77.8%
Structure interaction	94.1%
Structure in-house license office/department	86.7%
Control: Russell Group	17.8%
Control: Post-92 universities	48.2%
Control: Country	England: 80%

Quantitative variables

	Mean	Standard Deviation	Min.	Max.
Staff involved with community (%)	16.7	13.3	0	65
Staff involved with clients (%)	18.7	14.2	0	75
Staff involved with public partners (%)	22.6	15.5	0	80
Collaboration Research (£000 s)	96.4	205.5	0	995
Contracts (£000 s)	157.9	271.4	0	952
Consultancy (£000 s)	148.8	231.1	0	987
Facilities (£000 s)	144.8	234.8	0	908
IP Revenues (£000 s)	111.1	214.4	0	847
Spinoffs	1.11	1.9	0	12
Applied patents	16.7	36.4	0	298
Granted patents	6.0	17.7	0	175
Control: Size	2307.27	1995.14	88	10,523

References

- Abreu, M., Grinevich, V., 2013. The nature of academic entrepreneurship in the UK: widening the focus on entrepreneurial activities. *Res. Policy* 42 (2), 408–422.
- Audretsch, D.B., 2014. From the entrepreneurial university to the university for the entrepreneurial society. *J. Technol. Transf.* 39 (3), 313–321.
- Becher, T., Trowler, P.R., 2001. *Academic Tribes and Territories Intellectual Enquiry and the Culture of Disciplines*. The Society for Research into Higher Education & Open University Press, Buckingham.
- Bénabou, R., Tirole, J., 2006. Incentives and prosocial behavior. *Am. Econ. Rev.* 96 (5), 1652–1678.
- Benneworth, P.S., 2007. Seven samurai opening the ivory tower? University commercialisation communities of practise promoting economic development in less successful regions. *Eur. Plan. Stud.* 15 (4), 487–509.
- Benneworth, P.S., Charles, D.R., 2005. University spin off companies and the territorial knowledge pool: building regional innovation competencies? *Eur. Plan. Stud.* 13 (4), 537–557.
- Benneworth, P., Pinheiro, R., Sánchez-Barrionuovo, M., 2016. One size does not fit all! New perspectives on the university in the social knowledge economy. *Sci. Public Policy* 43 (6), 731–735.
- Benneworth, P., Zeeman, N., Pinheiro, R., Karlsen, J., 2017a. National higher education policies challenging universities' regional engagement activities. *Ekonomiaz* 92 (2), 146–173 (in press).
- Benneworth, P.S., Pinheiro, R., Karlsen, J., 2017b. Strategic agency and institutional change: investigating the role of universities in regional innovation systems (RISs). *Reg. Stud.* 51 (2), 235–248. <https://doi.org/10.1080/00343404.2016.1215599>.
- Bentler, P.M., 1995. *EQS Structural Equations Program Manual*. Multivariate Software, Encino, CA.
- Berman, E., 2011. *Creating the Market University: How Academic Science Became an Economic Engine*. Princeton University Press, New Jersey.
- Besley, T., Ghatak, M., 2005. Competition and incentives with motivated agents. *Am. Econ. Rev.* 95 (3), 616–636.
- Browne, M.W., Cudek, R., 1993. Alternative ways of assessing model fit. In: Bollen, K.A., Long, J.S. (Eds.), *Testing Structural Equation Models*. Sage, Newbury Park, CA, pp. 136–162.
- Cesaroni, F., Piccaluga, A., 2015. The activities of university knowledge transfer offices: towards the third mission in Italy. *J. Technol. Transf.* <https://doi.org/10.1007/s10961-015-9401-3>. (published online 18 March 2015).
- Chapple, W., Lockett, A., Siegel, D., Wright, M., 2005. Assessing the relative performance of UK university technology transfer offices: parametric and non-parametric evidence. *Res. Policy* 34 (3), 369–384.
- Charles, D.R., Conway, C., 2002. *Higher Education Business Interaction Survey*. HEFCE, Bristol.
- Charles, D., Kitagawa, F., Uyarra, E., 2014. Universities in crisis? -new challenges and strategies in two English City-regions. *Camb. J. Reg. Econ. Soc.* 7 (2), 327–348.
- Clark, B.R., 1998. *Creating the Entrepreneurial University*. IAU Press/Pergamon, Oxford.
- Clarisse, B., Tartari, V., Salter, A., 2011. The impact of entrepreneurial capacity, experience and organizational support on academic entrepreneurship. *Res. Policy* 40, 1084–1093.
