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1. Strategic knowledge management models and tools for entrepreneurial universities

1.1 Introduction

In the last decades, universities have moved from focussing exclusively on their primary two missions of education providers and scientific knowledge creators, to be considered as key actors of economic and cultural growth, transforming themselves into engaged institutions with industry and society at large (Etzkowitz, 2000; Vorley and Nelles, 2008). This movement has been frequently described as “third mission” focussing on knowledge transfer, commercialisation and innovation as third pillar of a university (Lambert, 2003; Laredo, 2007; Zomer and Benneworth, 2011; Secundo et al., 2017).

Although there is no general definition, third mission activities comprise three dimensions performed by universities about external environments: technology transfer and innovation, continuing education and social engagement (E3M, 2010). In this perspective, the term “entrepreneurial university” (Clark, 1998; Philpott et al., 2011; Etzkowitz, 2016) has been adopted by academics and policymakers to describe universities that effectively deliver on their “third mission” contributing to the regional economy simultaneously (Clark, 1998; Van Vught, 1999; Lambert, 2003).

The recognition that in today’s economic landscape Entrepreneurial Universities can play the fundamental role of key enablers in the areas of technology, innovation and economic development, points out their role as knowledge-based agents for local value creation dynamics. Indeed, an Entrepreneurial University can be seen as an entrepreneurial hub with multiple and integrated knowledge-based functions ranging from the traditional pure knowledge and technology development to innovation ecosystems development as well as social innovation and community engagement catalyzer (Margherita and Secundo, 2011; Philpott et al., 2011; Etzkowitz, 2016; Maas and Jones, 2017). Knowledge Management (KM) in academia is any systematic activity related to support and enhancement of the creation of scientific knowledge and achievement of research goals, including both social process and relevant KM technology tools (Tian et al., 2009).

Therefore, the understanding the knowledge models, processes and tools that can support the entrepreneurial universities as entrepreneurial hubs or knowledge agents, is of fundamental importance. The way Entrepreneurial Universities act strategically as creators and disseminators of new knowledge, organisers of multidisciplinary and boundary-spanning knowledge application activities as well as facilitator of university-industry links represent a critical area of research investigation. Entrepreneurial Universities as belonging to the public sector have specific labour divisions that are a disincentive to knowledge sharing and “this situation makes knowledge delivery in the public sector more difficult than that in the private sector” (Gau, 2011, p. 2).

To date, most of the studies on entrepreneurial university and academic entrepreneurship have focussed the attention on technology transfer offices (TTOs), incubators and science parks, stakeholder collaboration, innovation support, entrepreneurial training of highly skilled individuals and the development of new spin-off firms as tools used to achieve their entrepreneurial aspirations (Voisey et al., 2013; Somsuk and Laosirihongthong, 2014; Elia et al., 2017). In all these processes, a reconceptualization of knowledge production called the “Mode 3” Knowledge Production System (expanding and extending the “Mode 1” and “Mode 2” knowledge production systems) (Carayannis and Campbell, 2012) has been defined. The Mode 3 Knowledge Production System architecture
focusses on and leverages higher-order learning processes and dynamics that allow for both
top-down government, university, and industry policies and practices and bottom-up civil
society initiatives and priorities to interact and engage with each other towards a more
intelligent, effective, and efficient synthesis. This means that the entrepreneurial university
implements several strategies and new institutional configuration such as Entrepreneurship
centres (Cassia et al., 2014; Maas and Jones, 2017) to work together with the government,
industries and society to facilitate the diffusion the production, the application and the
exploitation of knowledge and technology (Leydesdorff and Meyer, 2006).

The convergence of these perspectives requires new updated models, strategies tools for
the strategic KM in the entrepreneurial universities. The growing relevance of this new
archetype of university calls for a more in-depth investigation of the strategic approaches,
models, processes and tools supporting the creation, transfer, development, valorisation,
exchange and integration of new knowledge at the core of their missions and strategic
actions. Thus, the goal of this special issue is to provide a knowledge-based analysis of
entrepreneurial universities investigating the strategic KM models and tools at the basis
of the management, creation and diffusion of knowledge, research and innovation.

In this special issue we present a variety of international studies at the forefront of
strategic KM in Entrepreneurial Universities. Overall 13 papers have been selected to
accomplish the above rationale and to illustrate the premises and future potential for such
interdisciplinary and cross-level research agenda on the knowledge strategies and processes
for universities. In the following sections we highlight the contents of the selected papers.
Finally a discussion of the overall contributions is provided and the future research venues
are outlined.

2. Identifying strategic KM research in entrepreneurial university

The first paper of the special issue presents a literature review to define the state-of-the-art.

Secundo et al. (2019) in “Knowledge Management in Entrepreneurial Universities:
A Structured Literature Review and Avenue for future Research Agenda” provide a review
and critique about the KM literature within Entrepreneurial universities. A systematic
literature review was conducted, in which 1106 articles indexed at Scopus were initially
submitted to bibliometric analysis. Finally, 150 papers published in a variety of academic
journals specialising in the field of Entrepreneurship, KM and Higher Education have been
analysed through content and a bibliometric analysis. Findings reveal that literature on KM
models and tools in the Entrepreneurial University is fragmented and dominated by
unrelated research. The content analysis identifies four major research streams: knowledge
transfer in University-Industry collaboration (UIC); knowledge creation in Entrepreneurship
Education; KM processes for University’s spin-offs; and Entrepreneurial University to
support Knowledge-based regional development. Findings show a failure to address the
implications of findings for policymakers, which risks relegating the KM in Entrepreneurial
Universities research to irrelevance. Finally authors outline a future research agenda.

Four main research areas are covered by the other papers gathered in this special issue.

2.1 Research area: knowledge creation in University-industry collaboration

Giones (2019) in the paper “University-Industry Collaborations: An Industry Perspective”
explores the UIC drivers from the industry side as a key element in the transition towards an
entrepreneurial university model. The paper analyses how, and to what extent, policy
interventions could increase the engagement of industry actors in UICs. Starting from a pilot
study with 36 firms with a satellite university campus, findings reveal that Firms involved
in universities students (academic forms of UICs) might not necessarily consider the
university as a research partner, even in a geographic proximity setting. Besides, there is a
potential dark side to proximity when industry participants build their perceptions using
second-hand experiences or indirect information. The pilot study provides valuable insights for researchers interested in a larger randomised control trial. It also provides insights for university managers that want to understand the motivations of industry participants in UICs. The experimental approach of the research generates evidence on the feasibility to intervene in the activation of UICs from an industry perspective, a central aspect in a transition towards an entrepreneurial university model.

The paper of Guerrero et al. (2019) “Strategic knowledge management within subsidised entrepreneurial university-industry partnerships” provides a contribution to the academic debate about how entrepreneurial universities and industrial organisations are strategically managing their knowledge when participating in subsidised partnerships in emerging economies. The proposed conceptual model was analysed with a retrospective multiple case study approach integrated by four subsidised entrepreneurial universities-industry partnerships of the Incentive Programme for Innovation from 2009 to 2014 in Mexico. Entrepreneurial universities and industrial organisations confirm insights about dual collaborative opportunistic behaviour within subsidised partnerships. The ex-ante collaboration agreement anticipated and protected intellectual capabilities. The originality of the paper resides in the discussion about public administrations opportunistic behaviours in emerging economies.

Centobelli et al. (2019) with the “Managing the mediating role of knowledge exploration and exploitation for the development of an entrepreneurial university” focus on the modern knowledge-based economy. The authors acknowledge the role of the third mission of universities related to the process of knowledge transfer as a driving force to face sustainability issues, in addition to the two traditional missions focussing on research and teaching. This paper aims to investigate the relationships between internal environment, external environment, knowledge exploitation, knowledge exploration, and university performance. The study applies confirmatory factor analysis and structural equation modelling (SEM) to test the conceptual model in the Chinese education system. The findings confirm the higher impact of internal environment on both knowledge exploitation and knowledge exploration as compared to external environment. Knowledge exploitation is more strongly related to university performance than knowledge exploration. These results highlight the imperative role of internal university stakeholders in fostering KM strategies. In addition, they encourage academicians, practitioners, and policy-makers to focus their attention on the impact of KM models, tools and practices in universities to achieve the entrepreneurial development that in turn has a positive impact on individual graduates and innovation ecosystems.

2.2 Research area: entrepreneurial orientation in the university’s context

Rybnicek et al. (2019) in the paper “Industry and leadership experiences of the heads of departments and their impact on the performance of public universities” identifies whether the prior industry experience (IE) or industry leadership experience (ILE) of the head might influence the departments publication output, the ability to acquire external research funds or its entrepreneurial activities (e.g. the commercialisation of research results through patents). Moving from data of 208 Austrian university departments results show a positive relationship between ILE and the patent output of the departments as one indicator for the commercialisation of research activities. Furthermore the scientific ability of researchers should be key when selecting the head of a department, because scientific performance is still essential for most of these units. However, when universities seek to focus more strongly on other entrepreneurial activities, then additional competencies come into play. As the actual focus of universities is currently subject to change, former IE and ILE will become increasingly more important, and the heads of departments will play a decisive role in the transition towards becoming an entrepreneurial university.
The paper “Entrepreneurial academics: a taxonomy with latent profiling analysis” of Rodrigues et al. (2019) aims to develop a taxonomy of academics from Higher Education institutions (HEI), based on their entrepreneurial orientation. The population in the study was composed of teachers and researchers from worldwide HEI. The data collection was conducted through a questionnaire sent by e-mail, and using the I-ENTRE-U scale to identify entrepreneurial oriented teachers and researchers from HEI. A latent profile analysis was conducted to identify profiles of researchers with similar values in the four entrepreneurial orientation dimensions. The study allowed to identify five profiles of researchers: downers; achievers; followers; defenders; and rebels. Findings allow the evaluation of the academics entrepreneurial orientation in a higher education sector. Few studies have yet focussed on individual entrepreneurial orientation of scientists/academics, considering different national and regional contexts.

Alvarez-Torres et al. (2019) in “Linking Entrepreneurial Orientation to SMEs’ Performance: Implications for Entrepreneurship Universities” analyses the relationship between Entrepreneurial Orientation (EO) and performance of small and medium-sized enterprises (SMEs). The final aim is to contribute to the extant literature about the role of EO for SMEs development, and more specifically to identify implications that can inform knowledge-based initiatives of entrepreneurship. A quantitative approach is adopted moving from the hypothesis that EO positively affects Performance of SMEs. This hypothesis has been tested by using a system of partial least squares (PLS-SEM) of structural equations modelling in 170 SMEs operating in the Bajio Region (Mexico). The results provide three main contributions. First, it proposes a working definition of EO. Second, the empirical research findings support an understanding of the relationship between EO and Mexican SMEs Performance and propose a multiple and reflective dimension of EO’s model. Moreover, finally, this research provides some implications for entrepreneurship universities aiming to create and diffuse an entrepreneurial culture and capabilities by fostering the development of the EO. Accordingly, entrepreneurial universities should be engaged in the development of EO of students, academic staff and companies by focussing on knowledge-based actions that can foster the improvement of some specific features of the EO.

2.3 Research area: knowledge strategies and models for the entrepreneurial university

Lombardi et al. (2019) in the paper “Entrepreneurial universities and strategy. The case of the University of Bari” investigate the reasons behind the choice of the entrepreneurial universities for a particular business strategy focussing on diversification and multinationalization. In doing this the Intellectual Capital (IC) lens as part of knowledge assets is taken for supporting such strategies. An exploratory case study of the University of Bari, Italy is chosen and analysed using Secundo et al. (2016) collective intelligence framework. Specific contingency factors, such as economic and historical reasons, justify both the diversification and internationalisation strategies and how they both rely on IC. The results of this study can be used by managers to support the development of entrepreneurial university strategies. Findings contribute to demonstrate how IC can be used to support diversification and internationalisation in a university and to support third mission goals.

The paper of Dolan et al. (2019) “The Role and Function of Cooperative Research Centers in Entrepreneurial Universities: A Micro Level Perspective” presents a micro-level examination of the role and function of cooperative research centres (CRCs) in entrepreneurial universities assuming the principal investigator (PI) perspective. The case of Centre for Research in Medical Device-based in Ireland whose multiple mission focus of supporting scientific excellence, industry engagement, educational and public engagement is studied. Findings reveal that from the micro level PI perspective, the role and function of
CRCs focus on: research quality enhancement; brokerage, networks and collaborations; addressing research impact; and resource enhancement and appropriation. The research emphasises the strategic relevance for the creation of CRCs as part of the entrepreneurial architecture of entrepreneurial universities that provide the necessary appropriate local environmental conditions and enhanced supports to enable micro-level actors to fulfil multiple mission objectives to research excellence, industry, educational and public engagement and impact.

The paper “Entrepreneurial university strategies in the UK context: Towards a research agenda” of Pickernell et al. (2019) contributes to the Entrepreneurial University literature by providing a clearer understanding of knowledge exchange (KE) strategy of UK universities in specific relation to their portfolio of KE activities with small and medium-sized enterprises. Based on the 2015-2016 Higher Education Business and Community Interaction Survey (HE-BCI) data set, this study employs the preference ranking organisation method for the enrichment of evaluations to assess the KE activities from 162 UK higher education institutions. The study reveals that entrepreneurial universities valorise university knowledge assets through five SME-focussed KE activities most beneficial to measuring the entrepreneurial university. It also uncovers four different archetypal categories (groupings) of universities based on their strategic focus of KE activities.

Ricci et al. (2019) in the paper “Entrepreneurial activities and models of advanced European science and technology universities” aim at identifying: a broad set of entrepreneurial activities; different university entrepreneurial models; and the entrepreneurial best practices of advanced European S&T universities. The empirical analysis has combined both quantitative and qualitative approaches mainly relying on primary data, collected through questionnaires and interviews with those in charge of the TTOs of 20 universities belonging to the CESAER association. Findings identified three main entrepreneurial university models: an “engage” model, which focusses on local economic development; a “formal” model, which focusses on the financial advantage of universities and their faculties; and a “comprehensive” model, which focusses on the local economic development and the financial advantage of universities and their faculties. Limitations regard the focus of the European area.

2.4 Research area: KM processes for university’s business incubators and Technology Transfer Offices (TTOs)

The paper “Analyzing technology transfer offices’ influence for entrepreneurial universities in Portugal ” by Mascarenhas et al. (2019) examines how important TTOs – which in Portuguese are called “industrial property support offices” or GAPIs – are in terms of fostering patent applications and technology transfer. Data have been collected from eight GAPIs among the existing 23 Portuguese GAPIs. Content analysis was performed on the data collected using NVivo software. The results show that GAPIs play an important role in the innovation life-cycle, speeding up the transfer of knowledge and technology to society. The major contribution is represented by the regulation of intellectual property ownership and royalty sharing with inventors, reinforcing the entrepreneurial universities’ role. The study’s results offer new insights into how GAPIs contribute to socio-economic growth by fostering more entrepreneurial universities and increasing the transfer of technology to society. Besides, these offices promote the creation of networks between GAPIs, enabling them to leverage universities’ potential for participation in socio-economic development.

The paper titled “Ranking Factors Influencing Strategic Management of University Business Incubators with ANP” of Kiani Mavi et al. (2019) provides a novel analysis and contribution to the literature related to the ranking university business incubators with a multi-criteria decision-making technique. Actual research prioritises the factors influencing strategic management of incubators using analytic network process (ANP). Data from
University-Business Incubators affiliated with science and technology park of Guilan, located in city of Rasht (Iran), using the ANP questionnaire have been collected. Findings identify the most relevant factors influencing strategic management of incubators comprised of 4 main criteria and 14 sub-criteria. “Talented managers” criterion has the highest importance for strategic management of university business incubators. Moreover, University managers and incubator directors can utilise the findings for better resource allocation and aligning the strategies of incubators with macro strategies of the country.

3. Conclusions and avenues for future research agenda

To conclude this special issue on strategic KM in entrepreneurial Universities, the Editors want to encourage a further expansion of KM research in the novel context of Entrepreneurial University so engaged into teaching, research and academic entrepreneurship. The special issue presents the first attempt to provide a comprehensive review and holistic overview of the current debate dealing with Models and Processes of KM in the Entrepreneurial University.

Despite the increasing literature, this research area is still fragmented and under theorized, thus requiring further systematic studies, considering both the managerial, economic and the social aspects of KM within universities thus offering insights into future research avenues. It is important to recall the initial motivation of this special issue was based on the argument that the Entrepreneurial University represents a particular research context because of different levels of representativeness, accountability and responsiveness of different stakeholders, requiring focused studies about KM studies in a University that for its threefold missions is involved into the creation, sharing, diffusion and commercialisation of knowledge and research.

Universities are now viewed as key social and economic actors within regions and are central actors in shaping and influencing entrepreneurial ecosystems. This has meant that universities now have to become more entrepreneurial in offerings, outlook and culture (Miller et al., 2018) thus requiring novel approaches and modalities to manage their knowledge assets. Universities develop strategies to fulfil their historic mission of teaching and research and they also undertake a significant role in producing, creating, and diffusing new knowledge in today’s ever-changing world (Olcay and Bulu, 2017). Moreover, KM processes adopted in universities to facilitate the diffusion of their knowledge and technology act as another channel to offer the research knowledge exploitable by external stakeholders (i.e. industry, government and society).

The debate on KM and the entrepreneurial university has received during the last 18 years growing attention. Although the two topics have been largely investigated, their intersection discloses several areas of deepening by highlighting a still fragmented debate and so requiring holistic and integrated frameworks aimed to comprehend the relevance and implications of KM in the context of entrepreneurial universities.

Despite the number of papers published on KM in Entrepreneurial University in the period 2001-2019 has reached a consistent volume, the analysis of their meaning, dynamics and specific requirement of KM in a public context still dominated by unrelated research. Trends observed in terms of contents and research aim depict a profile of a community of scholars and researchers still dispersed; despite this, the positive trends of growth registered in 2018 and 2019 is promising. In the same direction, the analysis revealed that the need of consolidating the relevance of the issues of KM and Entrepreneurial Universities has been found in terms of new empirical contexts of explorations (Secundo et al., 2019).

Four main research areas of specialisation within the scientific debate have been identified in the papers of our special issue; we categorise the main areas in: knowledge creation in UIC; Knowledge Strategies and Models for the Entrepreneurial University; entrepreneurial orientation in the University’s context; and KM processes for University’s...
Business Incubators and TTOs. The analysis of papers included in these areas allowed to derive a more robust awareness on state of the art on KM and Entrepreneurial University in terms of more conscious entrepreneurial orientation of the people, faculty and students, manager of the Entrepreneurial University, KM processes at the basis of the organisational models of the Entrepreneurial University and finally KM processes for the valorisation of the knowledge processes with the University’s incubators and TTOs. Avenues for future research are identified moving from the above research area and can be expressed in terms of following issues:

- What are the most relevant knowledge changes in the universities that can accelerate their transition towards entrepreneurial universities?
- How do entrepreneurial universities integrate their knowledge strategies to reach university goals in teaching, research, and outreach?
- What are the new entrepreneurial university models/archetypes, and how is it possible to classify their external and internal knowledge assets?
- What is the role of knowledge-based systems and new social media for the entrepreneurial university?
- How to sustain the Entrepreneurial Orientation within the Universities?
- Which knowledge outcomes of an entrepreneurial university affect regional development and social engagement?
- How do entrepreneurial universities make use of KE and transfer with stakeholders to shape society?
- What is the role of KM to support university-industry-society interactions?
- How do entrepreneurial universities valorise university knowledge assets?
- What are the most relevant knowledge processes supporting the development of an entrepreneurship ecosystem shaped by an entrepreneurial university?
- What is the role and function of entrepreneurial centres to drive the development of entrepreneurial universities?

All findings confirm the vision that conceptualise Entrepreneurial Universities as Stakeholders Universities, knowledge hubs and strategic orchestrators of processes of knowledge creation, absorption, transfer and dissemination as knowledge and research. The KM processes within the Entrepreneurial Universities are the result of a complex management of several knowledge assets (scientific output, publications, competence, research, technologies) coming from a distributed network of public-private stakeholders (Margherita and Secundo, 2011; Philpott et al., 2011; Romano et al., 2014; Etzkowitz, 2016; Maas and Jones, 2017) including faculty, staff, students, alumni, industries, managers, but also citizens and entrepreneurs all involved in the knowledge creating and disseminating processes typical of the innovation mission of the University so resulting in new regional innovative capabilities (Benneworth et al., 2009).

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Guest editorial
References


Further reading

Knowledge management in entrepreneurial universities

A structured literature review and avenue for future research agenda

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Abstract

Purpose – The purpose of this paper is to review and critique the knowledge management (KM) literature within entrepreneurial universities, providing an overview of the state of research and outlining a future research agenda.

Design/methodology/approach – In a systematic literature review, 1106 articles indexed at Scopus were initially submitted to a bibliometric analysis. Finally, 150 papers published in a variety of academic journals specializing in the field of Entrepreneurship, KM and Higher Education were analyzed through a content and a bibliometric analysis to minimize mistakes in interpreting findings of collected studies.

Findings – KM within entrepreneurial university is a research area of growing importance. Findings show that literature on KM models and tools in the entrepreneurial university is fragmented and dominated by unrelated research. Content analysis shows heterogeneous literature, but four major research streams emerge: knowledge transfer in university–industry collaboration; knowledge creation in entrepreneurship education; KM processes for university spin-offs; entrepreneurial university to support knowledge-based regional development. The results show a failure to address the implications of findings for policy makers, which risks making KM in entrepreneurial universities research irrelevant.

Research limitations/implications – Although different structured literature reviews (SLRs) exist separately in the field of KM and entrepreneurial universities, to the authors’ best knowledge, no studies exist in the intersection between the two fields.

Originality/value – The paper presents the first attempt to provide a comprehensive SLR of the articles dealing with models and processes of KM in the entrepreneurial university. Despite the increasing literature, this research area is still fragmented and undertheorized, thus requiring more systematic and holistic studies, considering both the economic and the social aspects of KM within universities. The paper’s findings can offer insights into future research avenues.

Keywords Knowledge transfer, Spin-offs, Knowledge management, Structured literature review, Technology transfer, Entrepreneurial universities, Third mission

Paper type Literature review

1. Introduction

Historically, the development of universities has been closely related to the growth of economy and society and the university’s mission evolved during the centuries to respond to changing societal needs (Paleari et al., 2015). Extant studies demonstrate that universities in developed countries have become increasingly entrepreneurial (Mowery et al., 2015; Siegel, 2006; Miller et al., 2018). Starting in the late ‘80s, academics and policy makers have coined the term “entrepreneurial university” (Etzkowitz, 1983; Clark, 1998; Röpke, 1998; O’Shea et al., 2005; Guerrero et al., 2006, 2018; Philpott et al., 2011; Etzkowitz, 2016) to describe universities that perform effectively their “third mission” contributing to the regional economic and cultural growth (Clark, 1998; Etzkowitz, 2000; Secundo et al., 2017).

In this context, the entrepreneurial university plays an important role as both a knowledge-producer and a disseminating institution (Guerrero and Urbano, 2012). To delimit the university activities involved in this “third mission,” the E3M (2010) has grouped them into three dimensions: technology transfer and innovation, continuing education, and
social engagement. Due to these dimensions, entrepreneurial universities are beginning to be seen as knowledge hubs and strategic orchestrators of processes of knowledge creation, absorption, transfer and dissemination defined as KM processes in entrepreneurial university. The KM processes are the result of a complex and distributed network of public–private stakeholders (Margherita and Secundo, 2011; Philpott et al., 2011; Etzkowitz, 2016; Maas and Jones, 2017) including faculty, staff, students, alumni, industries and managers, but also citizens and entrepreneurs all involved in the knowledge creating and disseminating processes typical of the university’s innovation mission (Etzkowitz, 2000; Vorley and Nelles, 2008).

In this vein, Mode 3 of knowledge production system has been defined by Carayannis and Campbell (2012) as the result of the reconceptualization of traditional knowledge production processes used by universities in responding to their traditional missions. Mode 3 is focused on learning and knowledge dynamics activated in local and global ecosystems facilitating the dissemination of creation, application and exploitation of knowledge and technology (Leydesdorff and Meyer 2006; Romano et al., 2014). As Mode 3 of the knowledge production system has gained acceptance, universities have invested many resources in supporting and increasing the transfer of scientific knowledge from academics to society, by analyzing their capacity to transfer knowledge through contracts with firms, to create university spin-offs (USOs), to patent and license and, in general, to generate, use, apply and exploit their knowledge base (Molas-Gallart et al., 2002). These perspectives have been mostly based on the belief that knowledge management (KM) is applicable not only in industrial and corporate organizations, but also in academia (Tian et al., 2009).

Moving from the definition of KM as any systematic process by which knowledge needed for an organization to succeed is created, captured, shared and leveraged (Rowley, 2000; Brewer and Brewer, 2010), KM in academia is any systematic activity related to support and enhancement of the creation of scientific knowledge and achievement of research goals, including both social process and relevant KM technology tools (Tian et al., 2009). Leveraging on the contributions of all the university’s stakeholders (faculty, staff, alumni, students, governance board) and enabling virtuous processes of knowledge exchange from the inside and outside of the organization, KM has a demonstrated impact on the sustainability, from the economic, environmental and societal perspective. This definition of KM processes in entrepreneurial universities represents our research’s unit of analysis.

KM in the public sector presents specific challenges due to specific organizational characteristics (Massaro et al., 2015) as compared to the traditional organizations. There are fewer studies focusing on public sector KM than those focusing on KM in the private sector (Oluikpe, 2012, p. 875; Ringel-Bickelmaier and Ringel, 2010, p. 524) although “KM initiatives have always been integrated in government tasks, inseparable from strategy, planning, consultation, and implementation” (Riege and Lindsay, 2006, p. 24). Entrepreneurial universities, belonging to the public sector, have specific labor divisions that are a disincentive to knowledge sharing. “This situation makes knowledge delivery in the public sector more difficult than that in the private sector” (Gau, 2011, p. 2). Despite KM’s evident implications in the context of entrepreneurial universities, its meaning and implementation is still under-researched and analyzed from fragmented perspectives focused on specific dimensions of the phenomenon, such as technology transfer, public–private collaborations and academic spin-offs.

The comprehension of models, processes and tools supporting KM strategies in the context of entrepreneurial universities discloses areas of further investigation where it is identified as a recognized lever for promoting innovation, cultural change and sustainable growth (Robinson et al., 2006; López-Morales et al., 2015; Centobelli et al., 2017). Therefore, studying KM in the entrepreneurial universities requires a separate research agenda from KM in public sector. This motivates the need for our study.
Accordingly, the need for comprehending its dynamics and boundaries becomes mandatory. This is the main motivation at the basis of the structured literature review (SLR) presented in this paper as contribution for the special issue. Although SLR about KM and entrepreneurial universities exist separately, such as understanding KM (Kakabadse et al., 2003; Anand and Singh, 2011; Serenko and Bontis, 2004; Mariano and Awazu, 2016), KM in the public sector (Massaro et al., 2015), KM in SMEs (small and medium enterprises) (Durst and Runar Edvardsson, 2012), university entrepreneurship (Rothaermel et al., 2007) university and technology transfer (O’Shea et al., 2004), academic engagement and commercialization (Perkmann et al., 2013), to our best knowledge, no SLR exists with reference to the intersection between KM in entrepreneurial university. According to Massaro et al. (2016), an SLR “is not the end of the road, but the beginning of new journeys.”

Additionally, the study calls to develop research to better understand the meaning of KM as the most used process enabling the transition of universities toward more entrepreneurial models. Interestingly, the findings show the focus of the extant literature primarily on four research areas: knowledge transfer in university–industry collaboration; knowledge creation in entrepreneurship education; KM processes for university’s spin-offs; and entrepreneurial university to support knowledge-based regional development. These results highlight the partial comprehension of the phenomenon observed and are a useful baseline for implications for practitioners and academics about the main evolution of strategic KM within entrepreneurial universities, providing some insights about future research needs.

The manuscript aims to identify emerging trends in the literature on KM and entrepreneurial universities by highlighting associated strategic and operational features. Additionally, the paper is aimed to identifying lessons learned and research gaps, and by this to provide an agenda for future research studies.

The remainder of the paper is structured as follows: after the introduction, in Section 2 the methodology is illustrated. Section 3 presents the review’s findings in terms of descriptive statistics and content analysis. Conclusions and implications are detailed in the final sections.

2. Methodology

This paper is based on a SLR as described by Massaro et al. (2016). It has been argued that an SLR is a rigorous and relevant approach that produces knowledge, contributes to identifying research trends and paths, as well as potential future research (Massaro et al., 2016; Petticrew and Roberts, 2006; Tranfield et al., 2003). An “SLR offers an empirical grounding that avoids missing seminal articles and reduces researcher bias” (Tranfield et al., 2003, p. 209). The paper also extends the SLR approach through the use of keyword and content analysis (McCulloh et al., 2013; Ribière and Walter, 2013) and the inclusion of more detailed content-driven analysis to develop findings. Recently, SLR are evolving thanks to the wide availability of academic articles and go beyond purely synthesizing and deducing prior contributions (Massaro et al., 2016).

To identify articles relevant to the literature review in this paper, we followed the approach suggested by previous studies (Dumay and Cai, 2014; Massaro et al., 2015). A number of steps have been followed to perform a systematic, transparent and replicable study (Christoffersen, 2013; Thorpe et al., 2005). Specifically, this study follows five steps:

1. define the research questions;
2. write a research protocol for the review;
3. determine the articles to include and carry out a comprehensive literature search;
4. develop a coding framework; and
5. critically analyze and discuss the results.
Following Massaro et al. (2016), the first step for performing an SLR is to define the research questions related to how the literature has developed, what is the focus and what are the implications. Therefore, the research questions in this paper are as follows:

**RQ1.** How is the KM for entrepreneurial universities literature developing?

**RQ2.** What is the focus of the literature within KM for entrepreneurial universities?

**RQ3.** What are the implications for the research?

Afterwards, the research protocol was established to determine the source of information, the methods to use, the studies to analyze and the means and tools for analyzing and synthesizing these studies (Petticrew and Roberts, 2008). It was chosen to perform both a SLR and a bibliometric analysis to minimize mistakes in interpreting findings of collected studies. Several authors, such as Feng et al. (2017) and Fahimnia et al. (2015) proposed crossing these two methods to enhance the value of the resulting findings. Specifically, these articles both state that sometimes SLR and bibliometric analysis lead the researcher to different findings. Therefore, by crossing the two analyses, this paper aims to find an intersection area between SLR and bibliometric analysis.

For article selection, we focused on the Scopus database. This choice was based on the previous research arguments widely contending that the use of the Scopus database for an article search provides wider coverage of academic journals. This is because it comprises over 20,000 peer-reviewed journals (Mishra et al., 2017) and more ample than web of science (WoS) (Thelwall, 2018). Moreover, nearly 97 percent of papers indexed in WoS are also enclosed in Scopus (Waltman, 2016). Consequently, the use of the Scopus database is one of the most appropriate data warehouses for literature review studies.

The search string used for searching articles useful for inclusion in this study was first identified by querying a set of relevant keywords. The keywords and combinations identified and used for the article search were KM and “entrepreneurial university*” OR “stakeholder university,” in the title, abstract, author keywords, author(s), number of citations, year, affiliations, source and document type. This way of searching articles results to be reproducible, comprehensive and unbiased. As a first result, a total of 1,106 articles were retrieved. Data were collected in September 2018–October 2018.

One criterion was to consider only journal articles published up to 2018 (inclusive), excluding conferences, book chapters, research notes, editorials and commentaries, (Keupp et al., 2012).

For a more comprehensive and useful set of articles, we also delineated inclusion and exclusion criteria. By following the diagram proposed by Vlaanderen et al. (2018), Figure 1 summarizes the data collection work flow. After our consideration for paper exclusion, resulting works span the timeframe 2001–2018.

To identify relevant articles, three researchers have been employed in reading abstracts and article titles. When just the concept of KM or entrepreneurial university was separately included in the abstract, the paper was eliminated from the sample. This first exclusion criterion reduced the initial number of articles (1,106) to 206 (Figure 1). Additionally, we also

![Figure 1. Steps for data collection](image-url)
excluded from the sample those articles that do not consider simultaneously KM and entrepreneurial university. Therefore, 56 other articles have been excluded, and we maintained 150 articles in the study for further analysis (Figure 1).

The next step consisted of developing the coding framework based on similar research frameworks. In this paper, we defined five categories for coding the articles, as follows:

1. Time evolution: number of articles published over time.
2. Geography of articles: article distribution among countries.
3. Journals: the distribution of papers among journals and citations received.
4. Author and citations analysis: number of citations, citations per year (CPY), citations and collaborations among authors.
5. Common keywords and focus topics: the type and frequency of keywords used and the emergent topic areas.

The aim of this coding framework was to analyze the state of the art of the literature, its evolution in time and its impact. We used as metrics for measuring the impact the citation index approach and the CPY as suggested by Dumay (2014), as well as citations and collaborations among authors. As for the keywords analysis, we used the author keywords occurrences to identify those most relevant and used. Another relevant coding category consisted of the distribution of articles among countries, aiming to underline how literature supports the development of a scientific discourse within specific national settings (Massaro et al., 2015).

According to Stanley (2001, p. 135), "after reducing the sample of studies to those that contain some relevant empirical estimate, test or finding, the next step is to identify important characteristics of the studies and to code them." Articles were coded manually by three of the authors using other research team members to solve discrepancies in coding. Manual codes were checked using text search queries to increase the validity of the results. Following the coding, data were analyzed to deliver insights and critiques.

To undertake such analyses, we used VOSviewer, a tool for constructing and visualizing bibliometric networks and clusters (Van Eck and Waltman, 2014). These outputs include journals, authors or individual publications and can be built up based on co-authorship, co-occurrence (keywords), citation, co-citation and bibliographic matching.