- Comunian, R., Taylor, C., Smith, D.N., 2014. The role of universities in the regional creative economies of the UK: hidden protagonists and the challenge of knowledge transfer. *Eur. Plan. Stud.* 22 (12), 2456–2476. <https://doi.org/10.1080/09654313.2013.790589>.
- Cooke, P., 1992. Regional innovation systems: comparative regulation in the new Europe. *Geoforum* 23, 365–382.
- Cooke, P., 2005. Regionally asymmetric knowledge capabilities and open innovation: exploring 'globalisation 2' – a new model of industry organisation. *Res. Policy* 34, 1128–1149.
- Cooke, P., Heidenreich, M., Braczyk, H.J., 2004. *Regional Innovation Systems*, 2nd ed. Routledge, London and New York.
- De Boer, Harry F., Enders, Jürgen, Leisyte, Liudvika, 2007. Public sector reform in Dutch higher education: the organizational transformation of the university. *Public Adm.* 85 (1), 27–46.
- D'Este, P., Iammarino, S., 2010. The spatial profile of university-business research partnerships. *Pap. Reg. Sci.* 89 (2), 335–350.
- D'Este, P., Patel, P., 2007. University-industry linkages in the UK: what are the factors underlying the variety of interactions with industry? *Res. Policy* 36, 1295–1313.
- Decter, M., Bennett, D., Leseure, M., 2007. University to business technology transfer—UK and USA comparisons. *Technovation* 27, 145–155.
- Dill, D., 1995. University-industry entrepreneurship: the organization and management of American university technology transfer units. *High. Educ.* 29, 369–384.
- Drucker, J., Goldstein, H., 2007. Assessing the regional economic development impacts of universities: a review of current approaches. *Int. Reg. Sci. Rev.* 30 (1), 20–46.
- Etzkowitz, H., 1983. Entrepreneurial scientists and entrepreneurial universities in American academic science. *Minerva* 21, 198–233.
- Etzkowitz, H., Leydesdorff, L., 2000. The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Res. Policy* 29 (2), 109–123.
- Feldman, M., Desrochers, P., 2003. Research universities and local economic development: lessons from the history of Johns Hopkins University. *Ind. Innov.* 10 (1), 5–24.
- Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement errors. *J. Mark. Res.* 18, 39–50.
- Geuna, Rossi, 2011. Changes to university IPR regulations in Europe and the impact on academic patenting. *Res. Policy* 40, 1068–1076.
- Goddard, 2009. *Re-Inventing the Civic University*. NESTA, London.
- Goddard, J.B., 2012. *Connecting Universities to Practical Growth: A Regional Guide*. IPTS JRC, Sevilla: Spain Available online at: http://ec.europa.eu/regional_policy/sources/docgener/presenta/universities2011/universities2011_en.pdf.
- Goldstein, H., 2010. The 'entrepreneurial turn' and regional economic development mission of universities. *Ann. Reg. Sci.* 44, 83–109.
- Goodall, A.H., 2009. Highly cited leaders and the performance of research universities. *Res. Policy* 38, 1079–1092.
- Grimaldi, R., Kenney, M., Siegel, D., Wright, M., 2011. 30 years after Bayh-Dole: re-assessing academic entrepreneurship. *Res. Policy* 40, 1045–1057.
- Guerrero, M., Urbano, D., 2012. The development of an entrepreneurial university. *J. Technol. Transf.* 37, 43–74.
- Guerrero, M., Cunningham, J.A., Urbano, D., 2015. Economic impact of entrepreneurial universities' activities: an exploratory study of the United Kingdom. *Res. Policy* 44, 748–764.
- Gunasekara, C., 2006. Reframing the role of universities in the development of regional innovation systems. *J. Technol. Transf.* 31 (1), 101–113.
- Hair, J., Anderson, R., Tatham, R., Black, W., 1998. *Multivariate data analysis*, 5th edition. Prentice Hall, New Jersey.
- HEFCE, 2009. *Evaluation of the Effectiveness and Role of HEFCE/OSI Third Stream Funding: Report to HEFCE by PACEC and the Centre for Business Research*. University of Cambridge Available at: <http://www.hefce.ac.uk/pubs/year/2009/200915/>.
- HEFCE, 2013. *Report on survey Higher Education – Business and Community Interaction Survey 2011–12*. HEFCE May 2013/11. Available at: <http://www.hefce.ac.uk/pubs/year/2013/201311/#d.en.81914>.