After processing the data set by excluding articles not falling into our research goals, we went back to Scopus database to select the identified articles again. This stage was needed because VOSviewer runs for csv data set from Scopus without managing it with any other format (xls, ods, etc.).

Thus, data were processed by following different techniques (van Eck and Waltman, 2017):

1. Co-authorship – the articles’ pertinence is assessed based on the number of co-authored documents. Unit of analysis: authors. We set the software to consider authors with two articles at least.

2. Co-occurrence (Eck and Waltman, 2009) – the articles’ pertinence is assessed based on the number of articles in which they occur together. Unit of analysis: author keywords. We set the software to consider articles in which keywords occur at least three times.

3. Bibliographic pairing (Kessler, 1963) – the articles’ pertinence is based on the number of references they share (Boyack and Klavans, 2010). Unit of analysis.
   - Documents: the pertinence is assessed by considering the articles that mainly share the same references. If so, they cluster. Each cluster shows a single paper number that may mark a specific topic/approach. We set the software to consider articles with 20 citations at least.
• Source: the pertinence is assessed considering the journals that mainly share the same references on the researched topic. If so, they cluster. Each cluster depicts a number of journals that published works in which some issues are common or are faced in the same way. We set the software to consider a journal with two documents at least.

For all these analyses by VOSviewer, fractional counting was used (Leydesdorff and Opthof, 2010). In doing that, the clustering technique is already set as appropriate for bibliometric analysis by VOSviewer developers (Van Eck and Waltman, 2014). Clustering refers to distances between nodes, and the groups are determined by minimizing such distances. This is only the point of departure of the well-explained clustering process (Waltman et al., 2010). Additionally, a networking technique is presented (Newman, 2004). Finally, a content analysis was conducted with the aim of comprehending the emerging trends, research gaps as well as future directions. In the next section, the main findings are presented and discussed.

3. Research findings: insights and critique

This section aims to present the results obtained from the analysis that answer the first two research questions of this study: RQ1 and RQ2. Accordingly, this section is organized into two main parts: the descriptive and the content analysis.

3.1 Descriptive analysis

Following the coding framework, this section explores articles by evolution on time, geographic distribution, author and citation analysis, journals, common keywords of the articles and focus topics.

The figures and tables that follow (Figure 2–Figure 7) present the main evidence resulting from the SLR and offer a comprehensive reading of the trends characterizing the advancement of the debate on KM and entrepreneurial universities from 2001 to 2018.

3.1.1 Articles’ evolution in time. The trend of the research papers developed over the years is depicted in Figure 2. As noted, there is a growing interest by scholars and researchers in the investigation of research topics at the intersection of the debates on KM and entrepreneurial universities until 2008 and a relative stable trend until 2013. In the years that follow, a sustained rate of growth can be observed until 2016, and while in 2017 the trend registered a meaningful reduction, the 2018 in its first 10 months presents a positive recovery. The peak year for relevant publications in these journals was 2008 followed by 2018. This means that...
the relationship between KM and entrepreneurial universities reached the maximum in 2008 and after some years of decrement, reached again a new peak in 2018. The first paper, published in 2001 by Henry Etzkowitz ("The second academic revolution and the rise of entrepreneurial science," published in *IEEE Technology and Society Magazine*) provides a first attempt to connect the importance of KM with the evolution of university toward a model with entrepreneurial configuration.

3.1.2 Geography of articles. The result of the analysis (see Figure 3) in terms of geographical distribution of the articles revealed that countries with the highest number of articles are the UK and USA, with 37 and 23 articles, respectively. These countries are followed by Spain (15), Italy (13) and Germany (9). It is possible to note a relevant interest for the topics in the European area with publications realized by a scientific community of scholars that shapes from northern to southern European countries. Although the numbers of papers in some countries are low, the bar chart also allows to derive nucleus of interest at global level, with the inclusion of emerging countries such as India, Uganda and Ghana.

---

**Figure 3.** Number of articles per country
Considering the different countries’ citation trend (Figure 4), it could be easily noticed that the contributions offered by the countries with higher productivity, such as the UK and USA, are more cited as well. On the other hand, analyzing the citations provides a different position of countries (compared to that of Figure 3): e.g. Italy, rising from fourth place for production to third place for the citations received; meanwhile, Australia, goes up to fifth place from the seventh in the previous figure.

3.1.3 Journals. Regarding the journals where the analyzed articles have been published, Table I provides the list of the top 15 journals by number of papers published. The most frequently used journal for KM in entrepreneurial universities publications is the *Journal of Technology Transfer* (with 17 articles) followed by *Research Policy*, which is home to ten articles. Other journals, where concentrations of KM articles on entrepreneurial university exist, are Technological Forecasting and Social Change (five article), *Technovation* (three articles), *International Journal of Technology Management* (five article).

However, it is worth discerning that only 14 journals out of 100 have published more than one article related to the theme. The rest of the journals publish just one article, in some cases with a high number of citations (*Journal of Engineering and Technology Management*, with one article and 341 citations) and in other cases with few or 0 citations. This could be easily noticed from Table II, which presents the top 15 journal by number of citations.

Table II also provides evidence of the top journals by number of citations. With reference to the citations’ trend, it is also evident that the *Research Policy Journal* is the most cited (with 870 citations), followed by *Technology Transfer* journal (with 341 citations). Therefore,
these two journals have the highest specialization in terms of KM in entrepreneurial universities, both in terms of number of publication and citations received, thus capturing greater interest from other researchers.

It is also interesting to observe the citations received by journals that have published a single related article. In fact, 11 out of 15 journals that have published a single article, gaining a large number of citations (341 and 324, respectively for one article published in Journal of Engineering and Technology Management and Journal of High Technology Management Research). These findings are useful to identify the most cited author/s and papers (see Table III).

The analysis performed here demonstrates that there is a high fragmentation of the research in the exploration of topics of KM in entrepreneurial universities, and also the lack of structured and mature research on the field.

### 3.2 Citations and most influential authors

The chart in Figure 5 depicts the relevance of the research developed by considering the number of the citations and presents a very jagged trend. It is possible to note a certain

<table>
<thead>
<tr>
<th>Journal</th>
<th>Number of records</th>
<th>Total cit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal of Technology Transfer</td>
<td>17</td>
<td>364</td>
</tr>
<tr>
<td>Research Policy</td>
<td>10</td>
<td>870</td>
</tr>
<tr>
<td>Technological Forecasting and Social Change</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>International Journal of Sustainability in Higher Education</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Industry and Higher Education</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Technovation</td>
<td>3</td>
<td>92</td>
</tr>
<tr>
<td>Journal of Cleaner Production</td>
<td>3</td>
<td>52</td>
</tr>
<tr>
<td>Education and Training</td>
<td>2</td>
<td>68</td>
</tr>
<tr>
<td>International Journal of Sustainability in Higher Education</td>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>Journal of Knowledge Management</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Studies in Higher Education</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>International Journal of Sustainability in Higher Education</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Sotsiologicheskie Issledovaniya</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>International Journal of Innovation Science</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Journal of Engineering and Technology Management – JET-M</td>
<td>1</td>
<td>341</td>
</tr>
</tbody>
</table>

Table I. Top 15 journal per number of records

<table>
<thead>
<tr>
<th>Journal</th>
<th>Number of records</th>
<th>Total cit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Policy</td>
<td>10</td>
<td>870</td>
</tr>
<tr>
<td>Journal of Technology Transfer</td>
<td>17</td>
<td>364</td>
</tr>
<tr>
<td>Journal of Engineering and Technology Management – JET-M</td>
<td>1</td>
<td>341</td>
</tr>
<tr>
<td>Journal of High Technology Management Research</td>
<td>1</td>
<td>324</td>
</tr>
<tr>
<td>Education + Training</td>
<td>1</td>
<td>136</td>
</tr>
<tr>
<td>Higher Education Research and Development</td>
<td>1</td>
<td>106</td>
</tr>
<tr>
<td>Technovation</td>
<td>3</td>
<td>92</td>
</tr>
<tr>
<td>IEEE Technology and Society Magazine</td>
<td>1</td>
<td>92</td>
</tr>
<tr>
<td>Journal of Management Studies</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Journal of Product Innovation Management</td>
<td>1</td>
<td>72</td>
</tr>
<tr>
<td>Education and Training</td>
<td>2</td>
<td>68</td>
</tr>
<tr>
<td>International Journal of Sustainability in Higher Education</td>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>Entrepreneurship: Theory and Practice</td>
<td>1</td>
<td>59</td>
</tr>
<tr>
<td>Journal of Visual Languages and Competing</td>
<td>1</td>
<td>53</td>
</tr>
<tr>
<td>Journal of Cleaner Production</td>
<td>3</td>
<td>52</td>
</tr>
</tbody>
</table>

Table II. Top 15 journals per number per citations
parallelism with the trend in the number of papers published, specifically concerning the years during which the interest in the two topics was highest (2003, 2004, 2008, 2009) as well as for the years of lowest interest (2005, 2013).

The value of citations for 2004, the highest registered in the period observed (as showed in Table III), allows positive recognition of the first works also in the papers that followed. This circumstance allows clearly understanding how the scientific community became interested to the exploration of KM topics in the context of entrepreneurial universities referred to seminal works of 2003, 2004, 2008, 2009 and 2015 in their new contributions.

The trends characterizing the number of citations received by each paper, as described in Table III demonstrate the relevance of the papers published in the first period, and specifically in 2001, 2003 and 2004, consolidated into the community of interested scholars.

Figure 6 presents the citations’ trends associated with the papers by year. The bar chart depicts a trend that is similar to the evidence highlighted in Table III and related to the advancement of productivity of papers; in the period with the largest number of works published, there is a direct implication in terms of citations’ growth.

Regarding the most cited authors and papers, Table IV discerns the rate of total citations and the relative CPY for the first ten most cited authors. Siegel D.S., Waldman D.A., Atwater L.E. and Link A.N. with two papers in (2004) and (2003) are the most cited authors.
Furthermore, the citation analysis reveals that the other top ten authors stand more or less on the same interval of citations (100–200 citations). To better evaluate the authors' citation trend, it is relevant to consider the CPY. It has been argued that having a large number of published articles decreases the CPY value (Massaro et al., 2015). In addition, articles published in recent years “have not had sufficient time to garner citations” (Dumay, 2014, p. 22). Also regarding CPY, Siegel et al. (2004) has the most cited paper. Our analyses reveal that the papers with the highest CPY are those published in 2003 and 2004, corresponding to earlier years of contribution on the theme of entrepreneurial universities and KM. Interestingly, the maximum CPY is 24.36, while the minimum CPY of the ten most cited is 5.41, showing a low level of CPY in general as well as wide differences among values that are five times lower than the most cited one.

These results suggest that prospective authors who want to publish on these topics should “think carefully about how their research is transformational […]” (Dumay, 2014, p. 20), and not only consider popular research frameworks and methods already utilized in previous research, but also propose new ones.

3.3 Topics and common keywords
This section defines the main keywords covered by the 150 articles analyzed. Keywords are used by authors, editors and publishers to signal important themes in articles. According to Silverman (2013, p. 275), keyword analysis “is a method that allows you to analyze very large amounts of text without losing touch with focusing on small amounts of the material in considerable depth.” In this paper, keywords are classified and analyzed through a social network analysis. Meanwhile, Booker et al. (2008, p. 240), argues that “practitioners search for articles based on topics or keywords as they are needed.” Similar to the study performed by Ribière and Walter (2013), keywords were extracted from the articles and a dictionary of terms was created by aggregating similar keywords (e.g. “entrepreneurial university,” “academic entrepreneurship” “university entrepreneurship” are all connected with the “university” dimension). Table V presents the occurrences of different keywords found in our sample that appear simultaneously at least three times, as well as the interrelationship and networking among them.

This analysis reveals that knowledge transfer is the most recurrent keyword (14 times) followed by technology transfer, academic entrepreneurship and entrepreneurial university.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Year</th>
<th>Source title</th>
<th>Cited by</th>
<th>CPY</th>
<th>Ranking CPY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siegel D.S., Waldman D.A., Atwater L.E., Link A.N.</td>
<td>Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies</td>
<td>2004</td>
<td><em>Journal of Engineering and Technology Management – JET-M</em></td>
<td>341</td>
<td>24.36</td>
<td>1</td>
</tr>
<tr>
<td>Bramwell A., Wolfe D.A.</td>
<td>Universities and regional economic development: the entrepreneurial University of Waterloo</td>
<td>2008</td>
<td>Research Policy</td>
<td>175</td>
<td>17.5</td>
<td>3</td>
</tr>
<tr>
<td>Lam A.</td>
<td>What motivates academic scientists to engage in research commercialization: “Gold,” “ribbon” or “puzzle”?</td>
<td>2011</td>
<td><em>Research Policy</em></td>
<td>118</td>
<td>16.85</td>
<td>4</td>
</tr>
<tr>
<td>Green W., Hammer S., Star C.</td>
<td>Facing up to the challenge: why is it so hard to develop graduate attributes?</td>
<td>2009</td>
<td><em>Higher Education Research and Development</em></td>
<td>106</td>
<td>11.78</td>
<td>7</td>
</tr>
<tr>
<td>Jones C., English J.</td>
<td>A contemporary approach to entrepreneurship education</td>
<td>2004</td>
<td><em>Education + Training</em></td>
<td>136</td>
<td>9.71</td>
<td>9</td>
</tr>
<tr>
<td>Etzkowitz H.</td>
<td>The second academic revolution and the rise of entrepreneurial science</td>
<td>2001</td>
<td><em>IEEE Technology and Society Magazine</em></td>
<td>92</td>
<td>5.41</td>
<td>10</td>
</tr>
</tbody>
</table>
These findings are interesting as they indicate how the most recurrent knowledge process considered in the studies related to KM and entrepreneurial university is the process of transferring knowledge, and to a lesser extent to other types of KM processes.

This is aligned with the main literature on entrepreneurial universities that mostly focuses on analyzing the capability to transfer knowledge from academics to society knowledge transfer through different ways (Secundo et al., 2017; Molas-Gallart et al., 2002).

Interestingly, analyzing the clustering of the keywords, the results show four main clusters as depicted in Figure 7. The size of the spheres in Figure 7 represents their relative importance (larger circles have connections to more articles) calculated using the degree centrality measure. As argued by McCulloh et al. (2013) the degree centrality specifies the agents with the major number of direct links to and from other agents.

<table>
<thead>
<tr>
<th>Cluster 1 (10 items)</th>
<th>Keywords</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic entrepreneurship</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Commercialization</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial universities</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Knowledge exchange</td>
<td>4</td>
<td></td>
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<tr>
<td>Knowledge transfer</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Technology transfer</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Third mission</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>University–Industry collaboration</td>
<td>3</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Cluster 2 (8 items)</th>
<th>Keywords</th>
<th>Occurrences</th>
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<tbody>
<tr>
<td>Business schools</td>
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<tr>
<td>Education</td>
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<td></td>
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<tr>
<td>Entrepreneurialism</td>
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<tr>
<td>Higher education</td>
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<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>4</td>
<td></td>
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<tr>
<td>Research</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Stakeholders</td>
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<td></td>
</tr>
<tr>
<td>Universities</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Universities</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cluster 3 (4 items)</th>
<th>Keywords</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurship</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Knowledge management</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Networking</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>University technology transfer</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cluster 4 (3 items)</th>
<th>Keywords</th>
<th>Occurrences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurial university</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurship education</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Experiential learning</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Table V. Keywords occurrences

3.4 Clustering and content analysis

The content analysis phase was conducted starting from the bibliographic matching (Kessler, 1963) using the 150 papers included in the data sample. As explained in the methodological section, the units of analysis were documents and sources, and the pertinence is evaluated by considering the articles that mainly share the same references (Boyack and Klavans, 2010). The result of this analysis produced seven clusters and 29 papers (as only papers with 20 citations at least are considered). We considered this clustering to avoid the fragmentation of results as well as the unpacking of same topic to different areas. The clusters considered bring together those articles that may mark a specific topic/approach. To guide the content analysis of the papers included in the sample, we performed the clustering algorithm proposed by (Van Eck and Waltman, 2014, 2017). The modularity class has been used to find network nodes that are more densely connected and identify clusters of papers (Figure 8, Table VI).
Figure 8 shows the clusters considering the strength of the closeness by considering the number of common bibliography entries appearing in the article. Therefore, the cluster technique of VOSviewer software works after running ten interactions.

Starting from bibliographic matching, four main research areas have been identified by carefully reading the 29 clustered papers, to synthesize the body of knowledge. The main research areas along with their focus, details and description are listed in Table VII as follows:

- Research Area 1: knowledge transfer in university–industry collaboration.
### Cluster 1
(8 items – red)

- **Bramwell and Wolfe (2008)**
  - Citations: 182
  - Title: Universities and regional economic development: the entrepreneurial University of Waterloo

- **Carayannis and Campbell (2011)**
  - Citations: 52
  - Title: Open innovation diplomacy and a 21st century fractal research, education and innovation (FREIE) ecosystem: building on the quadruple and quintuple helix innovation

- **Duberley et al. (2007)**
  - Citations: 23
  - Title: Entrepreneurial academics: developing scientific careers in changing university settings

- **Bridgman (2007)**
  - Citations: 20
  - Title: Freedom and autonomy in the university enterprise

- **Lam (2011)**
  - Citations: 121
  - Title: What motivates academic scientists to engage in research commercialization: “Gold,” “ribbon” or “puzzle”?

- **Lowe and Gonzalez-Brambila (2007)**
  - Citations: 80
  - Title: Faculty entrepreneurs and research productivity

- **Russo et al. (2007)**
  - Citations: 20
  - Title: Toward a sustainable relationship between City and university: a stakeholdership approach

- **Van Looy et al. (2004)**
  - Citations: 197
  - Title: Combining entrepreneurial and scientific performance in academia: toward a compounded and reciprocal Matthew effect?

### Cluster 2
(7 items – green)

- **Acworth (2008)**
  - Citations: 61
  - Title: University–industry engagement: the formation of the knowledge integration community (KIC) model at the Cambridge-MIT Institute

- **Guerrero et al. (2015)**
  - Citations: 70
  - Title: Economic impact of entrepreneurial universities’ activities: an exploratory study of the United Kingdom

- **Kalar and Antoncic (2015)**
  - Citations: 33
  - Title: The entrepreneurial university, academic activities and technology and knowledge transfer in four European countries

- **McAdam et al. (2012)**
  - Citations: 32
  - Title: The development of university technology transfer stakeholder relationships at a regional level: lessons for the future

- **Philbin (2008)**
  - Citations: 43
  - Title: Process model for university–industry research collaboration

- **Tijssen (2006)**
  - Citations: 55
  - Title: Universities and industrially relevant science: toward measurement models and indicators of entrepreneurial orientation

- **Van burg et al. (2008)**
  - Citations: 74
  - Title: Creating university spin-offs: a science-based design perspective

### Cluster 3
(4 items – blue)

- **Clarysse et al. (2011)**
  - Citations: 92
  - Title: Entrepreneurial origin, technological knowledge, and the Growth of Spin-off companies

- **Knockaert et al. (2011)**
  - Citations: 61
  - Title: The relationship between knowledge transfer, top management team composition, and performance: the case of science-based entrepreneurial firms

- **Krabel and Mueller (2009)**
  - Citations: 93
  - Title: What drives scientists to start their own company? An empirical investigation of Max Planck Society scientists

- **Wennberg et al. (2011)**
  - Citations: 103
  - Title: The effectiveness of university knowledge spillovers: performance differences between university spinoffs and corporate spinoffs

### Cluster 4
(4 items – yellow)

- **Bonardo et al. (2010)**
  - Citations: 53
  - Title: The M&A dynamics of European science-based entrepreneurial firms

- **Hannon et al. (2009)**
  - Citations: 24
  - Title: Exploring graduate entrepreneurship: a collaborative, co-learning based approach for students, entrepreneurs and educators

- **Gassol (2007)**
  - Citations: 20
  - Title: The effect of university culture and stakeholders’ perceptions on university–business linking activities

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**Table VI.**
Bibliographic coupling clusters

*continued*
3.4.1 Research Area 1. Knowledge transfer in university–industry collaboration arises as the most prominent area of specialization of the debate. In such area, contributions have been identified in terms of “models of knowledge transfer from university to firms” and “performance measurements in knowledge transfer.” Some of the most relevant contributions included into the first perspective are: Acworth (2008) that illustrate the role of knowledge integration community models to enhance university–industry links by providing a comprehensive and effective approach to a multidirectional process of knowledge sharing, which goes beyond traditional, unidirectional “knowledge transfers” from academia to industry; Siegel et al. (2004) that focus on identifying and analyzing the role of organizational practices in fostering and promoting successful university/industry technology transfers. In addition, Gassol (2007) analyzes the role and effects of university culture and structure on knowledge transfer activities that incur in the interactions between university and business. Kalar and Antoncic (2015) analyze the practices of knowledge sharing and transfer, occurring in a wide range of activities that go from more to less formal, such as business activity, collaboration, contract research, industry interactions, workshops or meetings and applied research from the point of view of academics’ perception. Rubin et al. (2015) analyze the role of universities as sources of new ideas for incubates and conclude that universities are especially relevant in later stages of incubators’ new product development processes. Other contributions focus on understanding the effectiveness of collaborative community–academic partnerships along with their characteristics as well as the common outcomes and influences on the collaboration process (Drahota et al., 2016).

A second perspective characterizes the area in terms of “performance measurements in knowledge transfer.” In such an area, Siegel et al. (2003) defined measures facilitating university–industry technology transfer for a more proactive exchange, the definition of targeted policy and funding, as well as joint mechanisms for a closer alignment of performance measurement, suggested as useful by McAdam et al. (2012). Tijssen (2006)
<table>
<thead>
<tr>
<th>Focus/Research area</th>
<th>Details</th>
<th>Authors and quotations</th>
</tr>
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<tbody>
<tr>
<td>Knowledge transfer in university--industry collaboration</td>
<td>Models of knowledge transfer from university to firms</td>
<td>“[...] collaborative entities, comprising academic researchers and educators, industry participants and government policy makers, are brought together to identify and pursue joint solutions to common problems [...]” (Acworth, 2008, p. 1242)</td>
</tr>
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<td></td>
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<td>“[...] social networks may be somewhat critical in UITT. These networks include academic and industry scientists, and perhaps, university administrators and TTO directors.” (Siegel et al., 2004 p. 136)</td>
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<td>“[...] the process development involves creating operational organizational structures within the university system in charge of organizing and coordinating the new business interacting role with the more traditional one that involves education and knowledge creation.” (Horowitz Gassol, 2007, p. 502)</td>
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<td>“[...] perceiving a university department as having a low or high entrepreneurial orientation may have an important effect on whether an academic would engage in some entrepreneurial activities, but a negligible effect on whether an academic would engage in more traditional activities.” (Kalar and Antoncic, 2015, p. 36)</td>
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<td>“[...] university becomes a modest source of ideas for the incubator but an important source for experts, infrastructure, consultants and employees.” (Rubin et al., 2015, p 21).</td>
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<td>“[...] Twenty-three facilitating and hindering factors influencing the CAP collaboration process emerged from the literature. Outcomes from the CAPs most often included developing or refining tangible products.” (Drahota et al., 2016, p. 164)</td>
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<td>“[...] it is indeed feasible to organize both scientific and entrepreneurial activities, without one jeopardizing the other. The observation that there is not necessarily a contradiction between both activities, does not exclude the possibility that there may be boundaries limiting the way in which “capital” is transferred between different realms” (Van Looy et al., 2004, p. 439)</td>
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<tr>
<td>Performance measurements in Knowledge transfer</td>
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<td>“[...] measures that firms can adopt to facilitate UITT (university–industry technology transfer) These include being proactive in their efforts to bridge the cultural gap with academia through frequent meetings and workshops with universities, hiring technology managers who know how to work with universities, and using the labor market to tap into UITT social networks” (Siegel et al., 2003, p. 129)</td>
</tr>
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<td></td>
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<td>“[...] greater targeted policy and funding, based on the stakeholder relationship approach, led to the development of joint mechanisms and a closer alignment of performance measures” (McAdam et al., 2012, p. 57)</td>
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<td></td>
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<td>“[...] research cooperation intensity (RCI) and the corporate citation intensity (CCI) [...] indicate that both indicators are, at best, partial proxies of a university’s entrepreneurial orientation” (Tijssen, 2006, p. 1574)</td>
</tr>
<tr>
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<td>“[...] in order for both universities and companies to develop fruitful collaborations that are well aligned with their respective strategies, there would appear to be advantages in linking the strategic features of the new process model [...]” (Philbin, 2008, p. 512)</td>
</tr>
</tbody>
</table>

(continued)
Focus/Research area | Details | Authors and quotations
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processes and strategies | business schools, TTOs and science departments.” (Wright et al., 2009, p. 560) “[…] the underpinning paradigm to one derived from a humanist philosophy suggests a co-learning approach in which both learner and educator participate in the learning process. This paper highlights the need for innovation in the supply of entrepreneurship education in UK higher education institutions to enhance graduate entrepreneurship.” (Hannon et al., 2006, p. 11) “[…] the process and responsibility of learning has largely been reversed through the process of student centred learning. This method of learning represents a challenging departure from the traditional mainstream teaching practices.” (Jones and English, 2004, p. 416).

KM processes for university’s spin-offs | Drivers for the development of spin-offs | “[…] spin-outs in particular raise very distinct challenges for the individuals involved and, in the long-term, for universities’ and commercialisation as a possible way of realising the potential of their particular science. Science and commerce were viewed as neither necessarily incompatible, nor complementary.” (Duberley et al., 2007, p. 493)

Research commercialization | Tacit knowledge is most effectively transferred when a substantial part of the original research team joins the new venture as founders. Commercial expertise and mindset are also required in the team on the condition that the cognitive distance between the scientific researchers and the person responsible for commercialization is not too large.” (Knockaert et al., 2011, p. 777)

| “[…] personal attitudes toward commercialization and individual perception of science affect entrepreneurship by scientists is crucial in understanding the process of academic spin-offs […]. experience in joint research with firms in the industrial sector, prior entrepreneurial experience, and patenting experience are the major drivers for scientists to engage in entrepreneurial activity” (Krabel and Mueller, 2009, p. 954)

| “[…] Especially in corporate spin-offs, time to market seems to be a key source of competitive advantage. This is not so in university spin-offs, although the fact that technological knowledge can be codified and thus patented does not explain later growth of these companies.” (Clarysse et al., 2011, p. 1436)

| “[…] The commercial knowledge gained in industry is potentially more valuable for entrepreneurial performance compared to the academic knowledge gained by additional research experience at a university. This leads us to posit that the average performance of CSOs will be higher than comparable USOs, but the gains from founder’s prior experiences will be relatively higher among USOs whose founders lack the corporate context.” (Wennberg et al., 2011, p. 1128)

| “[…] university affiliation does influence the evolution of firms […] SBEFs (science based entrepreneurial firms) have a higher probability of being acquired and a lower propensity to make an acquisition” (Bonardo et al., 2010, p. 143)

| “[…] there are two fundamentally different phases in building capacity for university spinoff creation: first, an infrastructure for spinoff creation (e.g. including a collaborative network of investors, managers and advisors) is developed, that then enables support activities to individual spinoff ventures.” (Van Burg et al., 2008, p. 114)
<table>
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<th>Focus/Research area</th>
<th>Details</th>
<th>Authors and quotations</th>
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| Entrepreneurial university to support knowledge-based models for regional development | “[...] the great majority of the scientists are motivated by the traditional rewards of the “ribbon,” using commercial activities as a means to generate resources for their research and professional goals [...] the intrinsic satisfaction derived from commercial engagement itself, as in puzzle-solving, emerges as a central motivation shared by many of the scientists” (Lam, 2011, p. 1365)  
“[...]the university is recast as an enterprise within a competitive marketplace where the “entrepreneurial academic” who commercialize research become the role model.” (Bridgman, 2007, p. 478)  
“[...] universities could be a driving force for urban development, provided cities succeed in embedding knowledge in the local social and economic networks, which is seen to depend to a large extent on the balance in the process of exchange between the various stakeholders of higher education: students and academic communities, entrepreneurs, and local communities.” (Russo et al., 2007, p. 199)  
“[...] for the majority of the United Kingdom’s universities, research activities have contributed the most to economic growth. However, it is also interesting to note that the entrepreneurial activities of universities contribute strongly to economic development as well” (Guerrero et al., 2015, p. 756);  
“knowledge transfer mechanisms from universities are far more robust than the linear process of commercialization would suggest. The University of Waterloo stands out as a particularly successful instance of an entrepreneurial research university that is deeply engaged in the local high tech industrial community.” (Bramwell and Wolfe, 2008, p. 1186).  
“Faculty entrepreneurs are also much more likely to be high impact scientists, based on citations to their work, than their graduate school peers, co-authors, others on their university campus, and the population of faculty in general. (Lowe and Gonzalez-Brambila, 2007, p. 192)  
“[...] research outcomes at universities, research centers and institutes may be organized around a knowledge-based model [...] These serve the organization by disseminating knowledge assets, by solving economic and social needs in different regions, and by creating value for researchers and for the organization.” (Cantu et al., 2009, p. 154)  
“[...] The “mode 3” knowledge production is at the heart of the fractal research, education and innovation ecosystem” (Carayannis and Campbell, 2011, p. 327) |
suggested the need to adopt a set of indicators for the evaluation of universities’
entrepreneurial orientation while Philbin (2008) argued the need for new process models for
periodically verifying the sustainability of the underlying activities.

By shaping from theoretical to empirical contributions, the paper included in this first
research area coverage a large period that starts in 2003, with the work of Siegel et al., 2003,
until 2016 with the work of Drahota et al. This first thematic area, with its two related
perspectives, can be assumed as one of the most interesting for the community of scholars
and researchers in the field of KM and entrepreneurial university. Despite its relatively
mature configuration and the interest recalled throughout the period observed, the presence
of more recent papers, such as Kalar and Antoncic (2015), Rubin et al. (2015), Drahota et al.
(2016), highlights the need for continuing to update the related knowledge in terms of modes
and metrics for the knowledge transfer.

3.4.2 Research Area 2. Knowledge creation in entrepreneurship education with a specific
focus on the “entrepreneurially equipped students: processes and strategies” in terms of new
roles and configuration of business schools (Wright et al., 2009), co-learning processes and
innovation in the supply of entrepreneurship education (Hannon et al., 2005) is a more
student-centered teaching practice (Jones and English, 2004). This is coherent with that
done in recent years in higher education institutions where dedicated entrepreneurship
centers have been established with the aim to support a broad spectrum of learning and
research initiatives, providing funding for various educational programs as well as
supporting social community development (Maas and Jones, 2017). All this is in line with the
second dimension of the third university mission focused on continuing education for
developing entrepreneurial competences (E3M, 2010). The time of the papers included in this
research area is in the first period of the debate on KM and entrepreneurial university, and
specifically cover a timeline from 2004 (Jones and English, 2004) to 2009 (Wright et al., 2009).
This circumstance highlights the recognized value associated with the topics of
entrepreneurial knowledge creation in the entrepreneurial university with a focus on
entrepreneurial education in terms of knowledge flows (Wright et al., 2009) and emerging
approaches of entrepreneurial education (Hannon et al., 2005; Jones and English, 2004). In
the meantime, the need is indicated for an in-depth investigation more focused on the recent
trends, tools and dynamics of entrepreneurial learning and knowledge creation.

3.4.3 Research Area 3. A third area regards the KM processes for the universities spin-
offs, with two thematic perspectives related to the “drivers for the development of spin-offs”
and “research commercialization.” About the first, different trends arise in the
commercialization of tacit and explicit knowledge as well as incompatibility and non-
complementarity of science and commerce (Duberley et al., 2007), effectiveness of knowledge
transfers when a substantial part of the original research team joins the new venture as
founders (Knockaert et al., 2011). While Krabel and Mueller (2009) analyze the factors that
influence scientists’ entrepreneurial activity, highlighting the relevance of patenting
activity, entrepreneurial experience and personal opinions regarding the benefits of
commercializing research.

A second perspective can be identified around the issue of “research commercialization”
in terms of different expectations of growth and performance. It is worth mentioning here
the contribution of Bonardo et al. (2010) that analyzes the acquisition process of science-
based entrepreneurial firms by underlining the importance of such entrepreneurial firms for
the processes of knowledge creation, transfer and dissemination. Van Burg et al. (2008)
through a case study of a USO, analyzes the different phases for the entrepreneurial
development and enabling infrastructure. The contributions of Clarysse et al. (2011) and
Wennberg et al. (2011) focus on analyzing the differences between AOS (academic Spin-offs)
and CSO (corporate Spin-offs) on the performances achieved as well as in terms of different
commercial competitive knowledge assets gained by entrepreneurs and academics. Regarding the timing of the papers analyzed, this third area is more concentrated in a limited timeframe that starts in 2007 (Duberley et al., 2007; Bridgman, 2007) and ends in 2011 (Knockaert et al., 2011; Clarysse et al., 2011; Wennberg et al., 2011). Considering that currently the issue of university’s spin-offs also continues to have importance in the most recent political agendas of countries, mainly in the USA and EU, this area arises as one of the most promising for future studies and contributions.

3.4.4 Research Area 4. It comprises entrepreneurial university to support knowledge-based regional development, with thematic perspectives on “knowledge-based models for regional development” and “quadruple helix collaboration.” About the first, there is evidence for the roots of regional development driven by knowledge-based model in the study of Russo et al. (2007) that reflected on the role of universities as driving forces for urban development and as measurement of the universities’ impact for economic development (Guerrero et al., 2015). Bramwell and Wolfe (2008) discuss the different mechanisms of knowledge transfer through which universities can contribute to growth and innovation of local and regional economies. Meanwhile, Lowe and Gonzalez-Brambila (2007) focus on analyzing the role of faculty entrepreneurs by assessing their productivity performance in terms of knowledge creation as expressed in publications, licenses, etc.

Another perspective can be identified in the “quadruple helix collaboration,” one of the most important contributions is the article (Carayannis and Campbell, 2011) that focus on the “entrepreneurial university” approach to emphasize the relevance of diversity, heterogeneity, innovation and collaboration for addressing the current and future challenges. In the same line, Cantù et al. (2009) introduce a knowledge-based model that is rooted on the creation of an extended ecosystem that bring together university human and intellectual capital, products, funding and spin-offs, with the aim to provide economic development for territories.

Regarding the time distribution of the papers included in this fourth area, it is possible to note how the thematic characterization on the knowledge-based model for regional development belongs to a second generation of scholars and researchers in the field of KM and entrepreneurial university. Starting from the first papers of Russo et al. (2007) and Lowe and Gonzalez-Brambila (2007) until the most recent work of Guerrero et al. (2015), the thematic perspectives of knowledge-based models for regional development and quadruple helix collaboration have awakened the interest of scholars and researchers with theoretical and empirical contributions. Further investigation, contextualization and replication of the models belonging to this area can be identified as future foundations for the agenda of scholars and researchers.

4. Discussions and Implications
The aim of this section is to discuss and critique the main findings for answering RQ3. The answer to this question moves toward implications organized into the following sub-sections.

4.1 Implication 1: authors’ specialization on the topics, timing and individual contributions to the debate
In terms of authors’ contribution and focus on the identified areas, it is possible to highlight that many authors have contributed to the debate. Our analysis produced 150 papers that focus on the intersection of KM and entrepreneurial university. The exploration of phenomena covers a meaningful timeframe (from 2001, 18 years). In such a considerable period, however, productivity has been fragmented, with some positive choices in 2004, 2008 until becoming consistent in 2018. However, it is worth noting that the majority of contributions stand alone, dispersed among different journals. Just two journals published
ten or more papers; in all the other cases, there are fewer than five published articles. This trend is also confirmed by considering the citation results. In fact, the resulting CPY is low (max 24.36). This trend could be also explained through the limited number of international co-operations among authors, which is a recognized as a means to increase the number of citation impacts (Nomaler et al., 2013). All this does not allow identifying elements of a superstar effect, argued by Serenko et al. (2011), the circumstance in which a small number of authors have produced the majority of work. In coherence with the paper of Massaro et al. (2016), the analysis suggests some useful implications in terms of low barriers to entry, a related low specialization of the authors on the topics, a still-fragmented debate and in consequence the need for systematization work.

4.2 Implications 2: journal specializations and impact
The analysis about the publications’ venues has disclosed an interesting overview about the journals more focused on the topic as well as on their influence in terms of citations within a specialized community of scholars interested in. Journal of Technology Transfer presents the higher number of paper published, and it is second in terms of citations counted. This trend explains the most debated research area developed until now, the one related to knowledge and technology transfer in entrepreneurial university. Also keywords recurrences confirm such tendency, as the main keywords are knowledge transfer, technology transfer and entrepreneurial university. In terms of higher performances of citations on the number of published papers, it emerges that some relevant journals register a large number of citations with only one paper published (as is the case of Journal of Engineering and Technology Management and Journal of High Technology Management Research). In highlighting the coherence between the areas of interest of such journals with our topics, this analysis offers useful implications for future studies. On one hand, they may provide the root of a major consolidation of the debate on the outstanding journals identified or which may decide to explore new venues through thematic focuses. In all the cases, the active involvement of scholars and editors in a larger dissemination activity, also through the co-organization and sponsorship of thematic tracks within international conferences could be useful for increasing the impact and interest, as pointed by Massaro et al. (2016). Finally, it is possible to highlight that the collective scholarship on KM in entrepreneurial university has created a critical mass over the last 18 years that not only can provide guidance for policy makers and other practitioners, but it has also progressed and evolved to a point at which it is ready to be published in many of the premier academic journals. The time is right to move beyond a niche field into the mainstream of scholarly debate.

4.3 Implication 3: a future research agenda about KM in the entrepreneurial university area
The analysis conducted in terms of thematic clustering, content analysis and citations’ impact allow deriving some useful insights about the most relevant areas where the future research could be concentrated. Besides understanding the nature of KM within a generic context, this study focused on the role of the university as a typical knowledge generating organization within the public sector, where, in the last decades, the organizational models and activities are evolving toward more entrepreneurial configuration. The results of this SLR have progressively illuminated our knowledge of how best to manage the KM in the entrepreneurial universities, with a specific focus in the process of science-based entrepreneurial firms’ creation through the relationship among knowledge transfer, team composition and performance, (e.g. Knockaert et al., 2011), on the knowledge transfer from university to industry and on the impact of the entrepreneurial university in the regional development. Furthermore, more insights have been gained regarding the importance of innovative entrepreneurship education strategies to educate the next generation of student’s entrepreneurs so impacting on the entrepreneurial society. Additionally, our analysis has
disclosed useful insights on the evolutionary pattern characterizing the debate on KM in entrepreneurial universities. There is a relevant interest for empirical evidences and context-based analysis addressed by a limited number of topics. This highlights the need for more research in the under-investigated areas, contribution of synthesis and systematization in the more mature ones, and embracing different investigative approaches based on action research (Martincic and Dovey, 2011) or interventionist research (Dumay, 2010).

Accordingly, several suggestions can be developed with reference to the future research agenda. As Serenko and Dumay (2015, p. 417) state, the implications for future studies are that researchers “need to think seriously about how their future research will be interesting enough and make a significant contribution.” This is an interesting and current debate if compared with all the pressure universities are facing in terms of funding acquisitions, research projects, commercialization of their research and finally the development of their surrounding areas.

First, a relevant aspect to consider is the rapid acceleration of digital technologies reshaping markets and society globally (Nambisan, 2017) on academic entrepreneurship (Rippa and Secundo, 2018). Among the actors involved in these disruptive changes, universities are challenged in the way they pursue and interpret their threefold missions; e.g. education, research and “third mission” (Lombardi et al., 2019; Etzkowitz, 2016). As far as the latter is concerned, the impact of digital technologies needs to be investigated encompassing activities like research collaborations with industry, patent applications, transformation of innovative ideas in spin-offs, entrepreneurial education of highly skilled individuals, technology transfer or business incubators. A second research area requiring more research is related to the dissemination of entrepreneurship education outside the business school to cover all the university’s departments. Society requires people who are educated in the “sense of initiative and entrepreneurship” (EC, 2006). Third, another neglected aspect of managing knowledge in universities is the “collective” involvement of all the stakeholders contributing to achieving the third mission (Secundo et al., 2017) that moves from the assumption that considers a university as a collective intelligence system (Vargas et al., 2019) in which alternate processes of exploration and exploitation generate a twisting learning path (Centobelli et al., 2018). Finally, the comprehension of how knowledge flows from industry to university remains underdeveloped since the prominent studies in the field analyzed how the knowledge moves from academia to industry (Chedid and Teixeira, 2019).

Given the vibrant nature of research on entrepreneurial universities from one side and KM from the other side, future studies that address the dynamic and multifaceted aspects of the above-mentioned future research areas should be welcome in additions to this literature. This may also be another entry point for micro research studies trained in psychology and information technology, a group currently conspicuously absent from this research stream. Additionally, the temporal distribution of publications of the four thematic areas implicate the need to continuously investigate, actualize and update some relevant research areas that result to be of great interest. All this provides useful implications for the definition of future research contributions by scholars that could offer additional perspectives of investigations, also thanks to the involvement of a larger number of practitioners.

5. Conclusions and future research
In the conclusions of this study, it is important to recall its initial motivation, based on the argument that the entrepreneurial university represents a particular research context because of a different level of representativeness, accountability and responsiveness of different stakeholders, requiring focused studies about KM studies. Universities are now viewed as key economic actors within regions and are central actors in shaping and influencing entrepreneurial ecosystems. This has meant that universities now have to become more entrepreneurial in offerings, outlook and culture (Miller et al., 2018).
Universities develop strategies to fulfill their historic mission of teaching and research and they also undertake a significant role in producing, creating and disseminating new knowledge in today’s ever-changing world (Olcay and Bulu, 2017). Moreover, KM processes adopted universities to facilitate the dissemination of their knowledge and technology act as another channel to offer the research knowledge exploitable by external stakeholders (e.g. industry, government and society).

The debate on KM and entrepreneurial university has received growing attention during the last 18 years. Despite the two topics having been largely investigated, their intersection discloses several areas of in-depth study, highlighting a still-fragmented debate and so requiring holistic and integrated frameworks aimed at comprehending the relevance and implications of KM in the context of entrepreneurial universities. In motivating our research to embrace a SLR, we have focused our attention on articles published in entrepreneurship and higher education journals.

Despite the number of papers published on KM in entrepreneurial university in the period 2001–2018 having reached a consistent volume, the analysis of their meaning, dynamics and implementation is still dominated by unrelated research. Trends observed in terms of authors’ productivity, impact of their research in terms of citations, and their geographical areas has depicted a profile of a dispersed community of scholars and researchers, with limited collaboration and the presence of a limited number of authors really focused on the topics with outstanding performances. Despite this, the positive growth trends registered during 2018 is promising. In the same direction, the analysis of publications’ venues has allowed identifying a coherent correspondence between the journals’ thematic specialization and the scientific contributions published, although the need for consolidating the relevance of the issues of KM and entrepreneurial universities has been found with some useful implications in terms of co-authorship with foreign authors and new empirical contexts of explorations.

Content analysis performed in the paper has allowed identifying four main thematic clusters as main areas of specialization of the scientific debate, with related sub areas. We categorize the main areas as: knowledge transfer in university–industry collaboration (focus on “models of knowledge transfer from university to firms” and “performance measurements in knowledge transfer”), knowledge creation in entrepreneurship education (focus on the “entrepreneurially equipped students: processes and strategies”), KM processes for the university spin-offs (focus on “drivers for the development of spin-offs” and “research commercialization”), and entrepreneurial university to support knowledge-based regional development (focus on “knowledge-based models for regional development” and “quadruple helix collaboration”). The analysis of papers included in these areas allowed deriving a more robust awareness on the state of art for the debate on KM and entrepreneurial university in terms of conceptual and organizational models, causal mechanisms of functioning, tools and performance metrics, and impact on regional development. Furthermore, the analysis of the time distribution of papers clustered into the four research areas has also offered additional implications for future studies in terms of continuous updating, areas of renewed interest and longitudinal investigations. All findings confirm the vision of Benneworth et al. (2009) that conceptualize universities as knowledge explorers, being one of the two sub-systems of regional innovation systems in which firms form the other sub-system, e.g. the knowledge exploiters, complementing and interacting with universities, resulting in new regional innovative capabilities.

Following the main themes being explored in the literature, some additional future research areas have been put forth, focusing on:

- impact of digital technologies encompassing activities of an entrepreneurial university;
- dissemination of entrepreneurship education outside the business school to cover all the universities’ departments;
• collective involvement of all universities’ stakeholders contributing to achieving their third mission;
• knowledge flows from industry to university;
• analysis of the entrepreneurial universities from multidisciplinary perspectives (e.g. psychology and arts, sociology, Information technology, etc.);
• emerging trends characterizing knowledge transfer in university–industry collaboration;
• smart technologies and strategies of knowledge creation in entrepreneurship education;
• the digital transformation of universities KM processes;
• the role of digital technologies for involving all the university’s stakeholders;
• cross-countries analysis of KM processes for the universities spin-offs; and
• best practices and empirical evidence on entrepreneurial universities in quadruple helix.

The exploration of such issues, through theoretical and empirical contributions, aims to overcome the limitations that still characterize the debate on KM in the context of entrepreneurial universities, and can allow achieving a major comprehension of the meaning and implications of KM in the context of entrepreneurial universities through holistic and multidisciplinary bases, to consolidate and increase the scientific background of a community of scholars and researchers specialized in such topics, and to identify unexplored and promising roots for scientific and practical speculations.

Some limitations can be identified in the nature of journals analyzed as well as the database selected. As authors, we are aware that this could represent a limitation since we cannot assume that valuable research related to our topics could have been published on different venues not listed in our database. Second, the validity of the evidence collected is limited to the timeframe considered. Third, as every beginning of a new journey (Massaro et al., 2016), a SLR is relevant for the contribution of inspiration more than for the state of the art it is able to provide. Accordingly, we hope this work contributes to identifying lacks in the debate on KM and entrepreneurial university and providing inspiration for the future works of scholars and practitioners interested in the advancement of such promising future research areas.

References


Further reading


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University–industry collaborations: an industry perspective

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Abstract

Purpose – The engagement with industry actors is a key element in the transition towards an entrepreneurial university model. The purpose of this paper is to explore the university–industry collaboration (UIC) drivers from the industry side. It analyses how, and to what extent, policy interventions could increase the engagement of industry actors in UICs.

Design/methodology/approach – An experimental research design has been used involving a feasibility and pilot study (January to June 2018) with 36 firms, in a non-urban region context, with a satellite university campus. The pilot study explores a randomised control trial (RCT) design, with a training intervention to a randomized group of participants in the pilot study.

Findings – Firms involved in universities’ students (academic forms of UICs) might not necessarily consider the university as a research partner, even in a geographic proximity setting. In addition, there is a potential “dark-side” to proximity, when industry participants build their perceptions using second-hand experiences or indirect information. A training intervention facilitates to overcome pre-existing biases but does not trigger a substantial change in the UICs’ behaviour of the firms in the short-term.

Research limitations/implications – The pilot study provides valuable insights for researchers interested in a larger RCT. It also provides insights for university managers who want to understand the motivations of industry participants in UICs.

Originality/value – The experimental approach of the research generates evidence on the feasibility to intervene in the activation of UICs from an industry perspective, a central aspect in transition towards an entrepreneurial university model.

Keywords University–industry, Collaboration, Pilot study, Randomized-control trial, Entrepreneurial university

Paper type Research paper

Introduction

The call for universities to embrace the entrepreneurial university model is strong and urgent (Klofsten et al., 2019). Governments see the opportunity to activate universities as part of their regional growth strategy (Delgado et al., 2014; Guerrero et al., 2016; Sánchez-Barrioluoeng and Bennworth, 2019), advancing towards a more dynamic capitalism that relies on the contribution of a broad range of entrepreneurial activities (Thurik et al., 2013). The entrepreneurial university adopts an entrepreneurial management style, in their internal activities and organisation, but also with the outside environment (Guerrero et al., 2016). It pushes universities beyond the research and teaching mission dichotomy, embracing the entrepreneurial contribution as their third mission (Guerrero and Urbano, 2012).

As a result, industry players are not only at the receiving end of the university’s knowledge and technology, but also active actors in the generation of this new type of contributions. Consequently, university–industry collaboration (UIC) has been heralded as a practice that accelerates innovation, effectively fostering universities’ knowledge diffusion to society. Prior research has explored the antecedents that make researchers more likely to engage in UICs (Perkmann et al., 2013); and the consequences for both researchers’ academic performance and industry participants’ innovativeness and growth. Nevertheless, less is known on industry participants’ antecedents, and what motivates them to engage in such collaborations. In particular, when the participants are SMEs or organisations with limited experience in collaborative innovations projects.

Such research gap is particularly relevant for universities that want to transition towards the entrepreneurial university model, but that start with unfavourable conditions such as weak connections to the regional innovation ecosystem, or limited relatedness
between the regional industry activities and the university research fields, despite being geographically close (Etzkowitz et al., 2019).

This research follows an experimental approach to address this gap. First, a feasibility study informs on potential interventions, based on prior research that could have an effect on the intentions of SMEs to collaborate with universities. Second, a pilot study for a randomised control trial (RCT) with 36 industry participants (with an overrepresentation of SMEs) is completed. A training intervention is used to explore the changes on SME’s intentions and engagement in university collaborations. The pilot setting is in a Nordic non-urban region with a satellite campus of a university, with few but large industrial players and a substantial number of SMEs.

The results of the pilot study suggest positive effects of the proposed intervention, but also point to a substantial warning on how industrial participants might perceive UICs, even in close geographical proximity. The findings point towards a diversity of perceptions among industry actors regarding UIC. The consideration of UIC as an attractive activity might not correlate with an active engagement with the regional university or research centre. The study results have implications for university managers driving the transition towards an entrepreneurial university model, as well as for innovation policy makers looking for evidence-based approaches to trigger UIC activity in their region.

The paper starts with a review of the UICs research and the existing barriers; it continues with a presentation of the research design and the specifics of the pilot study; and it ends with a description of the results and a discussion of the findings and implications of the study.

**Background**

Despite the visibility of the entrepreneurial university concept, there is not, however, a clear model of entrepreneurial university. Instead, there is a multitude of models and transition paths that stress the necessity to develop further linkages with industry and society in general (Riviezzo et al., 2019). Establishing relationships with industry, collaboration networks and alliances are seen as stepping stones towards the entrepreneurial university (Guerrero et al., 2014). While much of the prior work has focused on describing the internal aspects of the university and their activities, less is known on the contextual factors that influence on the transition towards an entrepreneurial university (Guerrero et al., 2016; Riviezzo et al., 2019).

Universities find themselves in this transition process with multiple open fronts. Their teaching activities content and methods are changing, their governance and strategies are subject to reductions in public funding for education and research, and they see an increased, globalised, competition. Still, balancing the three missions (teaching, research and entrepreneurial) is possible, as long as there is an alignment with the needs of the region and other external demands (Guerrero et al., 2015). Hence, there is an opportunity to navigate (and survive) the transition to the entrepreneurial university model while generating a positive impact in the region’s social and economic development.

As previously mentioned, the UICs have a central role in the activation of innovation and entrepreneurship activities in the university (Elia et al., 2017; Guerrero and Urbano, 2012; Schmitz et al., 2017). UICs promise to combine specialized knowledge and technology transfer activities from universities, with production and market knowledge from industrial actors in the region (Rajalo and Vadi, 2017). They can be formalized in several different types of activities, including: creation of joint research facilities, research contracts, shared publications, consultancy agreements and training or industry secondments for students (D’Este and Patel, 2007). Universities can also approach these activities from different strategic perspectives, in some cases, the priority might be to monetize their knowledge contributions (using for example licensing or research contracts), in other cases, the goal is
an entrepreneurial contribution, for instance to generate new firms, stimulate the regional innovation capabilities, or the creation of local jobs (Giuri et al., 2019). Thus, the nature of UICs can be rather complex, suggesting the appropriateness to review the elements that define them.

Engaging with industry to transfer university knowledge

Universities’ technology transfer offices (TTOs) have been introduced with the ambition to facilitate the knowledge transfer from university to society (Brescia et al., 2016; Fitzgerald and Cunningham, 2016). The technology transfer paradigm assumes that universities generate new knowledge (including new promising breakthrough technologies), that can be patented and licensed. Thus, the more the ability of a university or research centre to generate patents, the more the possibilities to generate revenues and a positive socio-economic impact in terms of innovation (Kolympiris and Klein, 2017). This paradigm, strongly influenced by few star cases from US universities and research centres, has rarely been replicated in Europe (Mustar et al., 2008). Furthermore, recent research findings on the economic impact of universities’ innovation initiatives in Europe suggest the need to reassess the underlying dynamics of the phenomenon (Fini et al., 2017, 2018; Steinmo and Rasmussen, 2018).

Most of the prior research on university knowledge and technology transfer has had as a focal actor the motivations and incentives of the academic researcher (Azagra-Caro and Llopis, 2018; Bozeman et al., 2013). It is of particular interest the figure of the principal investigator (PI) as an individual who combines science innovation and entrepreneurial activities (Casati and Genet, 2014; Mangematin et al., 2014). PIs have to respond to the demand of producing science, build legitimacy in and outside their science field, while at the same time interacting with a broad community of actors (Casati and Genet, 2014). As a result, they experience tensions between supporting technology transfer activities (generating IP) and sustaining their scientific production (Cunningham et al., 2014). Interestingly, the more time PIs allocate for their research, the more they engage in direct consultation with the industry, their TTO and a larger number of industry partners in their projects (Cunningham et al., 2016). This finding resonates with the observation that industry engagement can coexist with academic’s research performance (Perkmann et al., 2013).

However, the motivations of PIs, or researchers in general, to engage with the industry can be very distinct. Academics follow different approaches depending on whether they see the industry engagement activities as valuable for their research, or if instead, they are perceived as an activity to monetise or commercialise their knowledge (D’Este and Perkmann, 2011). In addition, Perkmann et al. (2013) identify that not all commercialisation activities have the same effect, getting involved in commercialisation, via academic spin-offs or licensing, might have positive effects on research productivity. However, generic academic services (consulting or collaborative research) have no clear effects on researchers’ productivity. On the positive side, there is extensive evidence supporting the idea that academic engagement in general (even informal interactions) precedes more formal UIC activities such as academic research commercialisation (Perkmann et al., 2013).

Less is known on the perspective of the industry on the technology and knowledge capabilities of universities, in particular regarding the factors that affect firms’ expectations towards UICs (Azagra-Caro et al., 2014). For instance, firms often involve universities in research projects that are difficult and have additional risk or complexity (Hall et al., 2003) and are likely to find public research more useful if the firm has developed technology innovation capabilities in their organisation (Azagra-Caro et al., 2014). This opens the discussion on whether there are barriers or enablers that could explain the different responses of academics and firms in relation to UICs.
Barriers and enablers for university–industry collaborations

There are substantial differences in how academics and industry operate, in particular when it comes to manage the knowledge they generate or acquire (Tartari et al., 2012). Therefore, it does not come as a surprise that there are conflicts that create collaboration barriers. However, there are also enablers that help to smoothen or overcome such barriers.

The conflicts are often a scaled-up representation of the underlying tensions at individual level. While the PI or academic researcher builds an academic career based on publications and research outputs reputation, the industrial counterpart benefits from transforming knowledge and intellectual property into competitive advantages for their firm (Perkmann et al., 2013). Furthermore, there are institutional setting differences that introduce additional barriers, not necessarily related to individual-level tensions. For instance, overzealous TTOs valuations of the researchers’ intellectual property or competitive pressure for a quick market-ready solution in the firm context.

In an attempt to identify and classify the different elements that might deter the generation of UICs, Bruneel et al. (2010) proposed to classify them in two overarching categories: orientation and transaction barriers. Orientation barriers capture the aspects related to the different vision that academics and industry. They include aspects such as the distance between pure and applied scientific research, the conflicts between businesses’ short-term orientation and the long-term perspective of academic researchers and the distinct working practices and expectations in each context. For instance, it might be difficult to convince a researcher to give up on their autonomy to set the project’s research agenda, similarly it is not plausible for industry partners to allocate resources to long-term research projects without a business case (Tartari et al., 2012). Transactions barriers capture how the distance between academics and industry partners translates into additional transactions costs. They include the often unrealistic or unclear impact of universities’ research vs the need for specific deliverables in the industry context, the conflicts regarding IP or confidentiality arrangements, the incompatible rules and regulation, and the limited capabilities of universities (industry liaison offices) to engage in business with firms (Bruneel et al., 2010).

Nevertheless, there are also enablers that contribute to overcome such barriers. The enablers combine elements at individual and institutional level. At the individual level, trust between the parties involved facilitates exchanging information, knowledge, and materials that could be sensitive or that should not be released publicly. Such exchanges inform on the other side needs and the specifics of a useful collaboration (Santoro and Saparito, 2003). Also at an individual level, the prior experience in UICs facilitates the preparation and organisation of such activities, being able, both sides, to better estimate the costs and resources needed (Tartari et al., 2012).

At an institutional level, the variety of channels of collaboration can be an enabler. While having a narrow collaboration focus can foster efficiency, a broader scope of collaborations facilitates the identification of new opportunities and the convergence between the involved parties (Bruneel et al., 2010). Finally, the geographical proximity between the parties facilitates interactions (Boschma, 2005), even when there is institutional distance between them (Crescenzi et al., 2017). Geographical proximity and university’s research quality have a positive effect on the interaction likelihood and also on the firm’s innovative outcomes (Bishop et al., 2011). Even in cases where there is a distance between the university and industrial partner, there are options to introduce intermediary organisations (e.g. TTOs or joint research centres) that play a bridging function, increasing the proximity, accumulating knowledge and generating trust (Clayton et al., 2018; Villani et al., 2017).

Regardless of the barriers and enablers, there is a need for a starting point where both sides have a minimum willingness to engage in joint projects, without a minimal relational trust or pre-existent ties, it becomes very unlikely to see fruitful UICs (Al-Tabbaa and Ankrah, 2016).
Overcoming barriers with policy interventions

Given the significance of UICs for innovation and regional growth, there is a substantial interest in the identification of potential policy interventions that could trigger further interactions (Cunningham and Link, 2014). Such policy initiatives should be seen as part of the public entrepreneurship activities, where public institutions establish rules, new organisations or alternative management approaches of public resources, with the goal to better serve public interests (Klein et al., 2010).

Nevertheless, the scant systematisation of public policy evaluation regarding technology transfer or UICs makes it difficult to unequivocally identify the right intervention for each policy challenge (Kochenkova et al., 2016). The absence of a comparable evaluation leaves it to policy makers to estimate the policies’ effects, and the mechanisms to mitigate existing concerns on the effectiveness and efficiency of academic innovation and entrepreneurship promotion policies (Sandström et al., 2018). This problem is particularly prevalent when the objects of the policy or the desired outcomes are not well defined.

In order to avoid such shortcomings, policy interventions for UIC should consider prior research results and aim to address the orientation and transaction barriers towards UIC. The selection of potential interventions is intrinsically related to the assumption on what is causing the observed market failure (either from the supply or demand-side). In the context of UIC the assumptions are that resources, capabilities and perceptions towards the behaviour are the underlying factors that make the barriers difficult to overcome (Cunningham and Gök, 2012). These justify the identification of three of the possible interventions from the instruments analysed in recent reviews (see Kochenkova et al., 2016):

- grants to reduce resource limitations,
- vouchers to facilitate access to capabilities or training to modify perceptions and motivations.

The introduction of grants for innovation activities, R&D projects or intermediaries that can help to put together projects with a firm/s and university researchers is based on the assumption that financial resources (lack of) are an obstacle for UIC innovation (D’Este et al., 2012). Therefore, financial aid (in the form of grants) would be the missing element that would trigger the acquisition of knowledge resources to start innovation projects (Kochenkova et al., 2016). Innovation vouchers interventions assume that firms have projects and defined needs, but that they lack the specialized capabilities to activate them and also are not able to identify the right partner to get them started. The use of innovation or growth vouchers has been an innovation policy tool in use in different contexts in the last decade (Roper, 2018). Finally, training interventions assume that the barriers to innovation are related to the resistance to adjust to a new behaviour (locked-in) and/or resistance to engage in new practices that could destabilise core competences (D’Este et al., 2012). Therefore, training activities could provide the necessary stimuli to modify the attitudes and perceptions of the individuals in relation to the behaviour of collaborating with universities to explore innovation projects. Prior research on training and education effects on the behaviour of individuals in similar working contexts suggests that this intervention could have a sizeable effect (D’Este and Patel, 2007; Frese et al., 2016; Gielnik et al., 2017).

Summarizing, the activation of purposeful UICs has a central position in the transition towards an entrepreneurial university model (Guerrero et al., 2014). The ambition of UICs goes beyond the transfer of technological knowledge from universities to the industry, it is an activity that generates knowledge exchanges in both directions, shaping the future innovation trajectories of private players and public actors. The antecedents and consequences of academics’ involvement in UIC has been a subject of extant research, nevertheless, there is a paucity of research from the industry partner’s perspective. A recent review of 36 articles on UICs research identifies only two articles with industry participants data (Perkmann et al., 2013); in the Bekkers and Badas Freitas (2008) that involved university and industry researchers in their research, and in the Van Dierdonck et al. (1990)
where companies in the university science parks were included in their study of attitudes towards university–industry technology transfer. Significant exceptions would be the work by Bishop et al. (2011) on the effects on UICs on firm’s absorptive capacity and innovativeness, Hall’s et al. (2003) work on the characteristics of industry projects with the university as a research partner, or Azagra-Caro et al. (2014) study on how manufacturing firms would perceive public research.

Considering the significance of UICs in the further development of entrepreneurial universities, the prior research findings on barriers towards UICs, and the significant gap on industry perspectives on this topic; this research proposes to explore how and to what extent could a policy intervention facilitate the activation of industry participants in UICs.

Research design
This research follows an experimental research design. The use of experimental methods, RCTs is often considered to be the reference method to generate “reliable and action-oriented knowledge” (Williams et al., 2019, p. 3). It is particularly useful when researchers aim to clarify correlational vs causal relationships (Williams et al., 2019). For instance, to elucidate whether knowing about the university is enough to activate university-industry collaborations. Other approaches such as case studies would not have offered the possibility to isolate the effects of the knowledge acquisition and the subsequent behaviour.

While this methodological approach combines randomisation (in the allocation of participants into the treatment and control group) and realism (it replicates and is conducted in a real life context), it also introduces limitations regarding generalising the findings to a large population group, the subjects (industrial participants) who take part in the experiment might be the ones that expect the benefit the most from the programme, leaving a question mark on the effect on the potential participants that do not volunteer to participate (List, 2011).

Intervention assessment
To assess the most suitable of the alternative interventions, an assessment framework is introduced following the common practice in this type of research (Bowen et al., 2009). The framework includes five different intervention criteria: acceptability, demand, implementation feasibility, implementation practicality, and further adaptation or expansion of the intervention. The objective of this feasibility study is to identify the most suitable intervention given the research question and the research setting of the study.

The Table I summarises the assessment of each of the criteria for the proposed interventions. While grants and innovation vouchers are still popular in innovation policy interventions, the training intervention is expected to be a better fit to modify the attitudes and perceptions towards UICs. The underlying assumption is that monetary incentives might trigger a short-term response, but would not be conducive of changes in the behaviour perceptions and motivations in industry participants (Dalziel, 2018). This would effectively aim to mimic (at a reduced scale) the innovation and entrepreneurship training activities for researchers (Klofsten et al., 2019), focusing instead on the industry participant side. As a result, the remaining part of the research design is built taking into consideration that the type of intervention selected is a training session for private firms.

Intervention specifics
A central aspect of the transition towards an entrepreneurial university is the generation of collaborative interactions between academics, industry and other institutions. It is often these informal, individual, interactions that generate the dynamics that will then end in
more formal and institutionalized innovation and entrepreneurial activities (D’Este and Perkmann, 2011). This is two-side dynamics, where academics and industry participants have common interests and motivations to engage in these informal interactions. It is established that a supportive institutional environment (including university support mechanisms and established industrial partners) facilitates commercialisation of research and technology transfer (Guerrero et al., 2016). But less is known on how the institutional context can be modified in order to facilitate the transition towards becoming an entrepreneurial university. This is particularly relevant in regional contexts where the supportive innovation ecosystem is missing or is still underdeveloped.

In this setting, the intervention aims to assess the potential benefits of a training programme to build-up or modify the environment where the entrepreneurial university transition occurs. The training intervention is conceived as a half-day workshop delivered by an external facilitator, it is delivered in the innovation lab of the university. The short and intense design aims to reduce the participation barriers for industry participants (with limited time availability). The content of the workshop is defined with the assumption that the training can modify behavioural aspects of the participants.

The theory of change behind the intervention is the Theory of Planned Behaviour (Ajzen, 1991), well tested in short- or long-duration training programmes (see Sánchez, 2011; Frese et al., 2016; Nabi et al., 2017), that have shown that individual motivations and perceptions

<table>
<thead>
<tr>
<th>Intervention type</th>
<th>Acceptability</th>
<th>Demand</th>
<th>Feasibility (implementation and practicality)</th>
<th>Adaptation and expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grants or direct funding for UIC activities and projects</td>
<td>High: participants are used to public funding instruments for joint R&amp;D projects with universities and research centres</td>
<td>Medium–Low: already common instrument, granting institutions, often struggle to receive qualified applications, tends to attract the same group of participants, requires expertise</td>
<td>Very low: the programme managers of grants are rather unlikely to accept randomisation of grant assignment, it would require additional resources and a specific new programme</td>
<td>High: it can be replicated with additional budget but there are learning effects and possible spill overs from participants in the programmes</td>
</tr>
<tr>
<td>Innovation vouchers</td>
<td>Medium–Low: the concept of voucher is known, but not used commonly in business support programmes in the region of the study</td>
<td>Medium: can be attractive to address small or early-stage innovation projects or specific services, but not likely to connect distant institutions (like university–industry)</td>
<td>High: existing pool of innovation services suppliers, but rather limited experience in the university (at least in the region of study) as a service partner for innovation projects</td>
<td>Medium–High: would require for similar settings and pools of actors in the demand and supply side to replicate the intervention. Additional budget can facilitate the extension of the programme</td>
</tr>
<tr>
<td>Training seminars</td>
<td>Medium–High: common form of developing knowledge and capabilities in firms, but limited experience of the university in supply of in-company training</td>
<td>Medium: interest in companies in the region in getting more out of the university campus, low cost effort to assess future potential collaborations</td>
<td>High: can be replicated if content and dynamics structured are defined, can be carried out with limited additional resources, it requires a training space</td>
<td>High: training content and delivery methods can be adapted, expansion of the training is feasible with additional programme delivery support and basic resources</td>
</tr>
</tbody>
</table>

Table I. Validation of the interventions using the assessment framework
can be modified through training. The objective of each part of the training session (see Table II) is to influence on the participants’ perception on the UIC behaviour, in particular, their awareness and attitudes, the social norm and their perceived behavioural control or self-efficacy towards the behaviour (Gielnik et al., 2017).

The workshop’s session includes content related to models for collaboration with university (international and local success stories), practical aspects on how to make the first steps, and identification of potential topics for a first collaboration, see Table II for details on the training structure.

The group that does not receive the intervention (control group – business as usual), receives a short guide (electronic support) on how to get started with UIC based on a review of literature on the topic and suggestions for first steps. This guide is also shared with the intervention group.