- Hermannsson, K., Lisenkova, K., McGregor, P.G., Swales, J.K., 2013. The expenditure impacts of individual higher education institutions and their students on the Scottish economy under a regional government budget constraint: homogeneity or heterogeneity? *Environ. Plan. A* 45 (3), 710–727.
- Hewitt-Dundas, N., 2012. Research intensity and knowledge transfer activity in UK universities. *Res. Policy* 41, 262–275.
- Hicks, D., Hamilton, K.S., 1999. Does university-industry collaboration adversely affect university research? *Issues in Science & Technology*. Summer 99 (16), 74–75.
- Howells, J., Ramlogan, R., Cheng, S., 2012. Innovation and university collaboration: paradox and complexity within the knowledge economy. *Camb. J. Econ.* 36 (3), 703–721.
- Hu, L.-T., Bentler, P.M., 1995. Evaluating model fit. In: Hoyle, R.H. (Ed.), *Structural Equation Modeling: Concepts, Issues and Applications*. Sage, Thousand Oaks, CA, pp. 76–99.
- Hu, L.T., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct. Equ. Model. Multidiscip. J.* 6 (1), 1–55. <https://doi.org/10.1080/10705519909540118>.
- Huang, C.C., Wang, Y.M., Wu, T.W., Wang, P.A., 2013. An empirical analysis of the antecedents and performance consequences of using the Moodle platform. *Int. J. Inf. Educ. Technol.* 3 (2), 217–221.
- Huggins, R., Kitagawa, F., 2011. Regional policy and university knowledge transfer: perspectives from devolved regions in the UK. *Reg. Stud.* 46 (6), 817–832.
- Hülsbeck, M., Lehmann, E.E., Starnecker, A., 2013. Performance of technology transfer offices in Germany. *J. Technol. Transf.* 38, 199–215.
- Huyghe, A., Knackaert, M., 2015. The influence of organisational culture and climate on entrepreneurial intentions among research scientists. *J. Technol. Transf.* 40 (1), 138–160.
- Jacob, M., Lundqvist, M., Hellsmark, H., 2003. Entrepreneurial transformations in the Swedish University system: the case of Chalmers University of Technology. *Res. Policy* 32, 1555–1568.
- Jongbloed, B., Enders, J., Salerno, C., 2007. Higher education and its communities: interconnections, interdependencies and a research agenda. *High. Educ.* 56 (3), 303–324.
- Kitagawa, F., 2004. Universities and regional advantage: higher education and innovation policies in English regions. *Eur. Plan. Stud.* 12 (6), 835–852.
- Kitagawa, F., Lightowler, C., 2013. Knowledge exchange: a comparison of policy, incentives and funding mechanisms in English and Scottish higher education. *Res. Eval.* 22 (1), 1–14.
- Klofsten, M., Jones-Evans, D., 2000. Comparing academic entrepreneurship in Europe – the case of Sweden and Ireland. *Small Bus. Econ.* 14, 299–309.
- Landry, R., Saihi, M., Amara, N., Ouimet, M., 2010. Evidence on how academics manage their portfolio of knowledge transfer activities. *Res. Policy* 39, 1387–1403.
- Larédo, P., 2007. Revisiting the third Mission of universities: toward a renewed categorization of university activities? *High. Educ. Pol.* 2007 (20), 441–456.
- Laursen, K., Reichstein, R., Salter, A., 2011. Exploring the effect of geographical proximity and university quality on university-industry collaboration in the United Kingdom. *Reg. Stud.* 45 (4), 507–523.
- Lawton Smith, H., Bagchi-Sen, S., 2012. The research university, entrepreneurship and regional development: research propositions and current evidence. *Entrep. Reg. Dev.* 24 (5–6), 383–404.
- Little, T., 2013. *Longitudinal Equation Modelling*. Guilford Press.
- Lockett, A., Wright, M., Franklin, S., 2003. Technology transfer and Universities' spin-out strategies. *Small Bus. Econ.* 20, 185–200.
- Martin, B.R., 2003. The changing social contract for science and the evolution of the university. In: Geuna, A., Salter, A.J., Steinmueller, W.E. (Eds.), *Science and Innovation: Rethinking the Rationales for Funding and Governance*. Edward Elgar Publishing Limited, Cheltenham, UK.
- Martinelli, A., Meyer, M., Von Tunzelmann, N., 2008. Becoming an entrepreneurial university? A case study of knowledge exchange relationship and faculty attitudes in a medium sized, research oriented university. *J. Technol. Transf.* 32 (2), 259–283.