Pilot study design

The structure of the pilot study is described in Figure 1. It includes a baseline measurement, a randomisation, a treatment and control group and a follow-up measurement. The target population to reach are the 150–180 firms in the proximity region of the university. The randomisation of the baseline participants into treatment or control group is done with a computer in the researcher’s office, ensuring that the treatment group includes participants with different degrees of prior experience in UIC.

Context and sample

The context of the pilot study is a significant aspect. It is in a non-urban region, yet with presence of large industrial players and manufacturing SMEs. In the region there is a university campus that is a satellite of a larger university in the same country. The university covers almost all the disciplines, but the regional campus has a strong focus on

<table>
<thead>
<tr>
<th>Activity</th>
<th>Method/time*</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction and explain workshop dynamics</td>
<td>Lecture (15 min)</td>
<td>Set the expectations for the workshop</td>
</tr>
<tr>
<td>2. Identification of general challenges across participants</td>
<td>Brainstorming (15 min)</td>
<td>Build a shared understanding and empathise with the industry challenges, set a departure point</td>
</tr>
<tr>
<td>3. What are university–industry collaborations? Examples and results</td>
<td>Lecture (15 min) Case studies discussion (15 min)</td>
<td>Raise awareness on UICs Introduce role models, activate attitude towards UIC behaviour</td>
</tr>
<tr>
<td>4. How can a UIC collaboration help your organisation challenges?</td>
<td>Individual work (10 min) Group work (20 min)</td>
<td>Make a desirable match between challenge and UIC collaboration Foster perceived behavioural control/self-efficacy on engaging in the UIC behaviour</td>
</tr>
<tr>
<td>5. What barriers do you see to get this UIC collaboration started? What would make it possible?</td>
<td>Individual work (10 min) Group discussion (20 min)</td>
<td>Explore the barriers and triggers from intention to behaviour Increase likelihood of short-term action on the challenge at hand</td>
</tr>
<tr>
<td>6. Building an action plan with an UIC collaboration</td>
<td>Individual work (10 min) Individual presentation and discussion (20 min)</td>
<td>Rise commitment towards the behaviour Use goal-setting as driver of action</td>
</tr>
<tr>
<td>7. Summarizing and takeaways</td>
<td>Lecture (10 min) Round discussion (5 min)</td>
<td>Assess the expectations achievement Collect improvement ideas and suggestions</td>
</tr>
</tbody>
</table>

Note: *For a group of 5–8 participants, breaks between activities not included (up to 3, 10 min break were used)

Table II. Training intervention details
engineering education, and it is the most international (in staff and students) of the different campuses of the university across the country. The university has recently had its 50th anniversary, but the regional campus in its present location was established 10 years ago. It is a university in a transition towards an entrepreneurial university model, trying to find the right equilibrium between being locally driven, responding to the regional demands, but also generating research that is excellent at a global scale (Benneworth et al., 2017).

The entrepreneurial university transition is activated as a response to the continuous reductions in public education budget, targeting commercialisation activities as a revenue and regional legitimacy source. These changes are being materialized with the introduction of a cross-disciplinary unit to support the innovation and entrepreneurial activities, as well as strategic support (including financial resources) for large regional initiatives in collaboration with industrial partners. The engineering focus of the satellite campus and the dynamic industrial manufacturing firms in the region make the university configuration particularly open to change and adaptation (Sánchez-Barrioluengo and Benneworth, 2019).

The target population were companies in the region (in an area of 30 km) of the university campus. The invitation to participate was done with a survey shared with the local business agency and the university’s innovation office (that does the function of the TTO). In addition, companies that attended a job fair in the university were directly invited to participate either using the online baseline survey or a printed copy delivery by hand. From over 165 requests for participation (January–February 2018), 36 confirmations were received (that completed also the baseline survey), a 22 per cent participation rate. That included micro companies or start-ups (25 per cent), small companies (19 per cent), medium-size companies (17 per cent) and large companies (39 per cent).

From the 36 baseline participants, 20 were randomly selected and invited to join the control group (with an invitation to an intervention). Finally, 8 participants from 6 different companies accepted to participate in the intervention workshop (May 2018). The follow-up measurement was completed by 10 participants (6 from the treatment group – had taken the intervention – and 4 from the control group).

**Measures and other data**

General data is collected to identify the participants and to contact them for the further interactions during the project duration. Information on the firm size (number of employees), location and types (research or academic) prior experience in UICs (prior res. UIC, prior ac. UIC) and degree of satisfaction (prior exp. UIC) is also collected.
Regarding the variables of the study (see Table III), it is important to highlight that there are two measurement points, the baseline and the follow-up. The baseline measures also provide the indicator (prior exp. UIC) to stratify the randomisation (satisfaction with their prior experience with UIC). The baseline measurement includes time invariant aspects such as the degree of firm innovativeness (Calantone et al., 2002) with the variable firm innovativeness or their perceptions of the barriers towards UICs (Bruneel et al., 2010) recorded as orient. barrier (orientation barriers) and transact. barr (transaction barriers). In both, baseline and follow-up, the elements of the TPB: attitudes, social norm, perceived behavioural control and intention of the UIC behaviour are measured; for the baseline these are recorded as: UIC attitude, UIC SocialNorm, UIC P.Beh.Cont and UIC Intention; for the follow-up a shorter coded format is used: fuatt_uic, fusn_uic, fupbc_uic and fuint_uic.

Besides the data coming from the two survey measuring points, the researchers collected observational data during the delivery of the training session’s interventions (that were also recorded). The additional follow-up with the firms also generated data on the behaviour of the firms beyond the initial time scope of the pilot study.

Outcomes and proposed statistical analysis
The primary outcome of the pilot study is the intention to engage in UIC projects. The change, if any, on the intention of participants from the baseline to the follow-up measure would determine whether there has been a treatment effect or not. The statistical analysis is based on a group t-test to identify whether there is a significant difference between those that were in the treatment or control group. In addition, there are other outcomes that are of interest such as the actual behaviour of the firms participating in the study, in particular those that had been enroled in the treatment group.

Results
This section covers the results from the baseline and follow-up measurements, as well as the overall data collected to assess the proposed pilot study.

Baseline
The descriptive and variable correlations are presented in Table IV. The baseline participants had an overall positive prior experience with UIC (5.2 in a 1–7 scale); while only half of the firms had done some research collaboration, 71 per cent of them had had a student-based relationship (internships or student projects). This results suggest that in the sample there is presence of some of the enablers identified in the prior literature in the topic of UICs.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Reference</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm innovativeness, linear scale (1–7)</td>
<td>Firm innovativeness measure (Calantone et al., 2002)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Prior type of university–industry collaboration, multiple choice</td>
<td>Types of UIC: research contracts, joint projects, academic spin-offs, industry training, joint publications, patenting, licensing (Perkmann et al., 2013)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Overall satisfaction with prior UIC, Likert scale (1–7)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Orientation and Transaction barriers, multi-item question, Likert scale</td>
<td>Types of orientation and transaction barriers (Bruneel et al., 2010; Tartari et al., 2012)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Attitudes (ATT), social norm (SN), perceived behavioural control (PBC) and intention (INT) towards UIC</td>
<td>Adaptation of TPB to the UIC context, based on the EIQ scale (Liñán and Chen, 2009)</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Table III. Pilot study measures
<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. UIC Intention</td>
<td>34</td>
<td>4</td>
<td>2.17429</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>2. UIC Attitude</td>
<td>34</td>
<td>6.058824</td>
<td>0.7859052</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>3. UIC SocialNorm</td>
<td>36</td>
<td>5.75</td>
<td>1.105183</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4. UIC P.Beh.Cont</td>
<td>34</td>
<td>4.779412</td>
<td>1.207246</td>
<td>2.5</td>
<td>6</td>
</tr>
<tr>
<td>5. Firm Innovtiv.</td>
<td>34</td>
<td>5.588235</td>
<td>0.9028903</td>
<td>3.666667</td>
<td>7</td>
</tr>
<tr>
<td>7. Transact.Bar.</td>
<td>32</td>
<td>4.257813</td>
<td>0.9598479</td>
<td>2.25</td>
<td>6.5</td>
</tr>
<tr>
<td>8. Prior Exp.UIC</td>
<td>36</td>
<td>5.305556</td>
<td>1.007268</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>9. Prior Res.UIC</td>
<td>35</td>
<td>0.7714286</td>
<td>0.426043</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>10. Prior Ac.UIC</td>
<td>35</td>
<td>0.7714286</td>
<td>0.426043</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>11. Firm Size</td>
<td>36</td>
<td>2.694444</td>
<td>1.237958</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Table IV. Variable descriptive and correlation table.

---

|$r_{ij}$ | 0.0000 | 0.3613 |
| UIC Intention | 0.3613 | 1.0000 |
| UIC SocialNorm | 0.4405 | 0.5289 |
| UIC P.Beh.Cont | 0.7345 | 0.3641 |
| Firm Innovtiv. | 0.2736 | 0.2645 |
| Orient.Barrier | 0.1886 | 0.0037 |
| Transact.Bar. | 0.2500 | 0.0734 |
| Prior Exp.UIC | 0.1312 | 0.4571 |
| Prior Res.UIC | 0.1963 | 0.0221 |
| Prior Ac.UIC | 0.1355 | 0.1329 |
| Firm Size | -0.0222 | -0.0787 |

**MD**
Such as having prior experience in UICs, or engage through multiple channels of interaction (student and research collaborations). Yet, it also shows that about a third of the participants had no prior collaborations with universities.

The correlation table shows a high relationship between the perceived behavioural control (UIC P. Beh. Cont.) and the intention to engage in UIC in a near future, but no particularly strong relationship between the prior experience (as a potential enabler) and any of the perceptions or intention measures.

The distribution of the intention to engage in UIC and the measure of firm innovativeness (firm innovativ.), see Figure 2, is distributed across the different firm sizes (in employees). Interestingly, for medium-sized firms there appears to be more distance between the two measures.

In a similar manner, and being aware of the limited number of observations, for some of the participant’s firm size groups the orientation barriers are perceived to be higher than the transaction barriers. Figure 3 shows the distribution of their responses by firm size category.

Finally, as part of the exploration of the data of the baseline and to make sense of the effects of the different variables that were being measured, a simple regression model clarifies the influence and weight of the antecedents of the intentions towards UIC. It can be noticed that there are some indications towards the potential positive effect of having had prior experiences on research-based UIC towards future engagement with the university as a collaboration partner. Such results would actually support the theory on prior experience as a valuable enabler to overcome the barriers towards this behaviour (Tartari et al., 2012).

Also, there seems to be a positive relationship between a higher perceived behavioural control on the UIC behaviour (UIC P. Behav. Cont.), and the intention to engage in the behaviour (UIC Intention) can also be observed as part of the overall model coefficients (see Table V).

**Follow-up (post intervention measurement)**

Regardless of the small number of participants, and going beyond the objectives of a pilot study, the results from the follow-up measurement were used to get a preview on a potential full trial experiment with a similar design. The results are presented in Figure 4, the
responses from the baseline (UIC attitude (att_uic), UIC Social Norm (sn_uic), UIC P. Beh. Cont. (pbc_uic) and UIC Intention (int_uic)) are compared next (with same colour) as the follow-up responses (fuatt_uic, fusn_uic, fupbc_uic and fuint_uic); the two group responses, control = 0 and treatment = 1, are reported for data presentation purposes.

The reduced number of observation (n = 10) in the follow-up measurement does not support the generation of statistical insights or other quantitative conclusions. Nevertheless, the data collected does not show an overwhelming change of perceptions on the intentions in either group.
Pilot study and continued follow-up

The pilot study results are particularly informative to assess the necessary adjustments for a full-scale RCT. Beyond the limited data insights from the pilot study measurements, it helped to identify the unexpected difficulties to recruit participants from the baseline to be part of the treatment group. The intervention of the treatment group required the participants to join a half-day workshop in the university premises; although multiple dates were offered (and two identical workshops were finally celebrated), there was a low conversion rate from participants being invited (20) to the final 8 (6+2) participants (6 participants from different companies and 2 participants that joined a company colleague).

On the positive side, an additional follow-up (three months after the follow-up measurement) showed how the participants that remained engaged in the project till the end (10 out of the 36) had overall an increase in their activity in UIC. In some cases, it is an increase in the depth and breadth of their activities, in others it is a first-time collaboration. The details of each of the firm’s participant are described in Table VI.

Discussion

The transition towards an entrepreneurial university model requires the implementation of active strategies to engage with industry players. Such collaborations should not only be regarded as knowledge transfer activities, but as actual bidirectional exchanges. They contribute to the research and innovation of the industry players, but also to the academic’s research performance. Successful entrepreneurial university models suggest that a supportive context (an active innovation ecosystem) facilitates the development of the entrepreneurial mindset and activities in the university. Most of the attention in the transition towards such models has had the individual researcher, or scientist, as a focal point (Perkmann et al., 2013). However, much less is known on how to trigger the activation of the industry side. This research gap is relevant as a broad scope of universities explore the transition path towards being an entrepreneurial university, with or without a rich innovation ecosystem.

The study followed an experimental approach to explore whether a training session could be a suitable policy intervention to influence on the intentions and future behaviour of
industry players in a non-urban region with a satellite university campus. Prior research on UICs identified that the different visions of the university and the industry on the applicability of scientific research, on their time orientation and on their working practices (including IP management) could hinder such type of collaborations (Bruneel et al., 2010). Still, the pilot data suggest that the perception of such barriers does not necessarily eliminate the intentions of industry partners to engage in UIC activities, even though such barriers are likely to be a source of future conflicts in such collaborations. In regard to factors identified as enablers in prior literature, the pilot data conform with the expectation that the diversity of interaction channels facilitates to sustain UIC activities. Yet, challenges the expected enabling function of social embeddedness and geographical proximity between university and industry participants.

The results of the study suggest that there is a heterogeneity of industry behaviours regarding UIC, that the geographical proximity limits the potential of UIC and that there are positive engagement effects of the training intervention.

First, industry participants experience in UIC can be categorised as purely based on academic talent recruitment (students’ internships and student projects), research-focused (joint research projects, joint patenting or licensing) or a combination of both. Interestingly, firms that have had most of their prior experience on the student recruitment category are less likely to consider other forms of UIC participation. Similarly to what D'Este and Perkmann (2011) identified with academics that either focus on commercialising their technology (licensing or academic spin-offs) or in general academic engagement (consulting or training with companies), a parallel pattern might be occurring with industry players. Industry participants might either see the regional university as a source of talented students or as a research partner but not necessarily both at the same time. Therefore, as exposed in Bruneel et al. (2010), UIC activities such as student secondments or company projects generate interactions between industry and university, but the university participants in such interactions might not be connected (or interact) with the university’s research services or scientists that could be interested in activating research collaborations or other knowledge exchanges.

<table>
<thead>
<tr>
<th>Participant profile</th>
<th>Treatment/ control</th>
<th>Follow-up behaviour (after 3 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large firm, very positive prior experience UIC, but only student-based</td>
<td>Control</td>
<td>Engaging with university-research project (1st time), continues collaboration with internships</td>
</tr>
<tr>
<td>Large firm, positive and varied prior experience in UIC</td>
<td>Treatment</td>
<td>Increased collaboration, launching joint events (hackathon) with the university</td>
</tr>
<tr>
<td>Large firm, extensive and varied UIC experience</td>
<td>Treatment</td>
<td>Sustains working collaborations with internships and industrial PhDs</td>
</tr>
<tr>
<td>Medium-sized firm, no prior experience in UIC</td>
<td>Treatment</td>
<td>No new activity has occurred. Considering a student project, not defined</td>
</tr>
<tr>
<td>Medium-sized firm, extensive and varied UIC experience</td>
<td>Control</td>
<td>Sustains working collaboration, involving university researchers in their R&amp;D projects</td>
</tr>
<tr>
<td>Micro firm, no prior UIC experience</td>
<td>Treatment</td>
<td>Not yet started any project but stays involved in events and other university activities</td>
</tr>
<tr>
<td>Start-up (micro), it is an academic spin-off, academic UIC experience</td>
<td>Control</td>
<td>Further engagement in academic collaboration (guest lectures), no new research collaborations</td>
</tr>
<tr>
<td>Start-up (micro), academic UIC experience</td>
<td>Treatment</td>
<td>Launched new project with students as interns, did attempt to start a research collaboration that has not crystalized</td>
</tr>
<tr>
<td>Micro firm, academic UIC experience</td>
<td>Treatment</td>
<td>Increased participation in events, guest lectures, exploring options for a research project in collaboration with university</td>
</tr>
<tr>
<td>Micro firm, academic UIC experience</td>
<td>Control</td>
<td>No new projects, they continue to offer internships to students</td>
</tr>
</tbody>
</table>

Table VI. Pilot study participants qualitative insights of follow-up after the study (3 months)
Second, geographical proximity is an enabler of informal and formal interactions between the university and industry in a region. In fact, the short distance between the university and industry partners translates into geographic and cognitive proximity (Roper and Hewitt-Dundas, 2013). Nevertheless, the relative novelty of the university campus in the region (not more than a decade in its current form), and its strong international profile results in an uneven network of connections and relationships between the university’s staff and the firms in the region. Such peculiar configuration favours non-interactive learning from both sides (Roper and Love, 2018), potentially weakening the expected positive effects of proximity on UIC interactions.

This is what could be described as a “dark side” of proximity, where geographical and cognitive closeness – but without a personal linkage – makes non-interactive learning dominant. The perceptions of the capabilities of the counterpart (the university) are built on public information or second-hand experiences. For instance, prior negative experiences with “the” university in the region, might make it less likely for other firms to consider it as a source of ideas or as a partner for innovation projects. Despite being geographically close, without interactive learning the perceptions might become biased or just distorted (Roper and Love, 2018).

Third, despite the attrition rate from the baseline to the follow-up, the post-study observation of an increased UICs activity level is an encouraging finding. The activation of UICs could require a threshold interest towards collaborative innovation activities and knowledge exchange activities. The intervention might actually be working as a “myth-buster”, removing biases built through non-interactive learning and offering a possibility to get a first-hand experience on what can be achieved in such types of collaborations. This finding opens the discussion on whether not only researchers should be receiving training on how to become more entrepreneurial (Klofsten et al., 2019), but to also include industry players in such training programs. University activities that could favour the initial informal interactions between researchers and industry actors (Perkmann et al., 2013), might render stronger results than an exclusive focus on the academic researcher as driver of UIC collaborations.

Finally, the adoption of an experimental approach offers the possibility to discuss the results also from a methodology perspective. The design and execution of a pilot study has proven to generate valuable insights on the participants’ recruitment strategy and needs, the delivery and participation in the intervention and on the overall dynamics of the trial. The results suggest the importance of defining whether the intervention should aim to generate awareness of the UIC practice or actually change the actual behaviour of the industry participants. The short intervention worked to raise awareness. The use of cases that were related to the profile of the participants and the identification of initial (relatively easy) steps to take action might have helped to reduce the perception of UIC’s barriers. However, such type of intervention is less likely to generate deep changes in the behaviour, thus multi-session programme would be a better approach if this is the objective.

Similarly, the content of the intervention (training session) was built mostly on a behavioural learning pedagogy (discussing how UIC work using examples and models), a social or existential learning (Robinson et al., 2016) design would be more conducive of deeper changes in the participants perceptions, attitudes and future behaviour. Therefore, the results of larger trial based on the pilot’s training session might differ if the learning approach is revised to incorporate additional constructivist learning activities.

Such challenges, are however to be expected in pilot studies, surprises and unexpected behaviours from the participants are part of the key learnings to take into account in future research designs (Abbott, 2014). This pilot study is also a step towards the call for more frequent use of experimental research designs in technology transfer or related research fields (Cunningham and O’Reilly, 2018; Williams et al., 2019).
Implications for policy and practitioners

From a policy and practice perspective, the study contributes to the call for more transparent and evidence-based decision making in innovation policy (Cunningham and Gök, 2012). In the context of public policy for university’s knowledge transfer this has been a concern shared by both policy makers and scholars (Kochenkova et al., 2016). As a result, despite the critiques on the viability to run RCTs to study business support programs (Dalziel, 2018), the experimental approaches should help policy makers to make better decisions.

The results of the study suggest that an in-depth understanding of the context and underlying dynamics between the university and industrial actors is necessary before introducing interventions. The pilot study has helped to identify that the effect of a policy intervention to activate further UICs might be concealed by existing pre-conceptions and biases. Those need to be addressed before engaging further in the delivery of training or other types of interventions directed to increase the participation of academic and industrial actors in innovation and entrepreneurial.

For university managers engaged in the transition towards an entrepreneurial university model, the findings of the research make explicit the challenges that young or loosely embedded (in their innovation ecosystem) universities might experience. It is relevant that such managers do not only focus on the university’s internal factors, but also on how they can contribute to generate a more supportive context for the entrepreneurial university. Otherwise, the alignment of the teaching, research and entrepreneurial missions with the regional demands might become a rather difficult task.

Limitations and suggestions for further research

This research reports a pilot study, as such, it has several limitations that hopefully motivate further research on the topic.

First, the assumptions behind the recruitment strategy of the participants and their response rate were too optimistic. The proximity of the university campus to some of the invited participants did not result in an automatic enrolment in the programme. Therefore, a much broader and intense recruitment strategy should be considered for a full-scale RCT. Additionally, the communication strategy regarding the programme should be tested before starting the recruitment period, considering, for example, hosting an official launch event or other more formal activities in relation to the initiation of the programme. Likewise, the low response in the e-mail communications suggests that other mechanisms – visits or phone calls – should have been in place to follow-up the participants. Ideally being able in such redesign to reduce the potential self-selection bias in the sample. Participants with an already high interest with developing UICs were more likely to respond and engage in the project than those with a low interest. Leaving open the question of whether these could actually, be the ones that benefit more from such type of intervention.

Second, the training session proved to be an effective intervention, but did not generate substantial different results (in the intention related measures) among the participants that completed the programme. However, the duration and intensity of the programme should be reconsidered if researchers aim to explore the effects to a broader target population. In such situations, interventions that could span over several days, or in different points in time, might have a stronger effect in behaviour changes. The redesign of the intervention and the overall programme should also then include a revision of the participation incentives. Additional mechanisms that facilitate to deliver the training intervention minimising the time and location constrains (i.e. hosting the seminar nearer to where the participants are based) or offering additional short-term incentives could be potential interesting tweaks.

Finally, this research mostly used data coming from surveys and observations on a reduced sample of participants. Future research could consider other sources of data (direct or indirect) that can better capture actual changes in the behaviour of the participants.
from a longitudinal perspective. This can be easier to achieve if instead of inviting several firms in the region, the experiment involves only employees from a specific organisation (Rigtering et al., 2019).

Conclusions

The transition towards an entrepreneurial university model can follow many different paths. A common element across these different paths is an active engagement with the industry actors in the university’s region. While prior research has substantially contributed to understand the barriers and enablers that facilitate the academic engagement with the industry, less is known on how to nurture and activate industry interest in engaging in UICs.

As the entrepreneurial university model is reinterpreted in different contexts, it is also necessary to consider the additional transitional challenges that might appear. In particular for universities that need to create or rebuild linkages and relationships with the innovation ecosystem that surrounds them. This study contributes to identify and explore the industry perspective on UICs. It takes advantage of the experimental approach to generate insights on the challenges and possible remedies for policy makers and university managers interested in activating UICs.

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Strategic knowledge management within subsidised entrepreneurial university-industry partnerships

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Abstract

Purpose – The purpose of this paper is to analyse how collaborative/opportunistic behaviours within subsidised university-industry partnerships are influencing the design/implementation of strategic knowledge management practices in emerging economies.

Design/methodology/approach – The proposed conceptual model was analysed with a retrospective multiple case study approach integrated by four subsidised entrepreneurial universities-industry partnerships of the Incentive Programme for Innovation from 2009 to 2014 in Mexico.

Findings – Entrepreneurial universities and industrial organisations confirm insights about dual collaborative-opportunistic behaviour within subsidised partnerships. The main effects of behaviours represent an increment in the knowledge management costs during the monitoring stages. The ex ante collaboration agreement anticipated and protected intellectual capabilities.

Research limitations/implications – This research contributes to the ongoing discussion about public administrations’ opportunistic behaviours in emerging economies (Tripsas et al., 1995), the effectiveness of the innovation and entrepreneurial programmes (Guerrero and Urbano, 2019b), and the link between dual behaviours (collaborative and opportunistic) and knowledge management practices (de Wit de Vries et al., 2018).

Practical implications – New questions emerged about the effectiveness of subsidies as new modes of knowledge generation among entrepreneurial universities and industrial organisations, as well as the need for implementing strategic knowledge management practices in the public administration.

Social implications – For policymakers, the study presents insights about the effectiveness of public resources. Policymakers should understand challenges and re-define/re-incentivize the productive value chain as well as implement mechanisms to control opportunistic behaviours on potential subsidised firms.

Originality/value – The paper contributes to the academic debate about how entrepreneurial universities and industrial organisations are strategically managing their knowledge when participating in subsidised partnerships in emerging economies.

Keywords Emerging economies, Entrepreneurial universities, Strategic knowledge management, University-industry partnership, Collaborative behaviours, Opportunistic behaviours

Paper type Research paper

1. Introduction

Research about determinants, outcomes and core activities (i.e., teaching, research, technology transfer and entrepreneurship) of entrepreneurial universities has increased significantly since the publication of Clarks’ book in 1998 (Guerrero and Urbano, 2019a). Previous studies have confirmed the significant contributions of entrepreneurial universities on society through the generation human capital, the generation of transferable and marketable knowledge, and the generation of graduate/academic entrepreneurs (Guerrero and Urbano, 2012;
Guerrero et al., 2016; Secundo et al., 2017). In the current socio-economic landscape, entrepreneurial universities have been legitimised, such as bridges that connect their core activities with social challenges. Consequently, the entrepreneurial universities’ community (students, academics, teachers and staff) is actively participating in the generation, the dissemination and the commercialisation of knowledge that strengthening societal, economic and technological development (Guerrero et al., 2015). This phenomenon has also represented a revolutionary process in the modes of knowledge production (Carayannis and Campbell, 2011). Although more than two decades of insights about entrepreneurial universities, research about how these universities are managing their knowledge capabilities is very limited (Numprasertchai and Igel, 2005; Acworth, 2008; Tian et al., 2009; Anand and Singh, 2011; Klofsten et al., 2019), especially, in emerging economies (Guerrero et al., 2019).

In the context of emerging economies, organisations tend to be influenced by institutional voids that should be filled by specific conditions to reduce the high levels of uncertainty/risks in the venture and knowledge creation inherent in that context (Puffer et al., 2010). Therefore, in these scenarios, entrepreneurial universities are oriented to foster entrepreneurship and innovation as well as to mitigate the effects of institutional voids through their core activities (Guerrero and Urbano 2017a, b). Following the institutional voids and market failures reasoning, extant studies have justified the implementation of subsidies to promote innovation and to incentivise private ventures to invest in research and development in emerging economies (Nelson, 1959; Arrow, 1962; García-Quevedo, 2004; Clarysse et al., 2009; Edler and James, 2015; Dimos and Pugh, 2016; Kochenkova et al., 2016). Consequently, subsidised university-industry programmes have gained relevance in the competitiveness agenda of multilateral organisations such as the Inter-American Development Bank, the World Bank and the Organisation of American States (Hall and Maffioli, 2008). Subsidies based on compulsory university-industry partnerships try to stimulate research collaboration, innovation, technological advances and impacts on society (Cohen et al., 2002; Takalo and Tanayama, 2010; Colombelli and Quatraro, 2018). Influenced by this type of government intervention, entrepreneurial universities have, directly or indirectly, assumed the responsibility for reducing institutional voids by enhancing the quality/quantity of research endeavours (Marozau et al., 2016). It explains why subsidised programmes that promote university-industry partnerships have become the most popular mechanism for knowledge transfer in emerging economies (Mahmood and Rufin, 2005; Van de Vrande et al., 2009; Guo and Guo, 2011; Guerrero and Urbano, 2016, 2017b).

Furthermore, the role of capabilities and behaviours are key factors in collaboration and innovation, meaning that strategic knowledge management practices should support organisations to become more effective collaborators/innovators (Salter et al., 2014), thereby developing the absorption capacity within subsidised partnership. Nevertheless, the influence of behaviours on the configuration of entrepreneurial university-industry partnerships that participate on subsidised research programmes (Zeng et al., 2010; Perkmann et al., 2013; Kovacs et al., 2015; Gianiodis et al., 2016), as well as, the mechanism implemented by the universities and industries for managing the knowledge generated as outcomes of subsidised collaborations (Guerrero et al., 2016; de Wit-de Vries et al., 2018) are part of a black box that requires theoretical foundations and evidence. To contribute to this academic debate, this paper analyses how collaborative/opportunistic behaviours within subsidised university-industry partnerships are influencing the design/implementation of strategic knowledge management practices in emerging economies. Our proposed conceptual model was analysed with four Mexican cases of subsidised entrepreneurial universities-industry partnerships. Research was set in Mexico by two reasons: during the last three government administrations have been established several subsidies to reinforce innovation and knowledge transfer via enterprise-university partnerships (OECD, 2013); and Mexican enterprises and universities have implemented several open innovation practices to exchange resources/knowledge (Guerrero and Urbano, 2016, 2017b).
The remained sections of this paper are organised as follows: Section 2 develops the conceptual framework for understanding strategic knowledge management in subsidised entrepreneurial universities-industry projects in emerging economies. Section 3 explains the methodological design applied in this paper. Section 4 describes the obtained results about the influence of behaviours/motivations on the outcomes of subsidies university-industry projects and entrepreneurial university mechanisms for knowledge management. Section 5 includes the discussion of our results in the light of previous studies. Then, Section 6 presents the main conclusions of the study, the implications for decision makers and future lines of research.

2. Conceptual framework

Subsidies allow turning an unprofitable project into a profitable one or complete an existent project. Entrepreneurial university-industry partnerships could view public funds such a relatively cheap way to finance innovative/technological projects, especially when the application costs are lower and the probability of selection is higher compared to alternative financing sources (Aschhoff, 2009; Aschhoff and Sofka, 2009). In this line, subsidies reduce the fixed costs of current/future research projects as well as increase the probability of being completed or undertaken (Benavente et al., 2007). A recent meta-regression analysis of R&D subsidies has evidenced how knowledge inputs/outcomes could be measured in terms of additionality or/and crowding out effects (Dimos and Pugh, 2016, pp. 798-800). These effects are intrinsically evidencing the influence of positive or negative motivations/behaviours among subsidised organisations. Therefore, in this section, it is discussed how subsidised projects may endorse both collaborative and opportunistic behaviours among entrepreneurial university-industry partnerships.

2.1 Collaborative behaviours, subsidised partnerships and knowledge management

Collaborative behaviour is founded by synergies, shared expectations, and long-term trust relationships. In this sense, this behaviour promotes open innovation practices among industries, entrepreneurial universities, and scientific centres where the partners’ contributions and expected outcomes are clearly expressed and shared (Chesbrough, 2003; Nieto and Santamaría, 2007; Kovacs et al., 2015). Therefore, in subsidised projects, collaborative behaviours allow the flow of resources, sharing risks as well as understanding subsidies just as additional resources that ensure the knowledge transfer, the generation of novel technologies and the achievement of goals (Carayannis et al., 2000; Whitley, 2002; Zeng et al., 2010). Based on the additionality effect, subsidies provide additional support instead of substitute private or collaborative investments (Autio et al., 2008; Clarysse et al., 2009; Dimos and Pugh, 2016). This additionality also produces a signalling effect regarding the quality of the project/team, reduces asymmetries of information and increases the access to additional funds (Lerner, 1999).

Any knowledge strategies requires a well-founded common ground with the harmony of interests, values, goals and obligations among partners (Nieto and Santamaria, 2007; Li and Kozhikode, 2009). The additionally effect produces that the R&D subsidy triggers a higher level of R&D output than the counterfactual state of no support (Dimos and Pugh, 2016). Therefore, collaborative behaviours produce a sharing effect affecting positively on the performance of the partnership (Belderbos et al., 2004) and also generate benefits for society with the results of the project (Hill, 1990; Bogers, 2011; Salmi, 2012). As a consequence, collaborative partners prefer to reduce any uncertainty by implementing collaboration agreements, ethics protocols, and knowledge protection at the beginning. The rigid degree in the execution of these control will depend on the level of trust among partners, the project objectives, the contributions (sharing human capital, funds, labs or technologies), as well as the way that the tacit or not tacit knowledge is absorbed, protected, and commercialised by the partnerships (Miller et al., 2016; 2018). In this vein, a collaborative behaviour: simplifies knowledge management practices during the transference, the acquisition, the learning
process and the outcomes’ property (knowledge, technologies and innovations) among entrepreneurial universities and industrial organisations (Darroch, 2003; Numprasertchai and Igel, 2005); and enables informal mechanisms for monitoring the advances across the stages of the research project (Durst and Runar Edvardsson, 2012; Venkitachalam and Willmott, 2017).

In this regard, our first research question is:

**RQ1.** How are collaborative behaviours within subsidised entrepreneurial university-industry partnerships strategically influencing knowledge management practices in emerging economies?

### 2.2 Opportunistic behaviours, subsidised partnerships, and knowledge management

Assuming that the government does not have the mechanism to identify behaviours within subsidised projects, opportunistic behaviour could appear when subsidies are perceived as the perfect substitute of the financial contribution that one or more partners should provide within a research project (Wallsten, 2000; Baldwin and Robert-Nicoud, 2007). Previous studies have associated this effect to crowding-out effects that allows stopping to spend funds during the subsidised years of a project because subsidies are enough to continue ongoing the planned R&D activities (Dimos and Pugh, 2016). In this sense, crowding out effect may come from innovation strategies based on using external funds for developing R&D activities (Fölster, 1995; Irwin and Klenow, 1996; Chen et al., 2002). These practices encompass moral hazard problems when one partner attempts to be more competitive appropriating its partners’ resources/capabilities for its benefit (Conner and Prahalad, 1996; Sutz, 2000; Klerkx and Aarts, 2013; Bäck and Kohtamäki, 2015; Frishanmar et al., 2015). At the same time, opportunistic partners take advantages of market failures, weakness institutions and asymmetries of information for obtaining resources/funds from several public programmes and external partners (Conner and Prahalad, 1996).