- McCormack, J., Propper, C., Smith, S., 2014. Herding cats? Management and university performance. *Econ. J.* <https://doi.org/10.1111/eoj.12105>.
- Morgan, J., 2017. Jo Johnson plans for KEF to measure knowledge exchange: framework to measure university-business links would follow TEF and REF. In: *Times Higher Education Newspaper*. 12th October 2017 available at: <https://www.timeshighereducation.com/jo-johnson-plans-kef-measure-knowledge-exchange>, Accessed date: 13 October 2017.
- Mowery, D.C., Shane, S., 2002. Introduction to the special issue on university entrepreneurship and technology transfer. *Manag. Sci.* 48 (1), v–ix.
- Nedeva, M., 2007. New tricks and old dogs? The 'third mission' and the re-production of the university. In: Epstein, D., Boden, R., Deem, R., Rizvi, F., Wright, S. (Eds.), *Geographies of Knowledge, Geometries of Power: Framing the Future of Higher Education*. London, Routledge, pp. 85–105.
- Nelles, J., Vorley, T., 2010. Constructing an entrepreneurial architecture: an emergent framework for studying the contemporary university beyond the entrepreneurial turn. *Innov. High. Educ.* 35 (3), 161–176.
- Olmos-Peñuela, J., Molas-Gallart, J., Castro-Martínez, E., 2013. Informal collaborations between social sciences and humanities researchers and non-academic partners. *Sci. Public Policy* October 17, 2013. <https://doi.org/10.1093/scipol/sct075>.
- Olsson, U.H., Foss, T., Troye, S.V., Howell, R.D., 2000. The performance of ML, GLS, and WLS estimation in structural equation modeling under conditions of misspecification and nonnormality. *Struct. Equ. Model.* 7 (4), 557–595.
- PACEC/Centre for Business Research (CBR), 2009. Evaluation of the effectiveness and role of HEFCE/OSI third stream funding: Culture Change and Embedding Capacity in the Higher Education Sector Towards Economic Impact. Report to HEFCE by PACEC and the Centre for Business Research. 2009/15 University of Cambridge.
- Peer, V., Penker, M., 2016. Higher education institutions and regional development: a meta-analysis. *Int. Reg. Sci. Rev.* 228–253.
- Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Brostrom, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., Sobrero, M., 2013. Universities and the third mission: a systematic review of research on external engagement by academic researchers. *Res. Policy* 42, 423–442.
- Philpott, K., Lawrence, D., O'Reilly, C., Lupton, G., 2011. The entrepreneurial university: examining the underlying academic tensions. *Technovation* 31 (4), 161–170.
- Pinheiro, R., Benneworth, P., Jones, G.A., 2012. *Universities and Regional Development: An Assessment of Tensions and Contradictions*. Routledge, London.
- Pinto, H., Fernandez-Esquinas, M., Uyarra, E., 2013. Universities and knowledge-intensive business services (KIBS) as sources of knowledge for innovative firms in peripheral regions. *Reg. Stud.* 1–19 (ahead-of-print).
- Ponds, R., Van Oort, F., Frenken, K., 2010. Innovation, spillovers and university–industry collaboration: an extended knowledge production function approach. *J. Econ. Geogr.* 10 (2), 231–255.
- Rafferty, M., 2008. The Bayh-Dole act and university research and development. *Res. Policy* 37 (1), 29–40.
- Raykov, T., 1997. Estimation of composite reliability for congeneric measures. *Appl. Psychol. Meas.* 21, 173–184.
- Reponen, T., 1999. Is leadership possible at loosely coupled organizations such as universities? *High Educ. Pol.* 12.3, 237–244.
- Rip, A., 2002. Regional innovation systems and the advent of strategic science. *J. Technol. Transf.* 27, 123–131.
- Rossi, F., Rosli, A., 2014. Indicators of university–industry knowledge transfer performance and their implications for universities: evidence from the United Kingdom. *Stud. High. Educ.* 1–22 (ahead-of-print).
- Rothaermel, F.T., Agung, S.D., Jiang, L., 2007. University entrepreneurship: a taxonomy of the literature. *Ind. Corp. Chang.* 16 (4), 691–791.
- Sánchez-Barrioluengo, M., 2014. Articulating the 'three-missions' in Spanish universities. *Res. Policy* 43, 1760–1773.