Based on above arguments, opportunist behaviours happen when partners tend to reduce failure/risks substituting private investment by public/external funds across time/scale of R&D projects or take more individual advantages rather than the subsidised partnership. At the beginning of any subsidised partnership, it is recommended that any partner contributes on the definition of formal controls (rules, procedures, policies and rewards) that ensure the coding, monitoring and safeguard of the knowledge (Das and Teng, 2001, p. 259), as well as, plus informal controls (norms, culture, value) that could be applied at different stages of the entrepreneurial university-industry partnership (Bijlsma-Frankema and Costa, 2005).

Consequently, when opportunist behaviours are detected, the partnership should implement the formal and informal controls until the end or dissolution of the subsidised project (Alexander et al., 2018; de Wit-de Vries et al., 2018). It will increase the cost of knowledge management and constitute a major cause of partnership instability (Williamson, 1987). For instance, opportunistic behaviour produces an appropriation effect affecting the R&D outcomes (Hottenrott and Lopes-Bento, 2016). This effect is temporal just if the company was not able to learn during the strategic knowledge management process (Söderblom and Samuelsson, 2013; Söderblom et al., 2015).

In this regard, our second research question is:

**RQ2.** How are opportunistic behaviours within subsidised entrepreneurial university-industry partnerships strategically influencing knowledge management practices in emerging economies?

### 3. Methodology

#### 3.1 Research setting and contextualisation

Research is setting in Mexico with particular emphasis on entrepreneurial universities-industries partnerships promoted by public programmes to incentive innovation. Since 2002,
the Mexican Science and Technology Law has been implemented by the National Council for Science and Technology (CONACYT) in collaboration with the Ministries of Education and Economy (Diario Oficial, 2014). During 2009–2016, the Mexican administration implemented the called “Incentive Programme for Innovation” with an investment of 2,932 millions of dollars (Guerrero et al., 2017). The purpose of this programme was encouraging growth, competitiveness, university-industry collaborations, innovations (new products/services, process) with value added to strategic sectors, and the creation/protection of intellectual property. This programme included three modalities: INNOVAPYME (technological innovation for micro, small and medium enterprises) that supported individual or collaborative projects submitted by SMEs; INNOVATEC (technological innovation for large enterprises) that supported individual or collaborative projects submitted by large enterprises; and PROINNOVA (projects innovation-oriented network) that supported collaborative projects submitted by least two universities or research centres.

3.2 Qualitative methodological design

Given the nature of the phenomenon, we design a quantitative analysis with multiple cases studies (Yin, 1984; Eisenhardt, 1989). In particular, we apply the retrospective case study that is a type of longitudinal multiple case study design in which all data are collected when the analysed events have already occurred, and the outcomes are known (Street and Ward, 2010). The criterion of selection were: entrepreneurial universities-industry partnerships should be subsidised by the incentive programme for innovation during 2009–2014; industry partners should be involved in collaboration practices with other entrepreneurial universities; the universities should be classified as entrepreneurial universities based on the criteria proposed by Guerrero and Urbano (2012); and the universities-industry partnerships should develop a project associated to the priority industries for the Mexican innovation strategy (automotive industry and footwear industry). To answer our research questions, the four entrepreneurial universities-industry partnerships were analysed in this study. By confidential agreements, we use anonym names of the participants from the automotive industry (AutoIn1 and AutoIn2), the leather and footwear industry (LeFoIn1 and LeFoIn2), as well as the entrepreneurial universities (EU1, EU2, EU3, EU4, EU5, EU6 and EU7). During September–December 2016, two managers from the automotive industry (AutoIn1 and AutoIn2) and two managers from the Leather and Footwear Industry (LeFoIn1 and LeFoIn2) were interviewed for 90 min. Furthermore, the seven entrepreneurial universities (EU1, EU2, EU3, EU4, EU5, EU6 and EU7) that participated with the four industrial organisations were identified and analysed using secondary sources of data provided by their university websites, official documents associated with the subsidised project, and one interview with at least one academic enrolled in the subsidised project (Appendix 1). Table I shows an overview of the selected cases with a description of the main characteristics.

The research protocol covered: the background of the interviewee and organisational characteristics (age, size, financial results, growth aspirations), their innovation processes (knowledge exploration/exploitation/retention, resources/capabilities), the R&D subsidies (types, number of projects, modality, per cent private/public investment), their innovation practices (types, purposes, obtained results, positive/negative experiences, continuity), the innovation outcomes (financial, intellectual and social), and their perception of collaborative/opportunistic behaviours in subsidised projects. With regard to the data analysis, the information was coded and analysed according to the patterns identified in the literature. The analysis of the encoded and triangulated data involved the search for common patterns among interviews (Yin, 1984; Eisenhardt 1989) to identify findings that were framed in the previous literature, thereby strengthening the internal validity of the research (Appendix 2). Concerning the validity (Eisenhardt, 1989), this research attempts to achieve “literal replication” (predict similar findings) and “theoretical replication” (predict contrasting results but for predictable reasons).
### Main characteristics of the industrial organisation that promoted the application Subsidies 2009–2015

<table>
<thead>
<tr>
<th>Modality</th>
<th>Industrial organisation</th>
<th>Age (years)</th>
<th>Size (employees)</th>
<th>Location</th>
<th>% ownership</th>
<th>Private (%)</th>
<th>Public (%)</th>
<th>Subsidised projects</th>
<th>Non-subsidised projects (number of collaborations with)</th>
<th>Subsidised projects’ outcomes (in average)</th>
<th>Intellectual property (outcomes)</th>
<th>Social impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNOVATEC</td>
<td>AutoIn1</td>
<td>31</td>
<td>&gt; 500</td>
<td>Centre and North</td>
<td>100% Foreign</td>
<td>71</td>
<td>29</td>
<td>11 individual and six in collaboration with EU1</td>
<td>One provider and one alliance with another enterprise</td>
<td>3% in sales</td>
<td>2 patents, 3 utility models, 1 property rights &amp; 1 thesis</td>
<td>22 new employees</td>
</tr>
<tr>
<td></td>
<td>AutoIn2</td>
<td>12</td>
<td>&gt; 500</td>
<td>Centre</td>
<td>100% Foreign</td>
<td>70</td>
<td>30</td>
<td>Eight in collaboration with EU2, EU3, EU4</td>
<td>One with EU2 &amp; 1 with a research centre</td>
<td>3% in sales</td>
<td>2 patents</td>
<td>55 new employees</td>
</tr>
<tr>
<td>INNOVAPYME</td>
<td>LeFoIn1</td>
<td>33</td>
<td>230–240</td>
<td>Centre</td>
<td>100% National</td>
<td>62</td>
<td>38</td>
<td>One individual &amp; six in collaboration with EU1, EU4, EU5, EU6</td>
<td>Two with EU1, EU4, EU5 and EU6 and with two research centres</td>
<td>30% in sales</td>
<td>2 patents, 3 utility models, 1 thesis and introduction in other sector</td>
<td>23 new employees</td>
</tr>
<tr>
<td></td>
<td>LeFoIn2</td>
<td>22</td>
<td>200</td>
<td>Centre</td>
<td>100% National</td>
<td>51</td>
<td>49</td>
<td>One in collaboration with EU7</td>
<td>One with EU7 &amp; 3 research centres</td>
<td>30% in sales</td>
<td>2 patents, 3 utility models</td>
<td>25 new employees</td>
</tr>
</tbody>
</table>

**Note:** *Aerospace industry also with the support from PROINNOVA in collaboration with five scientific organisations*

**Source:** Interviews
4. Results

4.1 Description of the selected priority industries

The automotive industry is one of the most relevant and representative industry for the Mexican economy. According to the INEGI[1] (2016), this industry produced products valuated in approximately 614,621m of pesos in 2014; representing the 47 per cent of total national production, 3.2 per cent of Mexican GDP and 18.3 per cent of manufacturing GDP. In terms of Foreign Direct Investment (FDI), this industry received around $39,319m represented 9.7 per cent of total Mexican FDI in 2015 (HSBC, 2015). According to the Mexican Automotive Industry Association, Mexico’s automotive industry will see its consolidation as one of the top countries in vehicle production and export. Concerning the main characteristics of the selected industrial organisations, AutoIn1 was founded in the first decade of the twentieth century and operated in the New York Stock Exchange. It is a multi-brand enterprise with a strong influence in the global market with more of 70 plants around the world. For instance, it is covering market segments in North America, South America, Europe, Middle East, Africa and the Asia Pacific. The core business includes designing, manufacturing, marketing, financing and servicing of different vehicles (e.g., cars, trucks, sports, electrified and luxury). For instance, the enterprise sells more than 6.6m units (around $140.6m) during 2015. Regarding AutoIn2, this organisation was founded in the nineteenth century and operated in the Frankfurt Stock Exchange. It is a multinational company with strong representativeness in more than 50 countries around the world and with the main headquarters in Europe. Since 1998, when was acquired by an important Mexican business group, this enterprise manufactures brake systems, systems and components for powertrains and chassis, instrumentation, infotainment solutions, vehicle electronics, tires and technical elastomers in several plants located in Mexico. For instance, the enterprise sells more than €39.2bn and evidenced an innovation expenditure of around €2.4bn during 2015.

The Leather and Footwear industry is integrated by around 80 large enterprises which produce 85 per cent of the total economic value of the industry and generated 46 per cent of employment of the sector too. According to the INEGI (2016), this industry produced products valuated in approximately 51,074m of pesos in 2014. In this sense, the manufacture of Mexican footwear is an important commercial activity in the national economy, which generates a highly competitive supply chain. For instance, the Footwear industry is the key actor in the leather-footwear-leather goods chain that is integrated by 7,400 establishments representing 68.4 per cent of the entire production chain (Secretaría de Economía, 2015). For this reason, the Mexican government has implemented several strategies to promote the productivity and the competitiveness of this industry. According to the Mexican Footwear Association, Mexico has the 9th place in the world rank of footwear manufacturers. Concerning the main characteristics of the selected enterprises in this industry, LeFoIn1 is a Mexican enterprise with a strong experience during the last 30 years in the tanned sector offering leather and skin leather both in the domestic and in the international market. The business core is the production of world-class footwear and supplier of automotive industries.
4.2 Strategic knowledge management influenced by collaborative behaviours within subsidised entrepreneurial university-industry partnerships in Mexico

The four interviewed managers highlighted a collaborative behaviour within their entrepreneurial university-industry partners in the development of subsidised projects (AutoIn1, AutoIn2, LeFoIn1 and LeFoIn2). The mode of knowledge varied according to the technological intensity, dimension and project. For multinational companies (AutoIn1 and AutoIn2), given their medium high-tech intensity and dimension, the mode of knowledge/technology is within their R&D departments and with specific collaboration with strategic alliances with suppliers or agents enrolled in their value chain (AutoIn1), as well as with international universities or research centres (AutoIn1 and AutoIn2). Subsidised partnerships with entrepreneurial universities (EU1, EU2, EU3 and EU4) represented a reduction of costs and new modes of knowledge generation motivated by the improvement of the production process and testing new products. Concretely, AutoIn1’s CEO explained:

 [...] our sector is very competitive, any movement is a highest risk. Therefore, we should be strategically oriented to collaborate with national and international partners to be technological updated. In our experiences, trust and sharing visions have been the key to our success or failure. We prefer to collaborate with commercial and scientific partners that understand the nature of company, our products, and our value chain. Subsidies represent for us an opportunity to improve processes, tools, equipment or introduce incremental innovations in our products. Any partnership is the best way to co-creation of value to capture clients’ satisfaction, economic profits, and positioning of our brand, our products in the domestic market [...].

For SMEs (LeFoIn1 and LeFoIn2), the perception of the subsidised partnership was associated with the idea of creating win-win conditions in the development of incremental innovation sharing risks/profits. The collaborative environment contributed on the achievement of the expectations, and long-term performance. After the subsidised partnership, LeFoIn1 started a disruptive innovation in a high-tech sector (Aerospace) with higher distance to its low-tech core sector (Leather and Footwear). In this case, the mode of generating knowledge was collaborating with the same entrepreneurial universities (EU1, EU4, EU5 and EU6) and two research centres that complemented Aerospace capabilities. This insight legitimises the role of entrepreneurial universities in the generation of innovations, spillover effects and reduction of intuitional voids in emerging economies. LeFoIn1’s CEO argued:

 [...] collaborations and subsidies allowed us to achieve our technological and performance expectations. Moreover, the development of new capabilities and the acquisition of new knowledge opened new windows of opportunities in our sector as well as new initiatives into different sectors/industries [...].

Regarding knowledge management within the entrepreneurial universities and industrial collaborations (Table II), ex ante, all partnerships defined the mechanisms (patents and licences) to protect knowledge and intellectual outcomes in initial agreement. Ex post, the mechanisms varied for minor inventions were protected with property rights (AutoIn1), utility models between three and five years (AutoIn1, LeFoIn1 and LeFoIn2), and major discoveries within the production process or designs were protected with patents between 14 and 20 years (AutoIn1, AutoIn2 and LeFoIn1). In a few cases, the cost of knowledge management was higher influenced by the lack of understanding among six partners regarding the objectives of disruptive innovations (AutoIn2 faced a negative experience based on motivations).

4.3 Strategic knowledge management influenced by opportunistic behaviours within subsidised entrepreneurial university-industry partnerships in Mexico

Almost all interviewed managers recognised opportunistic behaviour when applied for subsidies with entrepreneurial universities. CEOs recognised that their initial motivation of
## Table II: Knowledge management within subsidised university-industry partnerships

<table>
<thead>
<tr>
<th>Partners’ behaviours:</th>
<th>Models of knowledge/innovation</th>
<th>Measures of performance</th>
<th>Strategic knowledge management</th>
<th>Measures of control</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; Opportunism &gt; Collaboration</td>
<td>A higher number of individual subsidies (multinational) and with mixed collaborations for capturing external funds and with lower level of commitment</td>
<td>The performance is highly captured by the opportunist panthers</td>
<td>Rigid protection of the inventions once the behaviour is identified (patents, copyrights, intellectual property)</td>
<td>Rigid implementation of initial collaboration agreements: incentives, duties, period, ending clauses, penalties, etc.</td>
<td>Rigid and constant monitoring of behaviours Social reputation and social norms of penalisation</td>
</tr>
<tr>
<td>Mixed collaboration with commercial and scientific agents to share risks, capabilities, etc.</td>
<td>Outcomes are shared according to the initial collaboration agreement Learning process and absorptive capabilities</td>
<td>Shared property thesis utility models (&lt; 5 years) patents (&lt; 20 years)</td>
<td>Flexible implementation of the initial collaboration agreements: incentives, duties, period, ending clauses, penalties, etc.</td>
<td>Shared values, trust, culture, social reputation, legitimisation, etc.</td>
<td>Lower costs of monitoring that are shared among the partners</td>
</tr>
</tbody>
</table>

**Source:** Authors
subsidised university-enterprise partnerships were decrease costs. However, CEOs also acknowledged the returns to the society generated by the outcomes of subsidised partnerships. AutoIn2’s CEO mentioned that:

[...] directly or indirectly, we had opportunist behaviour when we decided to participate in collaborative or individual subsidies. Intrinsically, subsidies represented the best alternative to reduce the costs in a very competitive market. Our affordable lost was the amount that we received from subsidies. In our logic, in case of failure, we are assuming that the maximum amount of money that could lose the company is the amount of the subsidy. Usually, the government monitored the achievement or failure of the initial expected outcomes/impacts. However, they did not do a follow up in the creation of knowledge/technologies with public resources [...].

For instance, given the size, ownership and sector of AutoIn1 and AutoIn2, their private R&D investment is two times higher than the public R&D investment. Therefore, their costs decreased, innovations increased, intellectual capital (patents, utility models, property rights) increased, and growth impacts were less than 10 per cent in job creation and sales. Concretely, AutoIn2’s CEO explained:

[...] our subsidised projects with entrepreneurial universities generated several returns to partnership and society. The most important return to society was the generation of new employment with the incorporation of students into the company for developing their practices (it is temporary employment) and attracted talent students (long term employment). Another return was connecting our knowledge outcomes with the improvement of the quality of life in our society. Unfortunately, the legitimisation of our returns exists for us. Society still has the stigma that subsisted multinational firms are opportunistic for using public funds without understanding the other side of the coin [...].

If we consider that AutoIn1 and AutoIn2 are multinational companies located in Mexico, the impacts derived from Mexican subsidies will be accounted for their headquarters located in foreign country (North America). It could be an indicator of opportunist behaviours promoted by the government that incentive foreign companies thinking on attracting a foreign investment or improving competitiveness indicators without evaluating the quality/temporality of results. At university level, findings also show the participation of two entrepreneurial universities (EU1 and EU4) in multiple subsidised projects with different industrial organisations. Both entrepreneurial universities are multi-campus universities with a reputation in research.

5. Discussions and implications
The first insight about knowledge management is that collaboration is the mode of knowledge generation stimulated by the public administration in emerging economies. Neither theoretically nor empirically, there is no consensus about the effectiveness of incentives (Clarysse et al., 2009; Greco et al., 2016; Hall et al., 2016). The proponents consider that subsidies enhance innovation and reinforce economic growth (Garcia-Quevedo, 2004; Dimos and Pugh, 2016). The opponents argue that subsidies are not diverted to the best organisations because the selection could influence by pressure groups (Hall et al., 2016), as asymmetries of information (Callahan et al., 2012), or institutional voids (Guerrero and Urbano, 2017a). In this research, the Mexican government provided a higher percentage of the public funds to subside no collaborative projects of multinational organisations with the intention to incentive foreign investments in innovation. Adopting the public choice theory, the government may adopt an opportunistic behaviour to gain reputation about the effectiveness of programmes and to achieve competitiveness rates in their strategic sectors (Tripsas et al., 1995; Zeng et al., 2010). The available public information does not allow estimate societal, technological and economic impacts of subsidised multinational organisations. In this vein, this research contributes to the ongoing discussion about public administrations’
opportunist behaviours in emerging economies (Tripsas et al., 1995), the effectiveness of the innovation and entrepreneurial programmes (Guerrero and Urbano, 2019b), and the need of strategic knowledge management practices in the public administration.

The second insight is dual behaviours (collaborative and opportunist) among subsidised organisations. On the one hand, the paper contributes to the literature about the positive effect on knowledge production. It enhance the debate regarding collaborative behaviours among universities-industry partnerships stimulated by public R&D programmes (Zeng et al., 2010; Hall et al., 2016; Perkmann et al., 2013; Gianiodis et al., 2016; Colombelli and Quatraro, 2018) in emerging economies. On the other hand, the paper also contributes to the literature with evidence about mechanisms to identify opportunistic behaviours among subsidised partnerships. This enables the debate metrics to capture opportunism that previously were evidenced by additionally/crowding-out effects (Dimos and Pugh, 2016). The behaviour effect on knowledge management practices is moderated by the characteristics of subsidised firms (Wanzenböck et al., 2013) and entrepreneurial universities (Guerrero et al., 2016). However, dual behaviours could be prevented or controlled by the implementation of formal/informal knowledge management mechanisms (de Wit-de Vries et al., 2018). The success of these controls are observed on the quality of innovation (products, services, and process), a better innovation performance (sales, exports and revenues), production of intellectual capital (utility models, copyrights and patents) and good returns to the society (employment and spillovers). It opened an agenda for understanding the role of dual behaviours through metrics.

Several implications for the main actors involved in the Mexican innovation system emerge from our study such as policy makers, enterprise managers and university managers. For policymakers, the study presents insights about the effectiveness of public resources. The bright side, it allows evaluating the cost-benefit of this government intervention and the effects on priority industries to maintain or adjust their actions. The dark side, as a part of a competitiveness and protectionist strategy, the North American administration imposed border taxes for those American companies (most of them enrolled in Automotive Industry) that making investments or operations in Mexico (most of them received subsidies). Policy makers should understand challenges and re-define/re-incentivize the productive value chain (Dussel Peters et al., 2018), implement mechanisms to control opportunistic behaviours on potential subsidised multinationals (Takalo and Tanayama, 2010), and knowledge management practices within public administrations. For example, ex-post funding that provides a strong incentive to produce measurable output therefore subsidised organisations are closely monitored in terms of their production as well as ex ante mechanisms that allow funders to control what (research projects) and/or who (researchers) is to be supported. For enterprise managers, this study offers insights about experiences, mechanisms and practices of subsidise organisations. The bright side of collaboration evidences impacts on performance with social returns. The dark side is linked with appropriation behaviours of partners. For capturing value in long-term collaborations, is the implementation of knowledge management strategies (Söderblom and Samuelsson, 2013). For university community, the entrepreneurial university model is a good example of how modes of knowledge production are transformed. An example is collaboration practices with diverse agents involved in the entrepreneurial and innovative ecosystem to reinforce innovation activities (Guerrero and Urbano, 2016, 2017b). In fact, the outcomes of those innovation practices are also relevant to legitimise the role of entrepreneurial universities in society as well as contribution to decrease the effect of institutional voids in emerging economies.

6. Conclusions and future research
The paper aimed to analyse how behaviours within subsidised entrepreneurial university-industry partnerships are influencing knowledge management strategies in emerging economies. Setting our research in Mexico, we conclude that knowledge management helps to
collaboration partnerships to moderate the effect of dual behaviours (collaborative and opportunistic) on the expected intellectual outcomes. This research presents some limitations that provide new research opportunities. The first limitation is that this qualitative study did not include a control group (non-subsidised entrepreneurial university-industry partnerships) as a mechanism to contrasting the results obtained within our focus group (subsidised entrepreneurial university-industry partnerships). The second limitation was the definition of objective measures to approximate the collaborative and opportunistic behaviours. We need to recognise that opportunism is a negative stigma in the emerging economies and individuals avoid providing information. Future research should explore alternatives to evaluate the influenced of mixed degrees of collaborative/opportunistic behaviours in the effectiveness of public subsidies and innovation efficiency (Greco et al., 2016, 2017), as well as propose new metrics to understand the role of behaviours on strategic knowledge management within entrepreneurial universities, industrial organisations, and public administration. In this sense, multiple theoretical approaches (i.e. resource based view, opportunity cost, institutional theory, knowledge spillover, open innovation, etc) and methodological approaches (i.e. qualitative and quantitative) could help in-depth exploration about behaviours, outcomes and impacts (Kafouros et al., 2018). The third limitation is regarding the knowledge management practices influenced by institutional voids or negative externalities as corruption (Guerrero and Urbano, 2016, 2017a, b). The interviewed organisations are located in cities with higher levels of corruption that could condition the application/selection process of subsidies. It requires an in-depth analysis across regions to understand the effectiveness of university-industry cooperation (Marzucchi et al., 2015), through all stages from the submission to the justification of final outcomes. Similarly, a detailed analysis of industries by priorities requires more exploitation (Audretsch and Lehmann, 2005; Acs et al., 2009). As was identified in the automotive industry, the Mexican government has incentivized several multinational organisations for attracting foreign investment and it is relevant to analyse the socio-economic returns of R&D incentives; particularly, considering that the majority of headquarters of those organisations are located in North America.

Acknowledgements
The authors acknowledge the support from the interviewed enterprise-university partnerships. The authors also would like to thank to the anonymous reviewers for their insightful comments that contributed substantially to the development of the manuscripts. Fernando Herrera acknowledges financial support for PhD studies from Tecnológico de Monterrey. David Urbano acknowledges the financial support from the Spanish Ministry of Economy & Competitiveness (project ECO2017-87885-P), the Economy & Knowledge Department–Catalan Government (project 2017-SGR-1056) and ICREA under the ICREA Academia Programme.

Note
1. Instituto Nacional de Estadística y Geografía (INEGI).

References


HSBC (2015), *Growth of the automotive industry and impact on GDP*, HSBC.


<table>
<thead>
<tr>
<th>ID</th>
<th>Age (years)</th>
<th>Size (students)</th>
<th>Type</th>
<th>Research orientation</th>
<th>Main characteristics</th>
<th>Formal factors</th>
<th>Informal factors</th>
<th>Resources</th>
<th>Strong capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU1</td>
<td>76</td>
<td>&gt; 10,000</td>
<td>Private</td>
<td>Applied and Basic</td>
<td>Knowledge transfer normative</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EU2</td>
<td>204</td>
<td>&gt; 150,000</td>
<td>Public</td>
<td>Applied and Basic</td>
<td>Support measures for innovation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EU3</td>
<td>50</td>
<td>&gt; 30,000</td>
<td>Private</td>
<td>Basic</td>
<td>Reward system for inventors</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EU4</td>
<td>&gt; 50</td>
<td>&gt; 10,000</td>
<td>Public</td>
<td>Basic</td>
<td>Positive attitudes and culture towards entrepreneurship</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EU5</td>
<td>83</td>
<td>&gt; 150,000</td>
<td>Public</td>
<td>Applied and Basic</td>
<td>Role models</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EU6</td>
<td>280</td>
<td>&gt; 24,000</td>
<td>Public</td>
<td>Basic</td>
<td>Specialised human capital</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EU7</td>
<td>&gt; 50</td>
<td>&gt; 10,000</td>
<td>Public</td>
<td>Basic</td>
<td>Physical: TTO, incubators</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: Authors based on secondary sources and interviews
### Table AII. Data set

<table>
<thead>
<tr>
<th>Sector</th>
<th>Industrial organisation</th>
<th>Type</th>
<th>Subsidised projects</th>
<th>Period</th>
<th>Category of the incentive programme for innovation</th>
<th>Subsidised modality</th>
<th>Ext ante motives for participating in subsidised entrepreneurial university-industry partnerships</th>
<th>Ext ante expected outcomes from subsidised entrepreneurial university-industry partnerships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>AutoIn1</td>
<td>Multinational</td>
<td>4</td>
<td>2009–2012</td>
<td>INNOVATEC</td>
<td>Collaborative</td>
<td>Reduction of costs, gain competitive advantages</td>
<td>Yes – it represents our affordable lost Cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multinational</td>
<td>10</td>
<td>2009–2012</td>
<td>Individual</td>
<td>Collaborative</td>
<td>Very appropriate but with a bureaucracy cost</td>
<td>Very positive but should be regulated and do a follow up after finishing the programmes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multinational</td>
<td>2</td>
<td>2013–2015</td>
<td>Individual</td>
<td>Collaborative</td>
<td>Disruptive innovations</td>
<td>Licences Supplied and entrepreneurial universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multinational</td>
<td>5</td>
<td>2009–2012</td>
<td>INNOVATEC</td>
<td>Collaborative</td>
<td>Sharing risks, resources and lower costs</td>
<td>Yes – it is like banks that using our deposits without affecting us</td>
</tr>
<tr>
<td></td>
<td>AutoIn2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LeFon</td>
<td>LeFoIn1</td>
<td>Multinational</td>
<td>3</td>
<td>2013–2015</td>
<td>INNOVAPYME</td>
<td>Collaborative</td>
<td>Minimise risks and increase profits</td>
<td>Yes – it’s an alternative for capturing funds with a few requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMEs</td>
<td>1</td>
<td>2009–2012</td>
<td>Individual</td>
<td>Collaborative</td>
<td>Positive but with a lot of requirements</td>
<td>Positive with incremental and disruptive innovations</td>
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</tbody>
</table>

During the subsidised entrepreneurial university-industry partnerships

**Ex post evaluating the subsidised entrepreneurial university-industry partnerships**

**Ex post value captured from subsidised entrepreneurial university-industry partnerships**

(continued)
<table>
<thead>
<tr>
<th>Vision</th>
<th>Internal initiatives</th>
<th>Risk level</th>
<th>Proactivity level</th>
<th>Absorptive capacity</th>
<th>Costs of knowledge management</th>
<th>Initial expectation</th>
<th>Positive side</th>
<th>Negative side</th>
<th>Final result</th>
<th>Organisation Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoIn1</td>
<td>New plants, alliances, new business lines</td>
<td>Moderated</td>
<td>Conservative</td>
<td>Adoption of technologies that are applicable in other sectors (leather, plastics)</td>
<td>Lower</td>
<td>Development of new technology and improve process</td>
<td>Introduce new technological advances</td>
<td>Time</td>
<td>Product development, acquisition of knowledge and skills</td>
<td>Decrease of costs, increment in the efficient, achievement of all indicators</td>
</tr>
<tr>
<td>AutoIn2</td>
<td>New plants</td>
<td>Innovation programmes with incentives</td>
<td>Moderated</td>
<td>Rapid adopter</td>
<td>Based on benchmarking</td>
<td>Higher</td>
<td>Improve products and process</td>
<td>Acquisition of new knowledge and technology</td>
<td>Not aligned interests</td>
<td>Improvements in process and products</td>
</tr>
<tr>
<td>LeFoIn1</td>
<td>New sectors</td>
<td>New innovations are welcome</td>
<td>Higher risk</td>
<td>Pioneers</td>
<td>Adoption of good practices in the sector</td>
<td>Lower</td>
<td>Development of new technology</td>
<td>More talent</td>
<td>Time</td>
<td>Competitiveness</td>
</tr>
<tr>
<td>LeFoIn2</td>
<td>New markets, new products</td>
<td>Product development</td>
<td>Lower risk</td>
<td>Moderated leader</td>
<td>Adoption of good practices in the sector</td>
<td>Lower</td>
<td>Improve quality</td>
<td>Applied knowledge</td>
<td>Time</td>
<td>Quality</td>
</tr>
</tbody>
</table>

Table AII. Strategic knowledge management
About the authors

Maribel Guerrero is Professor of Entrepreneurship at the School of Business and Economics (Universidad del Desarrollo, Chile) and at the Newcastle Business School (Northumbria University, UK). Her research interests are related to entrepreneurial activities inside public (entrepreneurial universities) and private organisations (corporate entrepreneurship), their socio-economic impacts, as well as the configuration of entrepreneurship/innovation ecosystems. She participates in international research projects (e.g. the global entrepreneurship monitor, panel studies of entrepreneurial dynamics, HEInnovate initiative). Maribel Guerrero is the corresponding author and can be contacted at: maribel.guerrero@northumbria.ac.uk

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David Urbano is Professor of Entrepreneurship at the Department of Business and Researcher at the Centre for Entrepreneurship and Social Innovation Research (Universitat Autònoma de Barcelona), and ICREA-Academia Research Fellow. His research focuses on the analysis of factors affecting entrepreneurship in different contexts, using institutional economics as a theoretical framework, and combining quantitative and qualitative methodologies. He participates in several international research projects (e.g. GEM, PSED, GUESSS) and also regularly visits Haas School of Business (University of California, Berkeley).
The mediating role of knowledge exploration and exploitation for the development of an entrepreneurial university

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Roberto Cerchione
Department of Engineering, University of Naples Parthenope, Naples, Italy

Emilio Esposito
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Shashi
Chitkara Business School, Chitkara University, Rajpura, India

Abstract
Purpose – The modern knowledge-based economy acknowledges the role of the third mission of universities related to the process of knowledge transfer as a driving force to face sustainability issues, in addition to the two traditional missions focusing on research and teaching. The purpose of this paper is to investigate the relationships between internal environment, external environment, knowledge exploitation, knowledge exploration and university performance.
Design/methodology/approach – This study applies confirmatory factor analysis and structural equation modelling to test the conceptual model in the Chinese education system.
Findings – The findings confirm the higher impact of internal environment on both knowledge exploitation and knowledge exploration as compared to external environment. Knowledge exploitation is more strongly related to university performance than knowledge exploration. These results highlight the imperative role of internal university stakeholders in fostering knowledge management strategies. In addition, they encourage academicians, practitioners and policy makers to focus their attention on the impact of knowledge management models, tools and practices in universities to achieve the entrepreneurial development which, in turn, has a positive impact on individual graduates and innovation ecosystems.
Originality/value – The necessity to develop a more entrepreneurial university, as well as the lack of evidence of their development in emerging countries, highlights the need to investigate how specific factors and knowledge management processes are impacting the universities’ performance. In fact, although previous studies provide an explanation of the impact of internal and external factors on a university’s performance, contributions integrating these concepts with strategic knowledge management processes are still lacking.
Keywords Chinese education system, Entrepreneurship university, Entrepreneurial education, Entrepreneurial university performance, Knowledge exploration and exploitation, Knowledge management, Structural equation modelling (SEM), Theoretical framework, University’s third mission

Paper type Research paper

1. Introduction
In the last decades, different conceptual models have been developed in the body of literature to define the concept of “entrepreneurial university” (Etzkowitz and Leydesdorff, 1995; Clark, 1998a, b; Sporn, 1999, 2001; Kirby, 2006; O’Shea et al., 2005, 2008; Rothaermel and Hess, 2007; Carayannis and Campbell, 2009; Guerrero and Urbano, 2012; Centobelli et al., 2019). These models identify the main internal and external factors...
affecting the entrepreneurial transformation of universities and their impact on university missions. The internal factors are resources and capabilities belonging to the internal organisation of the university, whereas the external factors are formal and informal factors involving external stakeholders. Starting from the 1990s, the literature on the topic appeared to be affected by the triple helix model (Etzkowitz and Leydesdorff, 1995), the theory of entrepreneurial pathways of transformation (Clark, 1998a) and the theory of adaptation for building entrepreneurial universities (Sporn, 1999, 2001). From the 2000s, the literature was influenced by the university spinoff activity framework (O’Shea et al., 2005, 2008), the strategic actions theory (Kirby, 2006) and the entrepreneurial research university theory (Rothaermel and Hess, 2007). In more recent years, the quadruple helix model investigates the pivotal role of civil society and the media as the fourth component to model interactions between university, industry and government (Carayannis and Campbell, 2009; Carayannis and Campbell, 2010). This model justifies a societal responsibility of universities for the development of a competitive knowledge-based society. In line with this issue, the model of development of an entrepreneurial university (Guerrero and Urbano, 2012) analyses simultaneously the impact of the different factors defined in the previous models, namely, the impact of external factors (e.g. entrepreneurial governance structure, support measures for entrepreneurship, university community’s attitudes towards entrepreneurship, role models and reward system) and internal factors (e.g. human capital, status and prestige, networks and alliances) on the different university missions (teaching, research, technology transfer). These factors have an impact on the entrepreneurial university performance through a twisting learning path characterised by knowledge exploration and exploitation processes (Centobelli et al., 2019).

With these theoretical underpinnings in mind, this paper aims to develop and test a conceptual model to investigate the mediating role of knowledge exploration and exploitation on the development of an entrepreneurial university (RQ). To achieve this aim, this study included five important constructs in the conceptual framework proposed, namely, external environment, internal environment, knowledge exploitation, knowledge exploration and university performance, and further tests the relationships among aforementioned constructs through confirmatory factor analysis (CFA) and structural equation modelling (SEM). The paper takes into consideration the perceptions of the academics that are involved in the development of the entrepreneurial university to evaluate the above-mentioned relationships.

In this study, we focus on the Chinese education system as it offers interesting insights for the following reasons (Zhou and Etzkowitz, 2006; Zhou and Peng, 2008; Liu, 2012):

1. Since the late 1970s and the early 1980s, higher education in China recovered from the Cultural Revolution. Entering the end of 1990s, university system undertook an expansion strategy and over a 25 per cent gross enrolment rate.

2. Technology transfer is acquiring increasing attention as its potential for economic development. Despite technology transfer in China typically means technology movement of technology across national boundaries, national centres of technology transfer have been established by government policy in top ranking universities (e.g. Tsinghua University, Shanghai Jiaotong University, Xi’an Jiaotong University, China East University of Science and Technology, China University of Science and Technology and Sichuan University), and some universities have even launched international centres of technology transfer by themselves.

3. Creation of university-run enterprises (UREs) became a strategy of the Chinese education system and regional economic co-development in an era characterised by severe resource constraints. Under these constraints, the government is providing growing resources for the third mission of academic development.
During the early transition phases from a statist regime, the Chinese case represents a significant experiment in restructuring the relationship between the "public", the "private" and the "academic" that may be instructive to emerging countries and world regions suffering from institutional and organisational sclerosis.

UREs in China are quite different in their ownership compared to the spin-offs and start-ups created in European and American universities. A spin-off is an economic entity of academic origin that becomes an independent entity, whereas a URE is an economic enterprise that remains part of the administrative structure of the university.

The rest of the paper is organised as follows. The theoretical background and research hypotheses are reported in Section 2. The research methodology adopted is discussed in Section 3. The statistical analysis and the results are included in Section 4. Finally, conclusions and implications are presented in Section 5.

2. Theoretical background and research hypotheses

Starting from the different conceptualizations presented above in the introduction, this study adopts as conceptual framework the twisting learning path model of ambidexterity developed by Centobelli et al. (2019) to investigate the role of internal and external environment as antecedents of knowledge exploration and exploitation processes, that in turn affect university performance. In the literature, there is a debate regarding how exploration and exploitation processes have to be balanced. According to the results of Riviezzo et al. (2015), despite the balance dimension is generally calculated at a point in time, namely, the absolute difference between exploration/exploitation scale items, in the university context, the ambidexterity seems to be achieved over time. This means that investing in exploration and exploration processes simultaneously may not be most important, but rather oscillating between periods of exploration and periods of exploitation. This notion of university ambidexterity is in line with the definition of ambidexterity provided by Cao et al. (2009). The exploitation of existing capabilities is frequently necessary to explore new capabilities, which, in turn, enhances the university’s existing knowledge base. This means that exploration and exploitation processes produce a dynamic path that is like a twisting learning path crossing the different evolution phases of entrepreneurial universities (Centobelli et al., 2019). In fact, promoting entrepreneurship projects has an impact on the development of local innovation ecosystems and civil society (Klofsten and Jones-Evans, 2000; Cassia et al., 2014; Maas and Jones, 2015, 2017a, b; Centobelli et al., 2016; Elia et al., 2017; Secundo et al., 2017). This aspect reinforces the synergy and the continuous interchanges with the external environment, which, in turn, will encourage specific initiatives and policies to support the competitiveness of universities, increase the critical success factors influencing the development of the entrepreneurial university, and reduce the barriers hindering its development (Van Vught, 1999; Philpott et al., 2011; Somsuk and Laosirihongthong, 2014; Secundo et al., 2016).

In accordance with these theoretical premises, the following sections present the detailed analysis on the development of the research hypotheses.

2.1 Internal environment, knowledge exploration and exploitation

The enabling internal environment represents a critical success factor for the entrepreneurial university’s exploration and exploitation processes (Gorman et al., 1997; Guerrero and Urbano, 2011; Bodunkova and Chernaya, 2012; Urbano and Guerrero, 2013). Research emphasised that positive and responsive university leadership facilitates the exploitation and exploration of both existing and new knowledge, skills and processes (Gibb and Hannon, 2006). Meanwhile, entrepreneurial training of highly skilled personals, research collaboration and students’ involvement in decision making are the promising
practices to foster learning and creating knowledge in higher education institutions (Shane, 2004). The behaviour of managers and their focus on information and communication technologies significantly impact the process of university’s exploration and exploitation (Etzkowitz, 2003). Entrepreneurial university that comprises organisational commitment, organisational flexibility, adaptability (Gibb and Hannon, 2006), dynamic capacities, top management support, financial, technological and social capital (Guerrero and Urbano, 2011; Urbano and Guerrero, 2013) perform much better than competitors in the identification and exploration of entrepreneurial opportunities. Regular and free discussions among employees foster the external knowledge transformation and exploitation (Atkinson and Pelfrey, 2010; Guerrero and Urbano, 2011; Ahmad et al., 2016). Besides, the university age, size and structure are also associated with the tendency to exploration and exploitation (Lavie et al., 2010). According to Bramwell and Wolfe (2008), suitable entrepreneurial university environment assists in effectively managing the resource constraint problem through constantly seeking innovative ideas that further play a pivotal role in the survival of the university in a competitive environment and in complex times. However, a lack of systemic approach negatively affects entrepreneurial university exploitation (Gorman et al., 1997). Pinheiro and Stensaker (2014) emphasised that innovation in university results in renewing the traditional activities, roles, responsibilities and redistributing resources. An effective combination of research and teaching activities acts as a central engine to come and successfully introduce new learning modes (Louw and Moloi, 2013). Considering the above discussion, we hypothesise that:

_H1. Internal environment has an impact on knowledge exploration._

_H2. Internal environment has an impact on knowledge exploitation._

2.2 External environment, knowledge exploration and exploitation

Nowadays, the university needs not only to manage internal environment but also to develop and manage relationships with various stakeholders coming from public and private sector (Etzkowitz, 1983, 2016, 2017). A comprehensive understanding of entrepreneurial university’s competitors facilitates changes in existing strategies and the introduction of new courses (Gibb and Hannon, 2006; Urbano et al., 2016). Meanwhile, the pressure of globalisation is pushing the entrepreneurial university to meet global standards and find the best combination of exploration and exploitation activities (Leitch, 2006; Gibb and Hannon, 2006). Nevertheless, regular environmental turbulence negative affects the exploration efforts as it devalues existing knowledge as well as degrades new knowledge created through exploration (Kim and Rhee, 2009). Also, local governments encourage innovation projects and thus significantly influence organisations’ predisposition toward exploration or exploitation processes (Atkinson and Pelfrey, 2010). Etzkowitz (2003) also illustrated the effect of exogenous factors on entrepreneurial university exploitation. Besides, economic regulations and international policies also affect the entrepreneurial university exploitation (Urbano et al., 2016). By the above discussion, the following two hypotheses can be formulated:

_H3. External environment has an impact on knowledge exploration._

_H4. External environment has an impact on knowledge exploitation._

2.3 Knowledge exploration and university performance

For the entrepreneurial university, both the exploration and exploitation are important activities to achieve paramount performance. Previous research suggests that the effective
combination of exploration and exploitation significantly impact entrepreneurial university performance (Deluyi et al., 2014; Ahmad et al., 2016).

In this context, the exploration encourages entrepreneurial university experimentation, such as start new courses which ultimately generate competitive advantage and improve overall performance (Amiri et al., 2009; Carlsson et al., 2009). Similarly, entrepreneurial university continuously reconfigures and adapts their competences to the dynamic business environment through exploration activities (Etzkowitz, 2017). Carlsson et al. (2009) reported that exploration activities are positively associated with the entrepreneurial firm’s innovativeness and improvement. This leads entrepreneurial universities to identify new opportunities to grow and maximise their profit (Nelles and Vorley, 2011; Vorley and Nelles, 2008) and improve their research, teaching performance (Audretsch et al., 2006; Mueller, 2006).

However, the performance outputs associated with exploration are uncertain in short run, but it leads towards paramount performance outcomes in the long run (Lavie et al., 2010). Gibb and Hannon (2006) investigated how the university can easily handle the pressure of globalisation through exploration of new knowledge and opportunities. Furthermore, the university can develop novel research partnership and also promote interaction with the community which can be beneficial for both entrepreneurial university and society (Wright et al., 2004). Considering the above discussion, we hypothesise that:

H5. Knowledge exploration has an impact on university performance.

2.4 Knowledge exploitation and university performance
Entrepreneurial university competency in the industry is fully associated with how effectively they can utilise existing resources (Hark, 2016). Exploitation boosts university performance through refining, upgrading and controlling existing skills and practices of the entrepreneurial university (Kalair and Antonicic, 2015; McClure, 2016) to build capacity for growth and prevent firm from uncertain environment changes (Louw and Moloi, 2013). Previous research claimed that exploitation activities improve operation performance and process efficiency (March, 1991) through learning-curve effects, which minimise mistakes and transactional costs and foster decision-making implementation and control (Shane, 2000). In addition, it increases the efficiency of capital and assets through improvements in available technology, capabilities and skills (Rubino and Freshman, 2005). In the same vein, exploitation develops an entrepreneurial behaviour within students (Bramwell and Wolfe, 2008). Literature highlights that exploitation affects the entrepreneurial firm’s performance in the short run. However, the effects of exploitation networks are less risky and more predictable compared with exploration (Louw and Moloi, 2013). These contributions lead us to hypothesise that (Figure 1):

H6. Knowledge exploitation has an impact on university performance.

3. Research methodology
3.1 Data collection and measures
An online survey was developed to empirically test the research framework. We used a two-step procedure for respondents’ selection: recruitment from the list of the universities involved in projects aimed to raise the research standards of high-level universities and cultivate strategies for socio-economic development (e.g. “985 Project”, “211 Project”) (first group), and recruitment using snowball sampling (second group). According to Dillman (2000), using different procedures for respondents’ selection and data collection decreases the occurrence of biases. As for the initial sample, we sent invitations to the academic community involved in technology transfer activities supporting the development of entrepreneurial universities. Further, we asked interested academicians to provide
additional contact details (e.g. e-mail address, LinkedIn profile) of other academicians in their network with expertise in the development of entrepreneurial universities. Thereafter, we sent invitations to the second group of academicians explaining the study purpose to confirm their involvement in entrepreneurial university activities. As for the preparation of the questionnaire, a draft version was built up to reflect the general objectives of the investigation. Second, a focus group involving three academicians and three staff members involved in the university’s technology transfer activities was identified to design the questionnaire. Third, the questionnaire was improved on the basis of the feedback received during discussion and the final version was tested in three pilot interviews. Suggestions emerging during the pilot interviews were included in the final version.

The final version of the questionnaire was classified into two parts: demographic and construct statements. The demographic part includes information about respondent’s gender, working experience and academic background. In the second part, measurement items related to each construct are defined. The measurement items of the constructs were adapted from earlier studied, and responses were recorded on a seven-point Likert scale. On average, it took about 10 min to properly fill the questionnaire.

We extensively surveyed the literature to come out with valid measures for five constructs, namely, external environment, internal environment, knowledge exploitation, knowledge exploration and university performance. Thereafter, valid measures tested in the previous studies were included in the questionnaire to conduct the survey.

The measures of external environment and internal environment have been adapted from Guerrero and Urbano (2012). Nine items related to different external environment aspects were selected, namely, minimal regulations for new venture creation, entrepreneurial teaching methodologies, support for technology transfer, support for start-ups, appropriate reward systems, science park, entrepreneurship role models, entrepreneurship courses for students and entrepreneurship courses for academics. In the same vein, the following eight items related to internal environment aspect were considered: human resources, university history, financial resources, university status, physical resources, university alliances, commercial resource and, university localisation.

Respondents were asked to indicate the extent of importance of these measures for their university on a seven-point Likert scale ranging between 1 (“not at all important”) and 7 (“extremely important”).

Figure 1. Conceptual framework

![Conceptual framework diagram]
The construct knowledge exploitation includes five measurement items (i.e. refined the provision of knowledge and skills, implemented small adaptations to existing knowledge and skills, upgraded current knowledge and skills for familiar technologies, strengthened your knowledge and skills to improve the efficiency of existing operating activities, enhanced its capabilities in searching for solutions to problems that are near to existing solutions rather than completely new solutions), whereas knowledge exploration includes four measurement items (i.e. bought knowledge and skills entirely new to the university, experimented with entirely new managerial skills that are important for innovation, commercialised research, strengthened innovation skills in areas where it had no prior experience). The related items were adapted from Atuahene-Gima (2005), Jansen et al. (2006) and Chen et al. (2012). Respondents were asked to indicate the extent to which their university has considered each of the following measures on a seven-point Likert scale ranging between 1 ("not at all") and 7 ("to a very great extent").

The university performance measurement items were adapted from Guerrero and Urbano (2012). Seven items were selected (i.e. generate jobseekers, promote an entrepreneurial culture, publishing papers with practical implications, generate entrepreneurs, knowledge transfer, publishing scientific papers, contribution to regional and social development), and respondents were asked to indicate the extent to which they agree that their university has achieved the following objectives on a seven-point Likert scale with 1 ("not at all") and 7 ("to a very great extent").

The above-mentioned contributions confirm that the measurement items adapted for questionnaire have theoretical support from scientific literature on the topic analysed in this study. Herein, the Appendix reports the final version of the questionnaire including all constructs and measurement items.

With these theoretical premises, a cover letter demonstrating the aim of the study and the link to the questionnaire was sent to the list of 564 academicians identified. Within the two weeks, only 137 questionnaires were returned. According to Ding et al. (1995), the sample size should be above 150 to test measurement model using SEM; thus, returned responses were not enough to test our model. Therefore, an e-mail-based reminder was sent to non-respondents. After two additional weeks, 93 more questionnaires were returned. To strengthen the generalisability of research findings, an e-mail-based reminder was sent to non-respondents. In this phase, 76 questionnaires were returned. Within three months of survey window in Summer 2018, a total of 306 responses were returned showing the 54.25 per cent response rate. However, during data screening, we found 27 unengaged responses as deviation rate was zero among responses. Therefore, these responses were excluded, and only 279 valid responses were considered for final analysis. This shows a 49.46 per cent valid survey response rate. In this line, Malhotra and Grover (1998) reported 20 per cent, and Baruch and Holtom (2008) claimed 35.5 per cent as the minimum acceptable response rate.

Table I reports the demographic characteristics of the respondents including gender, working experience and academic background. The table shows that the males’ participation was 67 per cent and females represented 33 per cent. Within our sample, 8 per cent of the respondents had less than 5 years of working experience, 16 per cent had 6–10, 27 per cent had 11–15, 21 per cent had 16–20, 14 per cent had 21–25, 9 per cent had 26–30 and 5 per cent had above 30 years of experience. In last, 23 per cent responses came from engineering and architecture area, 29 per cent from management and computer science, 9 per cent from social and legal sciences, 19 per cent from health sciences, 14 per cent from experimental science and mathematics, and 6 per cent from arts and humanities.

3.2 Non-response bias (NRB) test
Further, NRB is empirically investigated considering differences between two groups based on time period of survey responses for all variables: first half and second half (Prahinski and
According to Armstrong and Overton (1977), the second half survey responses demonstrate the opinion of non-respondents. Scholars suggested dividing the survey responses into two aforementioned groups, and further to make comparison between them using a $t$-test (Armstrong and Overton, 1977; Prahinski and Benton, 2004; Podsakoff et al., 2012). The results of the $t$-test indicated no statistically acceptance difference between two groups. Therefore, the NRB is not a concern with survey data. Same method to assess the NRB was used by Katiyar et al. (2018) and Lucianetti et al. (2018).

### 3.3 Common method bias (CMB) test

In the next step, survey responses were evaluated for the CMB. CMB is defined as a “systematic error variance shared among measured variables caused by the function of the same method or source” (Richardson et al., 2009). To check the CMB, we performed widely known Harman’s one-factor test (Herman, 1976; Podsakoff et al., 2003). In this line, researchers suggested to apply exploratory factor analysis (EFA) considering all the observed variables. CMB is anticipated to presents if EFA’s results extraction of single factor including all the observed variables, or if the first extracted factor demonstrates equal to or above 0.50 cumulative variance (Podsakoff and Organ, 1986; Podsakoff et al., 2003). In this study, EFA’s extracted five distinct factors with eigenvalues higher than 1.0. The extracted factors explain 62.533 per cent cumulative variance, and the first factor explains only 27.345 per cent variance, which is not majority as below 0.50. The same method was used by Qrunfleh and Tarafda (2014) and Gligor et al. (2016) to assess the CMB. Hence, the CMB is not considered as an issue as both defined conditions had not been met.

### 4. Analysis and results

#### 4.1 Reliability and validity analysis

According to Hair et al. (2006), prior the testing of hypnotised measurement model, it is imperative to evaluate and adjust the reliability and validity issues.

##### 4.1.1 Construct and indicator reliability

In this phase, composite reliability (CR) and corrected item-total correlation (CITC) were taken into account to perform the reliability analyses (Fornell and Larcker, 1981; Kerlinger, 1986). Nunnally (1978) recommended that
constructs' CR should be greater than 0.70. In this study, all constructs' CR values are greater than 0.70, indicating that the constructs demonstrate suitable psychometric characteristics.

Furthermore, in literature, researchers recommended that CITC should be above 0.30 (Kerlinger, 1986; Nunnally and Bernstein, 1994). In this study, CITC values related to each construct are above 0.30, thus meeting the minimum recommended threshold. From the preceding outcomes, it is pertinent to report that measurement scales were internally reliable, and thus there is no construct reliability issues pertained to the proposed measurement model.

In addition, the measurement item's reliability is assessed evaluating the loadings. Hair et al. (2010) recommended that the item's loading should be above 0.50. Table II shows that all measurement items have significant loading above 0.50, thus met the minimum item's loading requirements. Hence, it can be concluded that measurement items are statistically reliable.

4.1.2 Convergent validity. Carmines and Zeller (1979) defined construct validity as extents to which the items in an instrument measure the abstract or theoretical construct. According to the scientific literature, three parameters ensure the convergent validity: all factor loadings weights should be greater than 0.50 (Hair et al., 2006); CR values should be greater than 0.70; and the average variance extracted (AVE) should be greater than the measurement error variance for each construct (Fornell and Larcker, 1981; Hair et al., 2010).

<table>
<thead>
<tr>
<th>Latent variable</th>
<th>Indicators</th>
<th>Standardised factor loadings</th>
<th>AVE</th>
<th>CR</th>
<th>CITC</th>
</tr>
</thead>
<tbody>
<tr>
<td>External environment</td>
<td>EE1</td>
<td>0.86</td>
<td>0.556</td>
<td>0.918</td>
<td>0.733–0.809</td>
</tr>
<tr>
<td></td>
<td>EE2</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE3</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE4</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE5</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE6</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE7</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE8</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EE9</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal environment</td>
<td>IE1</td>
<td>0.73</td>
<td>0.577</td>
<td>0.916</td>
<td>0.604–0.780</td>
</tr>
<tr>
<td></td>
<td>IE2</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IE3</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IE4</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IE5</td>
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<td>IE6</td>
<td>0.82</td>
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<td></td>
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<tr>
<td></td>
<td>IE7</td>
<td>0.78</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>IE8</td>
<td>0.61</td>
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<td></td>
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<tr>
<td>Knowledge exploitation</td>
<td>KI1</td>
<td>0.73</td>
<td>0.552</td>
<td>0.860</td>
<td>0.620–0.713</td>
</tr>
<tr>
<td></td>
<td>KI2</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KI3</td>
<td>0.77</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>KI4</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KI5</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge exploration</td>
<td>KR1</td>
<td>0.68</td>
<td>0.506</td>
<td>0.803</td>
<td>0.591–0.644</td>
</tr>
<tr>
<td></td>
<td>KR2</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR3</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KR4</td>
<td>0.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University performance</td>
<td>UP1</td>
<td>0.70</td>
<td>0.511</td>
<td>0.879</td>
<td>0.617–0.764</td>
</tr>
<tr>
<td></td>
<td>UP2</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UP3</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UP4</td>
<td>0.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UP5</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UP6</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UP7</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: AVE, average variance extracted; CR, composite reliability
Here, we used CFA to check the convergent model validity (O'Leary-Kelly and Vokurka, 1998). CFA evaluates whether the measurement model reach to an acceptable fit to the data (Anderson and Gerbing, 1988). Scholars recommended three fit indices to evaluate the goodness-of-fit models: $\chi^2$/degree of freedom (CMIN/df) should be below 5; NFI, IFI, TLI and CFI values should be greater than 0.90; and RMSEA values should be less than 0.08 (Browne and Cudek, 1993; Byrne, 1994; Hu and Bentler, 1999). We linked each measurement items with their related constructs, and covariance was freely measured among the constructs. Analysis reported CMIN/df of 1.361 for the measurement which is below 5, and thus satisfies the first condition. Results indicate that NFI, IFI, TLI and CFI values are above 0.9 which satisfies the second condition. In the end, the RMSEA value of the model is 0.036, which is less than 0.08, and thus fulfills the third condition. The discussed outcomes imply a good alignment between the measurement model and data.

In addition, Table II shows that all factor loadings weights are ranging between 0.57 and 0.86, and thus statistically significant as greater than 0.50. Besides, external environment, internal environment, knowledge exploitation, knowledge exploration and university performance have 0.918, 0.916, 0.860, 0.803 and 0.879 CR values, respectively. This indicates that all CR values are greater than 0.80, and statistically acceptable. Likewise, AVE values for all constructs are above 0.05 as ranging between 0.506 and 0.577. These results confirm the convergent validity and shows that all each measurement items were approximately equally important for measuring the concept of their related constructs.

4.1.3 Discriminant validity. Subsequently, discriminant validity of the proposed framework was assessed to understand that to which extent one construct differ from other constructs within the model (Churchill, 1979). Hair et al. (2010) describe the following two parameters to achieve the discriminant validity: maximum shared variance (MSV) should be lower than AVE; and square root of AVE should be higher than inter-construct correlations. The values in Table III show good discriminant validity as all MSV are lower than AVE, and the square root of AVE is higher than inter-construct correlations. Hence, measurement model is statistically reliable and valid, and there is strong correlation between the construct and their related items in comparison to the other constructs’ items. Furthermore, Table IV reports the descriptive analysis.

4.2 Structural model and hypotheses testing
The SEM methodology, also known as second-generation multivariate model, was used to test the study’s conceptual framework. Scholars claimed that the minimum sample size for choosing the maximum likelihood method for testing the measurement model should be

<table>
<thead>
<tr>
<th>CR</th>
<th>AVE</th>
<th>MSV</th>
<th>External environment</th>
<th>Internal environment</th>
<th>Knowledge exploitation</th>
<th>Knowledge exploration</th>
<th>University performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>External environment</td>
<td>0.918 0.556 0.104</td>
<td>0.746</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal environment</td>
<td>0.916 0.577 0.216</td>
<td>0.241</td>
<td>0.760</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge exploitation</td>
<td>0.860 0.552 0.352</td>
<td>0.233</td>
<td>0.465</td>
<td>0.743</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge exploration</td>
<td>0.803 0.506 0.174</td>
<td>0.288</td>
<td>0.309</td>
<td>0.232</td>
<td>0.711</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University performance</td>
<td>0.879 0.511 0.352</td>
<td>0.071</td>
<td>0.432</td>
<td>0.593</td>
<td>0.417</td>
<td>0.715</td>
<td></td>
</tr>
</tbody>
</table>

Table III.
Validating the measurement of CFA model

Notes: AVE, average variance extracted; MSV, maximum shared variance
above 150 (Ding et al., 1995). Hence, this study meets the minimum sample size condition for maximum likelihood method.

Thus, in the analysis properties, the maximum likelihood method was selected to test the degree of relationships among the constructs (Figure 2). Goodness-of-fit of the model was tested employing the $\chi^2$ test. Analysis provided CMIN/df of 1.418 for the measurement model, which is below the recommended maximum value of 5.0 (Bagozzi et al., 1991). In addition, the statistical model fit indices are greater than 0.9, and thus meet the recommended values (IFI $= 0.957$, TLI $= 0.953$, CFI $= 0.957$ and RMSEA $= 0.039$).

As per Kline (2011), these model fit values are satisfactory and guarantee an acceptable fit between the model and the data, and therefore, the proposed model is appropriate for hypotheses testing. Further, the strength of relationships was measured taking standardised path coefficients ($\beta$) into consideration. Table V reports to $\beta$, the critical ratio (CR) and $p$-value for each casual path. The SEM model was evaluated, and the six paths were found statistically significant. Herein, Figure 2 shows the $\beta$ values for each casual path.

Analysis supported $H1$, which posited that the external environment impacts knowledge exploitation ($\beta = 0.21$, CR $= 3.409$ and $p = 0.000$). Regarding the impact of external environment on knowledge exploration ($H2$), it can be noticed that external environment significantly impacts knowledge exploration ($\beta = 0.21$, CR $= 3.113$ and $p = 0.002$). $H3$, which asserted that the internal environment impacts knowledge exploitation, was supported ($\beta = 0.44$, CR $= 6.236$ and $p = 0.000$). Similarly, $H4$, which claimed that internal environment impacts knowledge exploration, was also confirmed ($\beta = 0.28$, CR $= 3.897$ and $p = 0.000$). $H5$, which predicted that the knowledge exploitation impacts the university performance, was strongly confirmed ($\beta = 0.53$, CR $= 7.16$ and $p = 0.000$). Lastly, results support the $H6$ ($\beta = 0.30$, CR $= 4.452$ and $p = 0.000$), which stated that the knowledge exploration impacts the university performance.

The research findings allow to effectively answer the research questions of the study. In particular, the study findings propose that the favourable external and internal environment foster the knowledge exploitation and exploration. Further, the knowledge exploitation and exploration lead to attain paramount university performance in terms of knowledge transfer, entrepreneurial culture, research publications, generation of entrepreneurs and jobseekers, and contribution to regional and social development.

5. Conclusions and implications
This study aims to develop and test a conceptual model integrating the learning processes of knowledge exploration and exploitation to the previous theories used to analyse the
entrepreneurial university. To achieve this aim, this study included five constructs in the conceptual framework, namely, external environment, internal environment, knowledge exploitation, knowledge exploration and university performance, and further tests the relationships among aforementioned constructs in the Chinese education system. Particularly, we investigated to which extent external and internal environments impact
knowledge exploitation and exploration in entrepreneurial universities. Furthermore, to which extent knowledge exploitation and exploration practices impact entrepreneurial universities’ performance. The results of the study offer comprehensive understating on the topic of entrepreneurial education and interesting insights to develop more entrepreneurial universities in the context of emerging countries.

As for the research implications, this study claims that the exploitation of existing capabilities is necessary to explore new capabilities, and the exploration of new capabilities also improves the university’s existing knowledge base. External environment has equal degree of impact on both knowledge exploitation and knowledge exploration. Another interesting finding shows that internal environment has a higher impact on both knowledge exploitation and knowledge exploration as compared to external environment. This implies an imperative role of internal environment in fostering the development of entrepreneurial universities. The universities’ management must give utmost care to issues associated to internal environment. Nevertheless, the entrepreneurial universities’ managers should not ignore the importance of external environment for knowledge creation processes. Likewise, our results highlight the pivotal role of knowledge exploitation and knowledge exploration in achieving paramount entrepreneurial university’s performance. Additionally, our results stress that, even though both knowledge exploitation and knowledge exploration positively influence university performance, knowledge exploitation is more strongly related to university performance.

Further, our study suggests several managerial implications concerning the support for technology transfer, entrepreneurship courses, and minimal regulations for new venture creation, as imperative elements for balancing knowledge exploration and exploitation processes. In the same way, university alliances have a crucial role to foster knowledge transfer. Likewise, universities are acquiring an increasing role in R&D projects, innovation performance and application of innovation results, which consequently contribute to knowledge transfer, as well as to regional and social development. Universities should pay more attention to high-tech entrepreneurship. In fact, university technology transfer is attracting greater attention from high-tech industries. Nevertheless, the problem is how to balance the generation of technologies and their acquisition from the environment, how to transfer and commercialise research results and how to encourage university high-tech entrepreneurship. Another practical implication is related to the exploitation of organisational aspects. The creation of entrepreneurial centres might be useful to develop practical entrepreneurial skills. The university can create these centres, but to achieve this aim, it needs a reorganisation of several aspects. Other implications concern the difficulty to create relationships among firms, policy makers and universities. The creation of such relationships might be a complex process because it needs another type of synergy, different from innovative teaching and researching. For university management, the results emphasise a societal responsibility of universities and the necessity of direct and continuous interchanges with firms and policy makers for the development of a competitive knowledge-based society.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>B</th>
<th>CR</th>
<th>p-value</th>
<th>Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1 The external environment positively affects knowledge exploitation</td>
<td>0.21</td>
<td>3.409</td>
<td>***</td>
<td>Yes</td>
</tr>
<tr>
<td>H2 The external environment positively affects knowledge exploration</td>
<td>0.21</td>
<td>3.113</td>
<td>0.002</td>
<td>Yes</td>
</tr>
<tr>
<td>H3 The internal environment positively affects knowledge exploitation</td>
<td>0.44</td>
<td>6.236</td>
<td>***</td>
<td>Yes</td>
</tr>
<tr>
<td>H4 The internal environment positively affects knowledge exploration</td>
<td>0.28</td>
<td>3.897</td>
<td>***</td>
<td>Yes</td>
</tr>
<tr>
<td>H5 The knowledge exploitation positively affects the university performance</td>
<td>0.53</td>
<td>7.116</td>
<td>***</td>
<td>Yes</td>
</tr>
<tr>
<td>H6 The knowledge exploration positively affects the university performance</td>
<td>0.30</td>
<td>4.452</td>
<td>***</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Notes:** Standardized path coefficients = (β); CR = critical ratio. ***Indicates 0.000

Table V. Results of hypotheses testing
This study has limitations that must be acknowledged and overcome in future studies. Main limitations of this study are related to the sample size and the identification of respondents. Another limitation of this study regards the way how measures of variables have been collected. Specifically, in this study, the perception of the respondents has been used to measure university performance.

Finally, this study highlights several areas for future research to extend and generalise the findings of this analysis, identify specific policies to support the development of entrepreneurial universities in emerging countries and the potential impact on innovation ecosystems and civil society. Further studies should focus on the definition of a set of indices to measure entrepreneurial university performance and evaluate the relationships with knowledge exploration and exploitation processes. In addition, a comparative study with entrepreneurial universities operating in other education systems would be a further interesting area of research for the future. Further, it would be interesting to introduce university ambidexterity as a construct and further analyse its impact on university performance. Thus, future contributions should investigate how the university ambidexterity is achieved over time and how universities oscillate between periods of exploration and periods of exploitation to achieve synergistic benefits in the university context and meet both economic and societal needs.

References


Further reading


Appendix. Measurement items

External environment: please indicate how you perceive the importance of each of the following measures for your university on seven-point scale (1 = not at all important, 2 = low important, 3 = slightly important, 4 = Neutral, 5 = Moderately important, 6 = Very important, 7 = Extremely important) (Source: Guerrero and Urbano, 2012).

<table>
<thead>
<tr>
<th>Items</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE1</td>
<td>Minimal regulations for new venture creation</td>
</tr>
<tr>
<td>EE2</td>
<td>Entrepreneurial teaching methodologies</td>
</tr>
<tr>
<td>EE3</td>
<td>Support for technology transfer</td>
</tr>
<tr>
<td>EE4</td>
<td>Support for start-ups</td>
</tr>
<tr>
<td>EE5</td>
<td>Appropriate reward systems</td>
</tr>
<tr>
<td>EE6</td>
<td>Science park</td>
</tr>
<tr>
<td>EE7</td>
<td>Entrepreneurship role models</td>
</tr>
<tr>
<td>EE8</td>
<td>Entrepreneurship courses for students</td>
</tr>
<tr>
<td>EE9</td>
<td>Entrepreneurship courses for academics</td>
</tr>
</tbody>
</table>

Internal environment: please indicate how you perceive the importance of each of the following measures for your university on seven-point scale (1 = not at all important, 2 = low important, 3 = slightly important, 4 = neutral, 5 = moderately important, 6 = very important, 7 = extremely important) (Source: Guerrero and Urbano, 2012).

<table>
<thead>
<tr>
<th>Items</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE1</td>
<td>Human resources</td>
</tr>
<tr>
<td>IE2</td>
<td>University history</td>
</tr>
<tr>
<td>IE3</td>
<td>Financial resources</td>
</tr>
<tr>
<td>IE4</td>
<td>University status</td>
</tr>
<tr>
<td>IE5</td>
<td>Physical resources</td>
</tr>
<tr>
<td>IE6</td>
<td>University alliances</td>
</tr>
<tr>
<td>IE7</td>
<td>Commercial resources</td>
</tr>
<tr>
<td>IE8</td>
<td>University localisation</td>
</tr>
</tbody>
</table>

Knowledge exploitation: please indicate the extent to which you perceive that your university has considered each of the following measures on seven-point scale (1 = not at all, 2 = to a small extent, 3 = to some extent, 4 = neutral, 5 = to a moderate extent, 6 = to a great extent, 7 = to a very great extent) (Sources: Atuahene-Gima, 2005; Jansen et al., 2006; Chen et al., 2012).