- Sánchez-Barrioluengo, M., Uyarra, E., Kitagawa, F., 2016. The evolution of the triple helix dynamics: the case of English Higher Education Institutions. In: *CIMR Research Working Paper Series*, Available at: www.bbk.ac.uk/innovation/publications/docs/WP32.pdf.
- Schoen, A., van Pottelsberghe de la Potterie, B., Henkel, J., 2014. Governance typology of universities' technology transfer processes. *J. Technol. Transfer.* 39, 435–453.
- Scott, W.R., 1995. *Institutions and Organizations*. Sage, Thousand Oaks, CA.
- Scott, P., 2014. The reform of English higher education: universities in global, national and regional contexts. *Camb. J. Reg. Econ. Soc.* 7 (2), 217–231.
- Sengupta, A., Ray, A.S., 2017. University research and knowledge transfer: a dynamic view of ambidexterity in British universities. *Res. Policy* 46, 881–897.
- Sharma, S., Mukherjee, S., Kumar, A., Dillon, W.R., 2005. A simulation study to investigate the use of cutoff values for assessing model fit in covariance structure models. *J. Bus. Res.* 58, 935–943.
- Siegel, D., Waldman, D., Link, A.N., 2003. Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study. *Res. Policy* 32 (1), 27–48.
- Siegel, D.S., Veugelers, R., Wright, M., 2007. Technology transfer offices and commercialization of university intellectual property: performance and policy implications. *Oxf. Rev. Econ. Policy* 23 (4), 640–660.
- Tartari, V., Breschi, S., 2012. Set them free: scientists' evaluations of the benefits and costs of university–industry research collaboration. *Ind. Corp. Chang.* 21 (5), 1117–1147.
- Teichler, U., 1988. Changing patterns of the higher education system. In: *The Experience of Three Decades*. Jessica Kingsley, London.
- Teichler, U., 2004. Changing structures of the higher education systems: the increasing complexity of underlying forces. In: *UNESCO Forum Occasional Paper Series Paper No. 6 Diversification of Higher Education and the Changing Role of Knowledge and Research*.
- Thompson, E.P., 1970. *Warwick University Ltd*. Penguin.
- Trippel, M., Sinozic, T., Lawton Smith, H., 2015. The role of universities in regional development: conceptual models and policy institutions in the UK, Sweden and Austria. *Eur. Plan. Stud.* 23 (9), 1722–1740. <https://doi.org/10.1080/09654313.2015.1052782>.
- Uyarra, E., 2010. Conceptualizing the regional roles of universities: implications and contradictions. *Eur. Plan. Stud.* 18, 1227–1246.
- Wallsten, S., 2001. An empirical test of geographic knowledge spillovers using geographic information systems and firm-level data. *Reg. Sci. Urban Econ.* 31, 571–599.
- Wang, Y., Hu, R., Li, W., Pan, X., 2016. Does teaching benefit from university–industry collaboration? Investigating the role of academic commercialization and engagement. *Scientometrics* 106, 1037–1055.
- Williams, L.J., Gavin, M.B., Hartman, N.S., 2004. Structural equation modeling methods in strategy research: applications and issues. In: *Ketchen Jr.D.J., Bergh, D.D. (Eds.), Research Methodology in Strategy and Management*. Vol. 1. Elsevier, Oxford, pp. 303–346.
- Wright, M., Clarysse, B., Lockett, A., Knockaert, M., 2008. Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries. *Res. Policy* 37, 1205–1223. <https://doi.org/10.1016/j.respol.2008.04.021>.

Mabel Sánchez-Barrioluengo is research fellow working at the Joint Research Centre of the European Commission as part of the Unit of Human Capital and Employment. Her main research interests are in economics of education (specifically higher education), employment and human capital. She has a degree in Statistics and holds a PhD from the Technical University of Valencia with a particular focus on higher education studies. Previously she worked at INGENIO (CSIC-UPV) in Spain and in the Technology Transfer Office at University Miguel Hernandez. Her research has been published in several international journals such as *Research Policy*, *Scientometrics* or *Science and Public Policy*.

Paul Benneworth is a senior researcher at the Center for Higher Education Policy Studies, University of Twente (the Netherlands). Paul's research focuses on the dynamics of innovation and regional development and in particular the ways in which cooperations and coalitions function in supporting regional innovation processes. He has been chief scientist of projects for a range of research funders. He has published more than thirty peer-reviewed scientific articles in the last decade, serves as reviewer for a range of journals, research councils and funding agencies and currently acts as special scientific adviser to research council funded projects in Norway, Austria and Belgium.