<table>
<thead>
<tr>
<th>Items</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>KI1</td>
<td>Refined the provision of knowledge and skills</td>
</tr>
<tr>
<td>KI2</td>
<td>Implemented small adaptations to existing knowledge and skills</td>
</tr>
<tr>
<td>KI3</td>
<td>Upgraded current knowledge and skills for familiar technologies</td>
</tr>
<tr>
<td>KI4</td>
<td>Strengthened your knowledge and skills to improve the efficiency of existing operating activities</td>
</tr>
<tr>
<td>KI5</td>
<td>Enhanced its capabilities in searching for solutions to problems that are near to existing solutions rather than completely new solutions</td>
</tr>
</tbody>
</table>
Knowledge exploration: please indicate the extent to which you perceive that your university has considered each of the following measures on seven-point scale (1 = not at all, 2 = to a small extent, 3 = to some extent, 4 = neutral, 5 = to a moderate extent, 6 = to a great extent, 7 = to a very great extent) (Sources: Atuahene-Gima, 2005; Jansen et al., 2006; Chen et al., 2012).

<table>
<thead>
<tr>
<th>Items</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR1</td>
<td>Bought knowledge and skills entirely new to the university</td>
</tr>
<tr>
<td>KR2</td>
<td>Experimented with entirely new managerial skills that are important for innovation</td>
</tr>
<tr>
<td>KR3</td>
<td>Commercialised research</td>
</tr>
<tr>
<td>KR4</td>
<td>Strengthened innovation skills in areas where it had no prior experience</td>
</tr>
</tbody>
</table>

University performance: please indicate the extent to which you perceive that your university has achieved each of the following measures on seven-point scale (1 = not at all, 2 = to a small extent, 3 = to some extent, 4 = neutral, 5 = to a moderate extent, 6 = to a great extent, 7 = to a very great extent) (source: Guerrero and Urbano, 2012).

<table>
<thead>
<tr>
<th>Items</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>UP1</td>
<td>Generate jobseekers</td>
</tr>
<tr>
<td>UP2</td>
<td>Promote an entrepreneurial culture</td>
</tr>
<tr>
<td>UP3</td>
<td>Publishing papers with practical implications</td>
</tr>
<tr>
<td>UP4</td>
<td>Generate entrepreneurs</td>
</tr>
<tr>
<td>UP5</td>
<td>Knowledge transfer (patents, licenses, spin-offs)</td>
</tr>
<tr>
<td>UP6</td>
<td>Publishing scientific papers</td>
</tr>
<tr>
<td>UP7</td>
<td>Contribution to regional and social development</td>
</tr>
</tbody>
</table>

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Industry and leadership experiences of the heads of departments and their impact on the performance of public universities

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Abstract

Purpose – The purpose of this paper is to identify whether the prior industry experience (IE) or industry leadership experience (ILE) of the head might influence the department’s publication output, the ability to acquire external research funds or its entrepreneurial activities (e.g. the commercialization of research results through patents).

Design/methodology/approach – The study is based on data from 208 Austrian university departments and combines data from different sources (CVs of the heads of departments, commercial register, funding data and publication data).

Findings – The results show a positive relationship between ILE and the patent output of the departments as one indicator for the commercialization of research activities. Low positive effects of IE on the extent of third-party funding were also found. Furthermore, the scientific experience of the head of department has a positive influence on the publication output of the whole department.

Practical implications – The findings suggest that the scientific ability of researchers should be key when selecting the head of a department, due to the fact that scientific performance is still essential for most of these units. However, when universities seek to focus more strongly on other, for example, entrepreneurial activities, then additional competencies come into play. As the actual focus of universities is currently subject to change, former IE and ILE will become increasingly more important and the heads of departments will play a decisive role in the transition toward becoming an entrepreneurial university. Therefore, universities are well advised to integrate these experiences in the job specifications and to establish processes that facilitate the change from an industrial to a university job or which allow “double lives” in university and industry.

Originality/value – Previous studies have mostly investigated the role of the scientific experience of academic leaders in the research performance of their institution in later decades. This study examines the
actual relevance of previous entrepreneurial experiences of heads of departments to the departments’ research performance, the ability to acquire external research funds or their entrepreneurial activities.

**Keywords** Collaboration, Entrepreneurial university, Leadership experience, Industry experience, Third-party funds

**Paper type** Research paper

1. **Introduction**

In recent decades, a number of concepts and strategies, such as the entrepreneurial university (Etzkowitz, 2003), new public management (Leisytë and Kizniene, 2006), the third mission of universities (Zomer and Benneworth, 2011; Pinheiro *et al.*, 2015), the Triple-Helix (Etzkowitz and Leydesdorff, 2000) and the Mode 2 of knowledge production (Gibbons *et al.*, 2002) have been proposed to progressively transform universities into entrepreneurial institutions. These universities are closely linked to the demands of industry, society and governments (Etzkowitz, 2016), they are often required to diversify their funding streams (Tijssen, 2006; Slaughter and Leslie, 2001), and they are characterized by the implementation of management tools primarily known from the private sector (Peus *et al.*, 2015). As a consequence, the role of scientists has changed from truth-seeking academics to entrepreneurial actors capable of considering the practical implications of their research and matching their knowledge with innovation (Elia *et al.*, 2017; Etzkowitz and Viale, 2010). Today, polyvalent scientists are required with “double lives” in universities, industry and/or government (Etzkowitz and Viale, 2010).

This study aims to take a closer look at the “double lives” of scientists and their impact on entrepreneurial and research activities. To be more specific, with our research, we seek to identify whether prior industry experience (IE) or industry leadership experience (ILE) of the heads of departments might influence the department’s entrepreneurial activities (e.g. the commercialization of research results through patents), its ability to acquire external research funds or its publication output. While previous studies have mainly investigated the role of the scientific experience of academic leaders in the research performance of their institution in later decades (Goodall, 2006, 2009; Goodall *et al.*, 2014), research on other non-scientific experiences of academic leaders is still in its infancy. Therefore, our study concentrates on the research question:

**RQ1.** Do the IE or ILE of heads of departments impact the departments’ performance?

We address this research gap and contribute to the literature by delivering a more comprehensive model, explaining the entrepreneurial and research performance of university departments. By adding this “entrepreneurial” perspective, our research enhances the understanding of how entrepreneurial universities can improve their performance to meet the increasing demands made by industry, society and governments.

Our research methodology has been organized in several phases: First, we analyzed the literature on entrepreneurial universities and leadership of universities to understand the relationship between different scientific and non-scientific experiences and other key performance indicators. Then, we captured data from 208 Austrian university departments in the natural and technical sciences and combined data from different sources. We have collected data about the heads of departments from CVs and the commercial register, used funding data from the biannual survey by Statistics Austria and collected publication data from internal publication databases of the universities. Finally, we conducted ordinary least squares (OLS), logistic and negative binomial regression analyses to test our hypotheses and to determine the importance of our variables.

The results show a positive relationship between ILE and the patent output of the departments as one indicator for the commercialization of research activities. Low positive effects of IE on the extent of third-party funding were also found. Furthermore, the
publication output of the head of department has a positive influence on the publication output of the whole department.

Our findings have important policy implications and suggest that the scientific ability of researchers should be key when selecting the head of a department, due to the fact that scientific performance is still essential for most of these units. However, when universities seek to focus more strongly on other, for example, entrepreneurial activities, then additional competencies come into play. As the actual focus of universities is currently subject to change, we assume that former IE and/or ILE will become increasingly more important and the heads of departments will play a decisive role in the transition toward becoming an entrepreneurial university. Therefore, universities are well advised to integrate these experiences in the job specifications of heads, professors or scientists in general and to establish processes that facilitate the change from an industrial to a university job or which allow “double lives” in university and industry.

In the next section, we review the relevant literature and propose testable hypotheses. The method and data used are described in Section 3 and the results are presented in Section 4. In Section 5, we discuss our results in the context of the literature, and the implications for academia and practice are highlighted in Section 6.

2. Theoretical background and hypotheses development
The entrepreneurial university and related concepts have induced multiple transformations at universities in recent years. Changing governance structures, greater autonomy, the need to diversify funding streams and the increasing request to transfer knowledge in collaboration with different partners will require new capabilities from academic leaders (Rybnicek, 2015). In this section, we discuss important aspects of entrepreneurial universities and academic leadership on a general level, before developing our hypotheses in detail.

2.1 Entrepreneurial universities
Today’s universities play a central societal and economical role and the effort to adapt policies and practices to better translate knowledge into economic activities has increased worldwide (Etzkowitz, 2016). In contrast to traditional universities, which focused mainly on teaching (first mission) and/or research (second mission; for a concise overview of the evolution of universities since the first industrial revolution, see Elia et al., 2017), entrepreneurial universities and their members need to collaborate more strongly with industrial and governmental partners to mutually create new innovations and to foster the development of a region (Elia et al., 2017). In this sense, entrepreneurial universities can be described as those universities that deliver on their third mission (Jones et al., 2013). Therefore, the performance of universities is nowadays not only measured by indicators referring to the first two missions (such as the number of publications or the number of students), but also by indicators referring to the third mission (such as the number of patents or the share of third-party funding; Laredo, 2007) to better reflect the actual challenges.

As noted by Etzkowitz (2016), key elements of an entrepreneurial university include the endeavor to move research out of the university as protected intellectual property (IP), to organize firms within the university, and to integrate academic and business elements into new formats such as university–industry research centers. According to Tijssen (2006), entrepreneurial universities embrace an entrepreneurial and innovative spirit, promote an entrepreneurial culture, foster relationships with industry, transfer knowledge and technologies, and integrate managerial and market-related practices and tools. In other words, many universities will have to change fundamentally.

Regarding the transition from merely academic to entrepreneurial universities, Etzkowitz (2016) identifies three phases: in the initial phase, universities seek to develop their own
strategies, set their own priorities and raise their own resources. In the second phase, they actively commercialize their IP arising from their research activities. Finally, in the third phase, universities seek to play a decisive and strategic role in encouraging innovation in their region by improving the efficacy of its regional environment, often in the form of collaborations with external partners. However, universities choose very different strategies to become entrepreneurial institutions and to face present competitive challenges; for example, two important approaches are diversification and internationalization (Lombardi et al., 2019).

Interestingly, as recently shown in an exploratory case study by Lombardi et al. (2019), a university’s decision to opt for a particular strategy is also influenced by contingency factors, such as economic or historical reasons. Both strategies also have an impact on the type of transfer and commercialization activities universities focus on.

Within the university, several levels exist on which entrepreneurial patterns occur. These levels either concern the university itself, the members of the university or the interaction with the environment of the university (Röpke, 1998). Many universities have taken various actions to raise awareness among students (Secundo et al., 2017; Packham et al., 2010) as well as staff members of the need for an entrepreneurial approach. These universities promote managerial and attributional changes toward the commercialization of research findings because the entrepreneurial orientation of universities relies largely on cultural determinants, such as the managerial culture at universities, the governance culture of the higher education sector or the overarching socio-economic culture of a country (Tijssen, 2006). Eventually, universities wanting to change into entrepreneurial institutions need scientists that accept an entrepreneurial culture and embrace change (van Vught, 1999). In this changing process, academic leaders play a crucial role, particularly when managing severe changes and merging the individual scientific autonomy with new organizational goals (Bergner, 2015). Therefore, the role of academic leaders will be separately discussed in the following section.

2.2 Academic leaders

Generally, leadership is seen as the ability to lead a group of people or an organization. It is necessary to translate goals and objectives into accomplishments (Simon, 1976 as cited in Rowley and Sherman, 2003). The vast number of leadership theories can be briefly grouped into three different approaches: trait theories, which focus on the impact of a leader’s relatively stable personality traits (like the Big 5; Costa and McCrae, 1992; Judge et al., 2002); behavioral theories, which refer to different leadership styles like those in Bass and Avolio’s (1994) full-range model of leadership; and situational theories, which emphasize the various situational aspects when leading, for example Vroom and Yetton’s (1973) contingency model. Despite the existence of these different theoretical approaches, there is ample evidence that successful leadership results from the interplay of personality traits, behavior and situational aspects (Bergner, 2015; Rosenstiel, 2006).

In our study, we focus on the heads of departments. Leadership at universities is different from other institutions (Bergner, 2015). For example, faculty members often find themselves in leadership roles without even having sought them (Rowley and Sherman, 2003). Furthermore, they might see leadership tasks as a tedious duty that impedes their progress in research, simultaneously knowing that they soon have to return to a regular faculty position, which might hinder them in making proper decisions in their role as a leader (Rowley and Sherman, 2003).

Despite these differences, there are also certain similarities between leaders at universities and private companies. Academic leaders are likewise responsible for the arrangement and implementation of changes and they have to develop appropriate plans and visions, provide necessary resources, facilitate productivity and motivate staff members (Peus et al., 2015). Furthermore, they have to consider stakeholder issues and they need to take accurate decisions as well as merge organizational needs with those of their staff (Rowley and Sherman, 2003).
In the light of the new challenges, tasks and strategies that come together with the entrepreneurial university, it is evident that a more entrepreneurial mindset and business-oriented culture is needed at universities. Therefore, different management tools, more commonly used in the private sector, have already been transferred to public universities (Peus et al., 2015; Rybnicek, 2015). Similar to the implementation of new management tools, it is also to be expected that the necessary leadership skills at universities will converge with those observed in the private sector. Thus, scientists in leading positions will have to take over similar roles and duties as those leading in the private sector (Peus et al., 2015; Rowley and Sherman, 2003). Unfortunately, as reported by Gosling et al. (2009), heads of departments feel evident tensions between their roles ("social identities") as academics and as leaders. Hence, the question remains as to whether there are leaders of university departments that link these two roles in a beneficial way. With regard to this question, it is likely that those leaders who are experienced in being a leader in industry also have a certain advantage when it comes to holding a leadership position in an entrepreneurial university. This might be particularly true as scientific capabilities will increasingly merge with business-oriented and market-driven forces (Tijssen, 2006) and universities require leaders who can establish a culture of mutual understanding, respect, and trust to properly deal with the changes caused by the reorientation of universities (Sporn, 2001).

2.3 Hypotheses
Assuming that today’s universities are becoming more entrepreneurial, we believe that new characteristics are becoming increasingly important in successfully leading a department. Subsequently, we develop our hypotheses in detail, which mainly concentrate on the impact of the IE and ILE of heads of departments.

Previous research suggests that leaders of expert organizations must themselves be acknowledged experts to be accepted by their subordinates (Mintzberg, 1980; Rybnicek et al., 2016). Thus, it can be clearly argued that leaders of research universities, faculties or departments need a high reputation as a scientist. Academic leaders have to define the research agenda in collaboration with their faculty, support the junior staff and help to promote the department within the scientific community. A high scientific reputation also ensures acceptance within the faculty of the university and departments. Goodall (2006) claims that world-class scholars, not administrators, make the best leaders of research universities. In several studies, Goodall identifies a relationship between the research productivity of academic leaders and the research performance of their institution in later decades (Goodall, 2006, 2009; Goodall et al., 2014). Based on a study of universities in the UK, she found that, on average, the research quality of a university (measured by the result of the research assessment exercise) improved some years after appointing a president who is an accomplished scholar (Goodall, 2009). In another study of 58 US universities over a 15-year period, Goodall et al. (2014) found that incoming heads of departments, whose publications were highly cited, generated a positive development in the departmental research productivity.

Based on these arguments we propose the following hypothesis:

\[ H1. \text{ The publication output of the head of department is positively associated with the publication output at department level.} \]

In the context of changing funding patterns, heads of departments have to increasingly acquire research funds from various sources. In the literature, it is argued that IE and ILE are of importance for budgeting and the acquisition of external research funds. Scholars studying entrepreneurial universities, for instance, stress the role of leadership capabilities and inter-sectoral mobility in the success of acquiring third-party funds and managing research departments. Regarding ILE, scholars recently delivered empirical evidence of the effect of leadership capabilities and management practices on the performance of universities.
McCormack et al. (2014), for instance, investigated 248 heads of departments in UK universities, revealing a direct link between management practices and performance in research and teaching. Teodorescu (2000) examined the role of individual achievements (such as those who held other academic jobs and non-academic jobs) in publication productivity by studying faculty members in ten different countries worldwide. However, he reports a weak positive influence of holders of other academic jobs only in a Korean subsample.

Regarding IE, previous studies reported that inter-sectoral mobility can facilitate the building of competencies and relationships that are important for the acquisition of research projects. Concretely, IE expands the social capital, which again helps to develop and acquire research grants in collaboration with various partners. The network of the head of department represents an important resource the entire department can benefit from (Harvey et al., 2002). In addition, IE helps to build up trust in collaboration with non-academic partners and to establish a cooperative culture. Social capital of the head of department developed in previous jobs also facilitates the emergence of a common language and a better understanding of collaborative research work (Rouse et al., 1992). Furthermore, the experiences gained in non-academic jobs help heads of departments to cope with the growing complexity and interdisciplinarity of research problems (Verbree et al., 2011).

Based on these arguments we state:

**H2a.** IE of heads of departments has a positive impact on the level of third-party funding.

**H2b.** ILE of heads of departments has a positive impact on the level of third-party funding.

A number of authors claim that successful research universities are able to integrate excellent research that is also relevant to industry or can be commercialized (e.g. Godin and Gingras, 2000; van Looy et al., 2004). Ziman (1995) and Etzkowitz (2003) argue in this context that research groups ought to behave like “firms”: they offer research results on a “market” in which the “customers” are funding agencies or private firms that buy results and offer funding. Today, both the publication output as well as the capability to acquire research funds are crucial for the success of research departments, and indeed, apart from refereed publications, the acquisition of research grants is often considered a success criterion by researchers too (Massy and Wilger, 1995). Hence, university departments need to be managed in such a way as to allow excellent research on the one hand and to promote the acquisition of external funds on the other. Therefore, we assume that the scientific output of the heads of departments as well as their IE and ILE jointly contribute to the ability to acquire external research funds.

We thus adopt an integrative approach and propose:

**H3a.** The publication output of the heads of departments positively moderates the relationship between IE and the level of third-party funding.

**H3b.** The publication output of the heads of departments positively moderates the relationship between ILE and the level of third-party funding.

The nature of research outcomes is influenced by the funding structure of the university. There is a broad literature about the effect of competitively acquired research grants on research performed at the university, department and individual level (e.g. Gulbrandsen and Smeby, 2005; Hottenrott and Thorwarth, 2011). Gulbrandsen and Smeby (2005) found in their study of Norwegian professors that academics who have strong relationships with industry have a higher publication output and also generate more patents. The average number of publications is lowest in the group of academics who have not acquired third-party funds. However, Gulbrandsen and Smeby (2005) also reveal that only a small group of researchers is able to publish extensively and to apply for grants. Departments who have high levels of external funds from industry are more likely to apply for patents, to conduct consultancy projects and to create spin-off companies. Altogether, they see no
evidence that industrial projects reduce research performance due to secrecy requirements, shortage of time or incompatibility between the academic and industry culture.

Nevertheless, the acquisition of too much competitive funding may have a negative impact on research performance. For example, Conraths and Smidt (2005) point out that the dependency on competitive funding may result in quality decline and eventually put the institution at risk due to volatile income streams and insufficient cost coverage. A major handicap can also be seen in the negative impact of competitive funding on research careers (Polster, 2007). Conraths and Smidt (2005) also highlight the risk of the enormous efforts associated with the acquisition process of competitive research grants possibly restricting the career opportunities of junior scientists in particular.

A number of studies have delivered further evidence for an inverse u-shaped relationship between the amount of third-party funding and research performance. Bonaccorsi et al. (2006) analyze the impact of private funding on efficiency and find an inverse u-shape for Italian universities. In a similar vein, Schmoch and Schubert (2009) present evidence of an inverted u-shaped relationship between external funds and the total number of academic publications in a research group. More recently, Banal-Estañol et al. (2015) show that little engagement in industry-funded research has a positive impact on research output, while too many external funds show negative effects and indicate a non-linear effect.

Based on these arguments we propose:

**H4.** There is an inverse u-curved relationship between third-party funding and publication output at the department level.

Apart from traditional forms of technology transfer by means of collaborative research projects and contract research, the commercialization of research results has become increasingly important in many countries in recent years. With the implementation of the Bayh–Dole Act in 1980, US universities are allowed to file patents on inventions they elect to own for almost four decades. In the 1990s a number of European countries started to establish Bayh–Dole-type regulation to foster academic patenting, aiming to enhance the utilization of industry-relevant scientific research, contribute to economic development and job creation and to improve resource generation (Weckowska et al., 2018). Promoting the commercialization of research by the university through patenting and the generation of spin-off companies is a key pillar of the entrepreneurial university but has also been considered in the context of fostering the “third mission” activities of universities (e.g. Zomer and Benneworth, 2011; Pinheiro et al., 2015).

In Austria, the University Act 2002 changed the legal framework and allowed universities on the institutional level to claim the IP of their inventions. Prior to that, it was solely the professor’s privilege to apply for patents, although this rarely occurred. In recent years, as in many other European countries (Pinheiro et al., 2015), a number of specific promotion programmes and initiatives with targeted funding schemes have been established, supporting universities in their commercialization activities. Austrian universities established Technology Transfer Offices, created IP policies and established long-term plans and goals to become more entrepreneurial (BMWF, 2016).

We claim that IE and ILE both have a positive impact on the likelihood of generating patents as both types of occupational engagement facilitate or enable the identification of business and market opportunities. This can be argued based on the diversity hypothesis (Dietz and Bozeman, 2005), reasoning that more diversity in work experience allows researchers to develop stronger network ties, skills and access to enhanced knowledge gatekeepers, which, in turn, enables the commercialization of innovative research outputs. In one of the few studies analyzing the role of the career experience of scientists, Dietz and Bozeman (2005) found that IE measured in years had a positive impact on the patent rate.

In a related vein, recent results suggest that third-party funding is also correlated with the generation of patents (Gulbrandsen and Smeby, 2005). Interestingly, Hottenrott and
Thorwarth (2011) found that while a higher share of industry funding has no effect on the number of patents generated by professors, it has a positive impact on citations per patent. The authors see this as a quality indicator as only granted patents can receive citations.

Based on these arguments we propose the following hypotheses:

\[
\begin{align*}
H5a & \quad \text{IE of the heads of departments is positively associated with the patent output.} \\
H5b & \quad \text{ILE of the heads of departments is positively associated with the patent output.} \\
H5c & \quad \text{There is a positive relationship between third-party funding and the patent output.}
\end{align*}
\]

Our conceptual model, which comprises the above-discussed hypotheses, is depicted in Figure 1.

3. Methods and data

In this section, we provide information regarding the research method, the sample, the data collection and the data analysis. Further information is provided in the Appendices.

3.1 Research method

Our research methodology was organized in several phases. First, we analyzed the literature on entrepreneurial universities and leadership of universities in order to understand the relationship between different scientific and non-scientific experiences of heads of departments and other key performance indicators. Then, we captured our data from the national statistical office, the reporting systems of the universities, the CVs of the heads of departments, and the national commercial register to acquire meaningful data. The research method adopted to test our hypotheses was a quantitative empirical study. Considering the different types of variables, we conducted OLS, logistic and negative binomial regression analyses. Regression analyses allow, for example, the examination of the relationship between one dependent variable and several independent variables, to determine the importance of the independent variables, to investigate contingencies among the independent variables or to compare sets of independence variables (Tabachnick and Fidell, 2014).

3.2 Sample

The study is based on a sample of 208 university departments in natural and technical sciences from ten public Austrian universities. We thus covered all public universities apart from medical universities and arts universities. We focused on natural and technical
sciences as in both disciplines external funding has grown considerably in the last two decades and plays a crucial role (BMFW, 2014). Therefore, we assume that in these disciplines academic research is relevant to industry and, vice versa, IE is relevant to the university departments and their heads. Considering the organizational and governance structure of Austrian universities, departments can be considered as relevant units of observation. These departments have a large autonomy, are requested to strategically steer development and typically have 20 to 40 employees. The faculties or schools of the universities are usually too big and heterogeneous to compare them and to analyze the impact of various input variables on the output.

We considered the development of the departments over a period of three years between 2013 and 2015 and selected those departments that had the same head of department over this period of time, which was the case for 77 percent of a total of 270 natural and technical sciences departments from the ten universities. As the turnover is rather small, we did not take into account those departments that changed their heads. In Austria, the recruitment of the heads of departments is the responsibility of the universities. There exist no laws or governmental rules about the required qualifications of heads, so the universities can determine their own rules. However, today many universities consider leadership or managerial experience in the appointment of professors (e.g. Vienna University of Technology, University of Graz), following the trend to integrate these qualifications and experiences already in the job specifications of a professorship (Rybnicek et al., 2016).

3.3 Data collection

We collected data from various sources to determine our dependent and independent variables. The measurements for IE and ILE are not overlapping and capture different aspects, qualities and qualifications of the CVs and the commercial register: to determine IE, we mainly analyzed the CVs from the heads of departments. We sought CVs on the department webpages but also on additional internet sites in order to ensure up-to-date CVs. For the analyses, we developed a coding system to collect data regarding IE (excluding positions at universities, non-governmental organizations and public institutions). Additionally, we included board responsibilities from the Austrian commercial register. For ILE we analyzed the Austrian commercial register and focused here on the functions “managing director,” “owner of the company” and “authorized representatives” of the company. In this context, we analyzed the type and duration of position. ILE is measured in months (reporting day was July 31, 2017), while IE is a binary variable as it was not possible to extract the number of years from all CVs. However, for the subgroup, for which we were able to collect the exact number of years, we ran all relevant statistical tests. These tests delivered no evidence for different results or a specific effect of the length of IE. In addition, we identified the age of the heads of departments, which served as control variable.

In order to determine the publication output of the departments we used the reporting system for Austrian universities, which is defined by law, and collected data from the public research portals of the universities. We constructed a publication measure encompassing articles in journals, monographs, edited books and proceedings and used full counting. In addition, the number of patents is disclosed by the reporting system. We collected the number of total publications for all members of the departments for the years 2013 to 2015 and calculated the mean.

In addition, we collected separately the number of publications of the heads of departments and calculated a dichotomous variable with those heads that belong to the top 25 percent in terms of the publication output, investigating the impact of the top performers. We thereby aimed to control for the fact that the publications of the heads of departments are also included in the research output of the departments with the intention of being able to disentangle both effects. We normalized the number of publications taking into account the discipline.
Data about R&D expenditures are collected by Statistics Austria, which biannually conducts an obligatory survey about the public and private third-party funding sources among the university departments. We used the amount of third-party funding as a percentage of the total funding. In addition, we distinguished between public and private third-party funds as the percentage of total funding. Total funding of the departments consists of the block grants from the Federal Ministry and all other third-party funds. Third-party public funding includes funding from national and international public science and research promotion funds, with the Austrian Science Fund (FWF) and Research Promotion Agency (FFG) being the most important sources in Austria. Funds from the European Commission and the Framework Programmes are also included. Third-party private funds cover funds from private organizations, with enterprises as the most important source. We also calculated the squared value to test possible non-linear effects of funding on the publication output (Bolli and Somogyi, 2011).

In addition, Statistics Austria collects data about R&D personnel, which is used to determine the number of researches, measured as full-time equivalent, at department level. We used the data for the survey in 2013 and 2015 and calculated the mean for the three-year period.

3.4 Data analysis
Considering the different types of variables, we conducted OLS, logistic and negative binomial regression analyses. We log-transformed the publication output variable in order to meet the requirements to run an OLS regression and analyzed residuals, error terms and outliers to check for heteroscedasticity and normality of the residuals. When using total third-party funding as dependent variable, normality tests and controls of error terms delivered no concerns that test requirements were not met. However, the private third-party funds did not meet the assumption of normality to conduct an OLS regression and we hence used a binary variable, distinguishing between the top 25 percent and employing a logistic regression. In addition, the number of patents, which serves as dependent variable in one hypothesis test, had a highly skewed count data and revealed over-dispersion. We thus ran a negative binomial regression model for studying the patent output. The variables location (Vienna), discipline (technical sciences), type of university (technical university), publication performance of the head of department (top group) and IE were binary variables coded with 0 (without the defining characteristic) and 1 (with the characteristic). When integrating these dichotomous independent variables in the logistic regression and negative binomial regression models, the first category coded as 0 served as reference group. The list of the used variables and their description can be found in Appendix 1.

We controlled for size, discipline and age, which should have an impact on the output, according to the literature (Carayol and Matt, 2006). For the variable size and age, we also calculated the squared value in order to control for any possible non-linear effects (Bolli and Somogyi, 2011). In addition, we used the location of the university (= Vienna) as control, took into account the discipline (natural science vs technical sciences) and checked whether the departments belong to a technical university. In order to differentiate between the disciplines, we used the “Austrian Systematics of the Sciences” (Statistics Austria, 2013). Natural sciences cover six subfields (e.g. mathematics, physics, biology) and technical sciences cover eleven subfields (e.g. construction, mechanical engineering, electrical engineering).

4. Results
Descriptive statistics for the variables used in the study, including means, standard deviation and correlation, are provided in Appendix 2. With regard to our main variables of interest, IE and ILE, the data show that among the 208 heads of departments, 83 had prior IE and 50 had ILE lasting, on average, 60 months. In total, 54 heads of departments belong
to the top 25 percent group in relation to their publication output. Overall, 100 departments are engaged in natural sciences and 108 departments belong to technical sciences and engineering. A total of 125 departments belong to one of the three technical universities and 77 departments are part of the three universities in Vienna.

4.1 Publication performance
For the analysis of H1, we conducted a regression analysis with the publication output as dependent variable and the publication output of the heads of departments as the main independent variable. The publication output of the heads of departments is a binary variable distinguishing between individuals who belong to the top 25 percent group in terms of their publication output or those who are below this threshold. In addition, we used size, discipline, university type and age as controls. We also incorporated size and age as squared terms in order to check for possible non-linear effects.

The results show that the publication output of the head of department has a positive impact (Table I, Model 1, $b = 0.199$) on the output of the department, providing support for H1. The regression model delivers further evidence that the size of the department, the discipline and the type of university have a significant impact on publication output. As can be expected, the size of the department measured by the number of research staff has the strongest effect (Table I, Model 1, $b = 1.290$) on the publication output, also showing a non-linear effect as the squared term has negative value (Table I, Model 1, $b = -0.765$). Technical sciences and engineering departments and departments in technical universities have, on average, a lower publication output compared to other departments. The error terms in the multiple regressions were also checked for outliers and heteroscedasticity and raised no concerns.

Although we have not proposed a specific hypothesis, we also tested in a further model the impact of IE and ILE (Table I, Model 2). This model revealed no effects for either variable.

4.2 IE and ILE and the impact on third-party funding
To test H2a and H2b dealing with the effect of IE and ILE, we conducted a regression model with the share of total third-party funds (Table II). We first analyzed the effect of IE (Table II, Model 1) and then investigated the role of ILE (Table II, Model 3), including different controls. For all models we checked outliers and heteroscedasticity, which raised no concerns of them violating any assumptions. Model 1 revealed a low positive coefficient for IE. ILE revealed no effect (Table II, Model 3). However, size, discipline and the location of the department had an effect on the amount of acquired third-party funds. Larger departments and departments in

<table>
<thead>
<tr>
<th>Independent</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publication output of the head of department (top)</td>
<td>0.199***</td>
<td>0.198***</td>
</tr>
<tr>
<td>Size</td>
<td>1.290***</td>
<td>1.303***</td>
</tr>
<tr>
<td>Size²</td>
<td>-0.765***</td>
<td>-0.763***</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>-0.207***</td>
<td>-0.205***</td>
</tr>
<tr>
<td>Technical university</td>
<td>-0.178***</td>
<td>-0.169***</td>
</tr>
<tr>
<td>Vienna</td>
<td>0.054</td>
<td>0.057</td>
</tr>
<tr>
<td>Age</td>
<td>0.643</td>
<td>0.651</td>
</tr>
<tr>
<td>Age²</td>
<td>-0.578</td>
<td>-0.575</td>
</tr>
<tr>
<td>IE</td>
<td>0.046</td>
<td>0.046</td>
</tr>
<tr>
<td>ILE</td>
<td></td>
<td>-0.073</td>
</tr>
<tr>
<td>n</td>
<td>206</td>
<td>206</td>
</tr>
<tr>
<td>F-value</td>
<td>54.297***</td>
<td>43.890***</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.675</td>
<td>0.677</td>
</tr>
</tbody>
</table>

Note: ***p < 0.001

Table I. Dependent variable: publication output of the department 2013–2015 (log) (standardized β)
technical sciences and engineering have a higher likelihood of acquiring third-party funds. Universities in Vienna have lower levels of third-party funds, which are partly explained by a lower share of private third-party funding and fewer industrial companies. The age of the head of department showed no significant impact. In both models we also included the publication output of the heads of departments, which revealed no influence either. Thus, we found support for $H2a$, but have to reject $H2b$.

In addition, we tested the effect of IE and ILE on the amount of third-party funding from private sources by separate models. As the private third-party funding variable was skewed and did not meet the requirements to run an OLS regression, we conducted a logistic regression, splitting the departments into two groups. We compared the departments that had private third-party funding of more than 20 percent of total funding with the reference group that received below 20 percent. We were particularly interested in explaining the determinant for the success of the top performing departments and thus cut at 20 percent. Table III (Models 1 and 2) depicts the results of this analysis. We found a positive coefficient

<table>
<thead>
<tr>
<th>Independent</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE of the head of department</td>
<td>0.167**</td>
<td>0.175**</td>
<td>0.029</td>
<td>0.030</td>
</tr>
<tr>
<td>ILE of the head of department</td>
<td>0.329***</td>
<td>0.328***</td>
<td>0.322***</td>
<td>0.322***</td>
</tr>
<tr>
<td>Size</td>
<td>0.210***</td>
<td>0.204***</td>
<td>0.243***</td>
<td>0.244***</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>-0.189***</td>
<td>-0.186***</td>
<td>-0.212***</td>
<td>-0.210***</td>
</tr>
<tr>
<td>Vienna</td>
<td>-0.101</td>
<td>-0.101</td>
<td>-0.119</td>
<td>-0.121</td>
</tr>
<tr>
<td>Technical university</td>
<td>0.597</td>
<td>0.579</td>
<td>0.637</td>
<td>0.632</td>
</tr>
<tr>
<td>Age</td>
<td>-0.601</td>
<td>-0.581</td>
<td>-0.656</td>
<td>-0.653</td>
</tr>
<tr>
<td>Age$^2$</td>
<td>-0.007</td>
<td>-0.026</td>
<td>0.026</td>
<td>0.042</td>
</tr>
<tr>
<td>ILE × Publication output of the head of department</td>
<td>-0.031</td>
<td>-0.031</td>
<td>-0.026</td>
<td>-0.026</td>
</tr>
<tr>
<td>n</td>
<td>207</td>
<td>207</td>
<td>207</td>
<td>207</td>
</tr>
<tr>
<td>F-value</td>
<td>6.060***</td>
<td>5.374***</td>
<td>5.967***</td>
<td>4.628***</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.164</td>
<td>0.160</td>
<td>0.140</td>
<td>0.136</td>
</tr>
</tbody>
</table>

Notes: **p < 0.01; ***p < 0.001
for the effect of IE on private third-party funding, although it was not significant. We found no evidence for an effect of ILE on acquiring private third-party funds. The discipline again explains the level of private third-party funding, showing that technical sciences and engineering departments have higher levels thereof. In contrast, size, age of the head of department and type of university had no significant effect. The variable location (Vienna) reveals a strong magnitude but the term was not significant.

We further analyzed the data by conducting a nominal regression model with three categories (Group 1: above 20 percent; Group 2: between 0 and 20 percent; Group 3: 0 percent) of the independent variable private third-party funding. This model revealed that IE has a positive significant effect on the extent of private third-party funding when comparing those departments that have no private funds at all with the top private-funding group (not shown here). Thus, among the group of departments that have not acquired any private external funds, heads of departments are more likely to not have any IE either. However, an analysis showed no effect of ILE on private third-party funding.

4.3 Joint interaction of publication performance, IE and ILE and the impact on third-party funding

We were further interested in a joint effect of the publication output of the heads of departments and their respective IE and ILE (H3a and H3b). Models 2 and 4 (Table II) portray the regression results by adding an interaction term. However, neither model showed significant effects, with very small coefficients for the interaction term, and thus we can conclude that the publication output does not moderate any possible effect of IE and ILE on the likelihood of successfully acquiring third-party funds. Therefore, H3a and H3b have to be rejected.

With regard to private third-party funding, we also tested for a possible interaction effect between publication output and IE and ILE (Table III, Models 3 and 4) showing no significant results.

4.4 Inverse u-curved relationship between third-party funding and publication performance

H4 suggests that there is an inverse u-curved relationship between third-party funding and publication output of the department. We conducted a number of models by investigating the role of the total share of third-party funding on the publication output, but also studied separately the role of private and public third-party funds. We entered quadratic terms to test possible non-linear relationships. Table IV (Models 1–4) shows the results of the corresponding regression models. We found clear evidence for an inverted u-shaped effect of third-party funding on the publication output for the total (Table IV, Model 2, $b = 0.504$) and public share (Model 4, $b = 0.356$) of third-party funds. The squared terms had significant negative signs revealing the non-linear effect. However, this pattern did not hold for the private third-party funds (Table IV, Model 4). The publication output of the heads of departments again had a significant impact on the total publication output of the departments. We also included IE and ILE in these models, which showed no effect on the publication output (Table IV, Models 3 and 4). There was no interaction effect between publication output of the head of department and managerial experience either (not shown here).

4.5 IE, ILE and third-party funds and the impact on patent output

Finally, we investigated potential predictors of a department’s patent output (H5a–H5c). Due to the nature of the dependent variable number of patents, which was skewed, we ran a negative binomial regression model. Table V depicts the results with the main effect variables and control factors. ILE was entered as a binary variable in this model.
The regression analysis shows that both IE and ILE had positive coefficients, with ILE being significant on the 1 percent significant level. The ILE coefficient is 0.778. Thus, heads of departments with ILE are more likely to publish patents, which provide support for our H5b. However, H5a has to be rejected.

In addition to IE and ILE we also investigated the impact of third-party funding on the likelihood of generating patents. However, we found no support for the assertion that there is a positive relationship between third-party funding and the patent output. Neither private nor public third-party funds showed any significant impact. Therefore, H5c has to be rejected.

The discipline and location of the university had no effect on the patent output either. However, we found that the age of the head of department had a negative significant effect and the size of the department a weak positive impact on the patent output. The publication

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### Table IV.
Dependent variable: publication output of the department 2013–2015 (log) (standardized $\beta$)

<table>
<thead>
<tr>
<th>Independent</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publication output of the head of department (top)</td>
<td>0.196***</td>
<td>0.186***</td>
<td>0.177***</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>1.407***</td>
<td>1.257***</td>
<td>1.276***</td>
<td>1.239***</td>
</tr>
<tr>
<td>Size squared</td>
<td>−0.855***</td>
<td>−0.735***</td>
<td>−0.738***</td>
<td>−0.711***</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>−0.180***</td>
<td>−0.186***</td>
<td>−0.181***</td>
<td>−0.167***</td>
</tr>
<tr>
<td>Technical university</td>
<td>−0.200**</td>
<td>0.198**</td>
<td>−0.199***</td>
<td>−0.173***</td>
</tr>
<tr>
<td>Vienna</td>
<td>0.052</td>
<td>0.039</td>
<td>0.039</td>
<td>0.033</td>
</tr>
<tr>
<td>Age</td>
<td>0.821**</td>
<td>0.703***</td>
<td>0.714*</td>
<td>0.630</td>
</tr>
<tr>
<td>Age$^2$</td>
<td>−0.785**</td>
<td>−0.650**</td>
<td>−0.651*</td>
<td>−0.567</td>
</tr>
<tr>
<td>Third-party funds total</td>
<td>0.508**</td>
<td>0.504**</td>
<td>0.497**</td>
<td>0.508***</td>
</tr>
<tr>
<td>Third-party funds squared</td>
<td>−0.557***</td>
<td>−0.546***</td>
<td>−0.544**</td>
<td>0.356**</td>
</tr>
<tr>
<td>Third-party funds public</td>
<td>0.039</td>
<td>0.048</td>
<td>0.074****</td>
<td>−0.065</td>
</tr>
<tr>
<td>Third-party funds public squared</td>
<td>−0.367**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third-party funds private</td>
<td>0.023</td>
<td>0.007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third-party funds private squared</td>
<td>−0.124</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IE</td>
<td>0.039</td>
<td>0.048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ILE</td>
<td>−0.074****</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$n$</td>
<td>206</td>
<td>206</td>
<td>206</td>
<td>206</td>
</tr>
<tr>
<td>F-value</td>
<td>45.050***</td>
<td>47.206***</td>
<td>39.774***</td>
<td>33.673***</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.674</td>
<td>0.708</td>
<td>0.694</td>
<td>0.691</td>
</tr>
</tbody>
</table>

**Notes:** *p < 0.05; **p < 0.01; ***p < 0.001; ****p < 0.10

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### Table V.
Dependent variable: patents 2013–2015, negative binomial model (coefficient $\beta$)

<table>
<thead>
<tr>
<th>Independent</th>
<th>$B$</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>−15.602**</td>
<td></td>
</tr>
<tr>
<td>Third-party funding public</td>
<td>−0.003</td>
<td>0.997</td>
</tr>
<tr>
<td>Third-party funding private</td>
<td>0.011</td>
<td>1.009</td>
</tr>
<tr>
<td>Size</td>
<td>0.049***</td>
<td>1.050</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>0.215</td>
<td>1.240</td>
</tr>
<tr>
<td>Technical university</td>
<td>−0.971**</td>
<td>0.375</td>
</tr>
<tr>
<td>Vienna</td>
<td>−0.438</td>
<td>0.656</td>
</tr>
<tr>
<td>Age</td>
<td>−0.664*</td>
<td>0.509</td>
</tr>
<tr>
<td>Age$^2$</td>
<td>−0.006**</td>
<td>0.999</td>
</tr>
<tr>
<td>Publication output of the head of department (top)</td>
<td>1.347***</td>
<td>0.260</td>
</tr>
<tr>
<td>IE</td>
<td>0.205</td>
<td>0.815</td>
</tr>
<tr>
<td>ILE</td>
<td>0.778**</td>
<td>0.459</td>
</tr>
<tr>
<td>$n$</td>
<td>208</td>
<td></td>
</tr>
<tr>
<td>Likelihood ratio $\chi^2$</td>
<td>161.434***</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** *p < 0.05; **p < 0.01; ***p < 0.001
output was positively correlated with the patent output of departments, revealing that the top-performing heads of departments are able to convert ideas that can be commercialized. Technical universities were less likely to generate patents, which might be explained by specific patent policies within some universities and a weaker position in negotiating arrangements on how to deal with IP rights in third-party-funded research projects. To check the robustness of the results we also conducted a logistic regression with a binary dependent variable (having patents or not), which delivered similar findings and confirmed our results.

5. Discussion
This section provides some considerations about the scientific (5.1) and entrepreneurial experiences (5.2) of heads of departments and some characteristics of departments (5.3) and their impact on research performance and entrepreneurial activities. Table VI summarizes the findings from the validation of our hypotheses. In line with recommendations of the American Psychological Association (2013), we reported all tested hypotheses in order to avoid selective reporting and thus to strengthen the explanatory power of the entire study.

5.1 Scientific experience of the heads of departments
We found evidence that the research performance of the head of department has a positive impact on the total research performance of his or her department. This result is in line with Goodall’s findings, which also revealed a positive relationship between the research ability of presidents and heads and the future research performance of their institutions (Goodall, 2006, 2009; Goodall et al., 2014). Goodall et al. conclude in their research that better researchers may have a better inherent knowledge about academe and about the organization’s core business, that they may have a better status, more credibility and greater respect within the scientific community, and that their appointment sets the academic standards and signals the institution’s priorities. In this context, it is necessary to bear in mind that universities are expert organizations with highly qualified specialists – the scientific researchers – as employees. Leaders of such organizations must themselves be acknowledged experts to be accepted by those who work under them and to gain power to lead them (Mintzberg, 1980; Rybnicek et al., 2016). Hence, a good scientific performance of the heads of departments seems to be the necessary basis to successfully lead and manage a department.

<table>
<thead>
<tr>
<th>Independent variable(s)</th>
<th>Dependent variable(s)</th>
<th>Results</th>
<th>Other results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>H1</strong></td>
<td>Publications of the head</td>
<td>Publication output of the department</td>
<td>Supported</td>
</tr>
<tr>
<td>a. IE of the head</td>
<td>b. ILE of the head</td>
<td>Third-party funds of the department</td>
<td>a. Supported b. Rejected</td>
</tr>
<tr>
<td><strong>H2</strong></td>
<td>a. Publications of the head</td>
<td>Third-party funds of the department</td>
<td>a. Rejected b. Rejected</td>
</tr>
<tr>
<td>b. Publications of the head x ILE of the head</td>
<td>Third-party funds of the department</td>
<td>a. Rejected b. Rejected</td>
<td>Size, university type and discipline have an impact on third-party funds</td>
</tr>
<tr>
<td><strong>H3</strong></td>
<td>Third-party funds of the department</td>
<td>Publication output of the department</td>
<td>Supported</td>
</tr>
<tr>
<td>a. IE of the head</td>
<td>b. ILE of the head</td>
<td>Patent output of the department</td>
<td>a. Rejected b. Supported c. Rejected</td>
</tr>
<tr>
<td>c. Third-party funds of the department</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table VI. Overview of the results
Entrepreneurial experience of the heads of departments

However, not every good scientist is a good leader (Goodall, 2009) and the scientific ability of leaders might only be a proxy for some other talent that is useful to leaders (Goodall, 2006). Expert leaders, such as the heads of departments, must certainly have expertise in other non-scientific areas too, which they might already have proven on their way to the top positions of a university (Goodall, 2009). Thus, if good scientific performance is only the foundation, which characteristics, talents or expertise are necessary beyond that? As mentioned in the literature review, entrepreneurial universities have to translate knowledge into economic activities (Etzkowitz, 2016), they have to deliver on their third missions (Jones et al., 2013), foster relationships with industry and they have to integrate managerial and market-related practices and tools (Tijssen, 2006). Leaders play a crucial role in this transition as they are responsible for the implementation of changes (Peus et al., 2015) and serve as entrepreneurial role models, and they must be able to identify business opportunities (Kirby et al., 2011).

Hence, we assumed that it is the IE and ILE of the heads of departments and hypothesized that those experiences should impact scientific and entrepreneurial key aspects such as the departments’ potential to acquire third-party funds or the departments’ patent output. With regard to the impact on third-party funding, our investigation revealed a low positive effect for IE. However, ILE had no effect and we further found no support that the publication performance of the heads of departments jointly interacts with the IE and ILE to be positively associated with the level of third-party funding. This leaves us with the question, does ILE generally not pay off in an academic environment? In this regard, we found evidence that ILE affects the patent output of departments. Presumably, heads of departments with ILE are more likely to take a possible route of commercializing research results. Therefore, our results suggest that entrepreneurial universities can profit from a head of department with IE in those activities, which Etzkowitz (2016) summarizes as the initial phase of entrepreneurial universities (e.g. raising additional resources). However, if universities seek to enter in the second phase of Etzkowitz’s (2016) classification, i.e. taking an active role in commercializing the IP of its members, the ILE of heads gains in importance.

Hence, for the interpretation of our results we have to differentiate between academic engagement and commercialization. Perkmann et al. (2013) describe academic engagement as a way to transfer academic knowledge to industry through collaborative research, contract research, consulting or informal activities, while they see the focus of commercialization as being primarily on gaining financial rewards. Contrary to patents, licensing or other entrepreneurial activities, the acquisition of third-party funding is not about reaping money. It is about accessing resources to support the scientists’ research agenda (Perkmann et al., 2013); a way to finance the own research, to maintain the required infrastructure or to employ research assistants. Patents, on the other hand, are aimed predominantly at making profit from research results. The protection of IP is a key element of entrepreneurial universities (Etzkowitz, 2016) and researchers must evaluate what ideas may be commercially valuable and seize opportunities to develop inventions that can be patented (Perkmann et al., 2013). Apparently, heads of departments with former ILE are more acquainted with this challenge or they are more likely to see and take the chance to apply for a patent and commercialize the own scientific research. Thus, our results are in line with Kirby et al. (2011), who postulate that nowadays university leaders must be capable of identifying business opportunities, and with Balconi and Laboranti (2006) who claim that researchers in applied fields must be intimately familiar with industry and industrial technology. Therefore, our results support the assumption that it is particularly advantageous for the commercialization of academic knowledge to have had ILE in the past.
5.3 Characteristics of departments

There are some further results, which we want to discuss critically in the following paragraphs. Regarding the characteristics of university departments, our results reveal some interesting relationships, which need further research. First, we found support for an inverse u-shaped relationship between external funding and the publication performance specifically for the public third-party funds. These findings are also in line with the studies of Bonaccorsi et al. (2006) and Schmoch and Schubert (2009). Bonaccorsi et al. (2006) found that in the first place productivity improves through collaboration with industry, but beyond a certain level the engagement in such collaborations may be too demanding and subsequently deteriorates the publication profile. They argue that universities initially benefit from more resources provided by industry. However, according to the authors, their preliminary results also suggest that at least for some institutions a trade-off applies when being exposed to industry requests, which eventually may reduce publication productivity. Similarly, Schmoch and Schubert (2009) reported that the acquisition of third-party funds may affect research efficiency negatively, especially if the level of third-party funds is already very high. The authors furthermore assume that different third-party types cause different effects. A result that is likewise supported by our findings, as private and public third-party funds revealed different effects. Second, the size of a department has an effect, but the question remains as to whether there is an “optimal” size for departments. Third, the location of a university plays a role but, contrary to other sectors, it must not be a metropolitan area. In fact, many successful universities (and not only the investigated ones) are located in smaller cities. Obviously, other factors are crucial for successful universities and future research might take a closer look at the location of universities and research performance. Finally, we found evidence that the discipline is an important factor in explaining the publication output as well as the third-party funding. Technical sciences and engineering departments and departments in technical universities have, on average, a lower publication output compared to other departments. On the other hand, these departments generate more third-party funds. However, this does not hold for the private funds. In general, technical sciences departments are often more applied in contrast to natural science departments and have closer relationships with industry. Moreover, technical universities generate fewer patents. This might be due to their having specific patent policies, with a more focused orientation toward patenting only in promising fields, which in the end results in a smaller number of patents.

6. Conclusions and implications

Today’s universities are confronted with increasing demands from industry and society (Pritchard et al., 2016). To meet these new requirements, universities have to reconsider their research and teaching focus, to adapt their funding sources and to adjust their internal rules and organization (Rybnicek and Königsgruber, 2019; Kailer, 2009; Elia et al., 2017). These changes also influence the necessary competencies and characteristics of academic leaders. Our study contributes to the literature by investigating whether prior IE or ILE of the heads of departments might influence the departments’ publication output, the ability to acquire external research funds or their entrepreneurial activities (e.g. the commercialization of research results through patents). Our research has several implications.

6.1 Theoretical implications

The paper at hand provides a more comprehensive model, explaining the performance of university departments. We found evidence that different experiences of the head stimulate the productivity of the department regarding its scientific and entrepreneurial activities. Depending on the actual focus of the university, this may influence the recruitment process and the necessary job qualifications of heads in the near future (see also the practical implications).
Most importantly in this context, our results suggest that new rankings are required to measure and compare universities and their scientists. If – and this is not set in stone – universities are to be more entrepreneurial and focus increasingly on their third mission, the other two missions (research and teaching) will have to be reduced in their importance. Eventually, the scientific capability of heads in particular, or scientists and professors in general, will become less important compared to today. This has multiple theoretical implications regarding the measurement of academic performance. Therefore, our results support Etzkowitz’s (2016) demand that the dominant metrics to determine university rankings and performance need revision. New measuring parameters have to be included while simultaneously balancing with the existing ones. However, our results regarding the inverse u-shaped relationship between external funding and publication performance also indicate how challenging this task might be. An increasing number of researchers, like Schmoch and Schubert (2009), advocate that third-party funds do not work well as performance indicators and therefore should be used only with great care. Although our findings support this conclusion, more research is needed to understand the relationship between the acquisition of third-party funds and other performance indicators in research and teaching.

6.2 Practical implications

Based on our research, we also derived several practical implications. First, in line with Goodall (2009) our results suggest that the scientific ability of researchers should be key when selecting heads of departments due to the fact that scientific performance is still a key factor that characterizes those organizations. However, when universities seek to focus on other, for example, entrepreneurial activities, then other competencies come into play. Importantly, recent concepts and ideas like the entrepreneurial university (Etzkowitz, 2003), the third mission of universities (Zomer and Benneworth, 2011), or the Triple-Helix (Etzkowitz and Leydesdorff, 2000) indicate that the actual focus of universities is currently subject to change. Similar to the changes in other sectors, the adoption of business logic will influence the universities’ habits of working, their modes of organizing activities and their orientation (Poutanen and Kovalainen, 2016). If these developments continue, the cards are likely to be reshuffled and former IE and ILE will become more important. We therefore believe, that the heads of departments will play a decisive role in the transition toward becoming an entrepreneurial university, and universities are well advised to integrate these qualifications and experiences in the job specifications of heads, professors or scientists in general.

Second, the entrepreneurial university requires scientists that can handle the demands of both universities and economy. In that regard, Etzkowitz and Viale (2010) refer to scientists with double and even triple lives in university, industry and government. Scientists with experiences outside the university will be capable of adapting quickly to changes introduced by the entrepreneurial university. The traditional “truth-seeking scientist” evolves toward the “entrepreneurial scientist,” linking virtuously knowledge and innovation (Etzkowitz and Viale, 2010; Elia et al., 2017). Our results suggest that heads of departments with ILE are better equipped to commercialize research findings and face the demands of the market. Hence, universities should create environments and processes that allow such double lives – for example, through part-time jobs (or even part-time professorships) or by facilitating the change from an industrial to a university job.

Third, the ambition to collaborate with industry and other non-scientific partners is both an opportunity and a risk for researchers. It certainly offers new possibilities and additional resources to enhance research productivity, but in some cases the requirements and expectations of industry partners might also become too demanding, which eventually impedes pure research (Bonaccorsi et al., 2006). As a matter of fact, in many scientific disciplines the researchers’ careers are still dependent on their ability to be published.
Therefore, when excessive third-party projects negatively influence the publication performance of researchers, in the long run this can have severe consequences, especially for junior scientists (Conraths and Smidt, 2005). This is supported by our results. We found that the IE of heads of departments positively impacts the departments’ third-party acquisition. However, after a given third-party level, the departments’ publication output can diminish. Hence, to protect the own scientific staff members it seems an important leadership task of those heads not to overdo the own ambitions regarding third-party projects. With this in mind, there are good reasons to be careful when implementing the acquisition of third-party funds as performance indicator (Schmoch and Schubert, 2009), and this applies to individual researchers (e.g. as criterion in tenure track positions) as well as entire departments (e.g. in performance agreements).

Lastly, our results support the idea of encouraging scientists to acquire leadership skills and leadership experiences. Recent research suggests that the motivation to lead significantly influences how well a leader performs (Bergner et al., 2019). This motivation is influenced by the individual’s interests and previously gained leadership experience (Bergner et al., 2019). However, way too often scientists end up in leadership roles without even seeking them (Rowley and Sherman, 2003). Our results show that the performance of the whole department might be influenced by the leadership experiences of its head. Therefore, policymakers should strive to support scientists to be more motivated in their roles as leaders and to gain leadership experience.

6.3 Limitations and final remarks
When interpreting the results of this study one has to bear in mind the limitations. We have measured the publication output of the institutes but have not measured the impact of research, as for instance by citations. We focused our research on natural sciences, technical sciences and engineering and the results can thus not be generalized to other disciplines. Moreover, we have excluded heads of departments who did not consistently carry out their position from 2013 to 2015, though this could have had an influence on our results. We have not dealt with dynamic effects. Such effects could occur, for instance, as more efficient researchers might more successfully acquire external funds, which further strengthen their capacity to publish and attract additional third-party funds. We have not considered experiences in the public sector or in non-profit organizations, as we assume that entrepreneurial universities increasingly align with requirements, tools and skills more commonly associated with the private sector. However, future studies might investigate whether there are also significant effects for other sectors. We investigated the relationship between third-party funding and publication output over a three-year period. As many departments are of a considerable size, with a number of researchers publishing and acquiring research funds simultaneously, we assume that the results are robust over time. In this context, we also ran some models with a time lag between the explanatory and dependent variable, which revealed no diverging results. However, time-lagged models might be used in future research to better deal with the reverse causality problem. We have used two categories for third-party funding, i.e. public and private funds, which capture heterogeneous funding sources. Studying different categories of funding streams in more detail might be worthwhile in a further study. Another potential limitation refers to our measurement of ILE as the number of years in supervisory positions, as experience alone does not necessarily improve the effectiveness of leaders (Bass and Bass, 2008; Fiedler, 1970). Furthermore, we are not able to draw any conclusions about the career choice of the heads of departments and possible motives for their change from industry to university. Moreover, we measured only the number of patents as one form of commercializing scientific findings; however, it might also be of interest to investigate the impact of spin-off companies.
Note
1. University of Vienna, University of Graz, University of Innsbruck, University of Salzburg, Vienna University of Technology, Graz University of Technology, Montan University of Leoben, University of Natural Resources and Life Sciences of Vienna, University of Linz, University of Klagenfurt.

References


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**Corresponding author**

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(The Appendix follows overleaf.)
### Appendix 1

<table>
<thead>
<tr>
<th>Independent</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>Source</th>
<th>Description</th>
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<tr>
<td>Publication output of the head of department</td>
<td>0.25</td>
<td>0.44</td>
<td>0</td>
<td>1</td>
<td>Research portal</td>
<td>Publications, monographs, edited books and proceedings</td>
</tr>
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<td>Publication output of the department</td>
<td>66.02</td>
<td>64.41</td>
<td>0.33</td>
<td>378.33</td>
<td>Research portal</td>
<td>Publications, monographs, edited books and proceedings</td>
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<tr>
<td>Patents</td>
<td>1.32</td>
<td>3.91</td>
<td>0</td>
<td>34</td>
<td>Research portal</td>
<td>Number of patents</td>
</tr>
<tr>
<td>Third-party funding total</td>
<td>30.47</td>
<td>13.06</td>
<td>0.00</td>
<td>67.26</td>
<td>Statistics Austria</td>
<td>Data from 2013 to 2015</td>
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<tr>
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<td>0.00</td>
<td>59.17</td>
<td>Statistics Austria</td>
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</tr>
<tr>
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<td>9.87</td>
<td>0.00</td>
<td>42.87</td>
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<td>Data from 2013 to 2015</td>
</tr>
<tr>
<td>Size</td>
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<td>15.40</td>
<td>1.01</td>
<td>101.35</td>
<td>Statistics Austria</td>
<td>Data from 2013 to 2015</td>
</tr>
<tr>
<td>Technical sciences</td>
<td>0.52</td>
<td>0.50</td>
<td>0</td>
<td>1</td>
<td>Statistics Austria</td>
<td>52% (108) of the departments belong to technical sciences and engineering</td>
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<tr>
<td>Vienna</td>
<td>0.37</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
<td>Statistics Austria</td>
<td>3 out of the 10 universities are located in Vienna, 77 departments (37%) are part of the 3 universities in Vienna</td>
</tr>
<tr>
<td>Technical university</td>
<td>0.60</td>
<td>0.48</td>
<td>0</td>
<td>1</td>
<td>Statistics Austria</td>
<td>3 universities among the 10 universities are technical universities; 125 departments (60%) belong to one of the technical universities</td>
</tr>
<tr>
<td>Age</td>
<td>55.05</td>
<td>7.20</td>
<td>38</td>
<td>75</td>
<td>CV</td>
<td>Category personal data or data from the commercial register</td>
</tr>
<tr>
<td>IE</td>
<td>0.40</td>
<td>0.50</td>
<td>0</td>
<td>1</td>
<td>CV</td>
<td>Including industry/private sector experience on the CVs (after master/diploma degree) and supervisory board function according to the commercial register and excluding university jobs, non-governmental organizations or other public positions</td>
</tr>
<tr>
<td>ILE</td>
<td>0.24</td>
<td>0.43</td>
<td>0</td>
<td>1</td>
<td>Commercial register</td>
<td>Number of functions within a company or in diverse companies (owner, manager or authorized representatives of companies)</td>
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<tr>
<td>ILE in months</td>
<td>26.61</td>
<td>59.95</td>
<td>0.00</td>
<td>277.00</td>
<td>Commercial register</td>
<td>Calculated from functions (owner, manager or authorized representatives of companies) until July 31, 2017 in case of active functions</td>
</tr>
</tbody>
</table>

**Table AI.** List of variables
## Table AII. Cross-correlation among the variables

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<th>4</th>
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<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Publication output of chair</td>
<td>1</td>
<td>0.365***</td>
<td>0.247**</td>
<td>0.063</td>
<td>0.112</td>
<td>−0.064</td>
<td>0.230***</td>
<td>0.000</td>
<td>0.160*</td>
<td>0.048</td>
<td>−0.088</td>
<td>0.074</td>
<td>−0.024</td>
</tr>
<tr>
<td>2. Publication output of dept</td>
<td>0.365**</td>
<td>1</td>
<td>0.212**</td>
<td>0.171*</td>
<td>0.328**</td>
<td>−0.208**</td>
<td>0.651***</td>
<td>−0.349***</td>
<td>0.238***</td>
<td>−0.193**</td>
<td>0.060</td>
<td>0.004</td>
<td>−0.045</td>
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<tr>
<td>3. Patents</td>
<td>0.247***</td>
<td>0.212**</td>
<td>1</td>
<td>0.123****</td>
<td>0.137*</td>
<td>−0.008</td>
<td>0.369***</td>
<td>0.015</td>
<td>0.062</td>
<td>−0.052</td>
<td>−0.092</td>
<td>0.020</td>
<td>0.025</td>
</tr>
<tr>
<td>4. Third-party funding total</td>
<td>0.063</td>
<td>0.171*</td>
<td>0.123****</td>
<td>1</td>
<td>0.694***</td>
<td>0.475***</td>
<td>0.240***</td>
<td>0.229***</td>
<td>−0.173**</td>
<td>0.041</td>
<td>−0.068</td>
<td>0.253***</td>
<td>0.089</td>
</tr>
<tr>
<td>5. Third-party funding public</td>
<td>0.112</td>
<td>0.328***</td>
<td>0.137*</td>
<td>0.694***</td>
<td>1</td>
<td>−0.304***</td>
<td>0.257***</td>
<td>−0.164**</td>
<td>0.016</td>
<td>−0.149*</td>
<td>0.000</td>
<td>−0.001</td>
<td>0.024</td>
</tr>
<tr>
<td>6. Third-party funding private</td>
<td>−0.064</td>
<td>−0.196**</td>
<td>−0.008</td>
<td>0.475***</td>
<td>−0.304***</td>
<td>1</td>
<td>0.003</td>
<td>0.504***</td>
<td>−0.249***</td>
<td>0.236***</td>
<td>−0.035</td>
<td>0.349***</td>
<td>0.089</td>
</tr>
<tr>
<td>7. Size</td>
<td>0.230***</td>
<td>0.651***</td>
<td>0.369***</td>
<td>0.240***</td>
<td>0.257***</td>
<td>0.003</td>
<td>1</td>
<td>−0.114****</td>
<td>0.208**</td>
<td>0.002</td>
<td>−0.019</td>
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<td>8. Technical sciences</td>
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<td>−0.349***</td>
<td>0.015</td>
<td>0.229***</td>
<td>−0.164**</td>
<td>0.504***</td>
<td>−0.114****</td>
<td>1</td>
<td>−0.067</td>
<td>0.496**</td>
<td>−0.055</td>
<td>0.278***</td>
<td>0.121*</td>
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<tr>
<td>9. Vienna</td>
<td>0.160*</td>
<td>0.238***</td>
<td>0.062</td>
<td>−0.173**</td>
<td>0.016</td>
<td>−0.249***</td>
<td>0.208**</td>
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<td>1</td>
<td>0.157*</td>
<td>−0.019</td>
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<td>−0.193**</td>
<td>−0.052</td>
<td>0.041</td>
<td>−0.149*</td>
<td>0.236***</td>
<td>0.002</td>
<td>0.496**</td>
<td>0.157*</td>
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<td>−0.045</td>
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<td>11. Age</td>
<td>−0.088</td>
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<td>−0.002</td>
<td>−0.068</td>
<td>0.000</td>
<td>−0.005</td>
<td>−0.019</td>
<td>−0.055</td>
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<td>−0.045</td>
<td>1</td>
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<td>12. IE</td>
<td>0.074</td>
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<td>0.253***</td>
<td>0.001</td>
<td>0.349***</td>
<td>−0.024</td>
<td>0.278***</td>
<td>−0.0147</td>
<td>−0.078</td>
<td>−0.078</td>
<td>1</td>
<td>0.328***</td>
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<td>13. ILE</td>
<td>−0.024</td>
<td>−0.045</td>
<td>0.025</td>
<td>0.089</td>
<td>0.024</td>
<td>0.089</td>
<td>0.136*</td>
<td>0.121*</td>
<td>0.029</td>
<td>0.077</td>
<td>0.096</td>
<td>0.328***</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: *p < 0.05; **p < 0.01; ***p < 0.001; ****p < 0.10
Entrepreneurial academics: a taxonomy with Latent Profile Analysis

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Abstract
Purpose – The need for dynamic and innovative skills and the importance of resources and individuals in pursuit of new opportunities prove to be extremely vital for the higher education institutions (HEI). The purpose of this paper is to develop a taxonomy of academics from HEI, based on their individual entrepreneurial orientation (EO).
Design/methodology/approach – The population in study was composed of teachers and researchers from worldwide HEI. The data collection was conducted through a questionnaire sent by e-mail and the authors used the I-ENTRE-U scale to identify entrepreneurial-oriented teachers and researchers from HEI. A Latent Profile Analysis (LPA) was conducted to identify profiles of researchers with similar values in four EO dimensions.
Findings – The study allowed the authors to identify five profiles of researchers: downers, achievers, followers, defenders and rebels.
Research limitations/implications – The results can be an important starting point for other researchers and practitioners hoping to evaluate academics' EO in a higher education sector. The taxonomy also allows wider predictions about the behaviour of the profile members of profiles and relates it with other variables such as performance. Further contributions may be added by extending the data gathering from different geographical areas and/or different academic contexts, such that future studies could apply other LPA techniques and compare the results.
Originality/value – Only few studies have focused on individual EO of scientists/academics, considering different national and regional contexts. To the best of the authors' knowledge, this is the first empirical study that develops a taxonomy of academics from HEI, based on their individual EO.

Keywords Entrepreneurial orientation, Taxonomy

Paper type Research paper

1. Introduction
The complexity and turbulence of global economies and societies affect a wide variety of organizations in which higher education institutions (HEI) and universities are included. Universities are increasingly moving towards more entrepreneurial configurations in an attempt to seek more development, more innovation and more social and economic commitment (Simeone et al., 2018). Universities have been increasingly recognized as a source of entrepreneurial activity (Etzkowitz, 2001), and within these are the academics who have come to play a more prominent role in the development of a knowledge society (Etzkowitz, 2001; Davey et al., 2016; Klofsten and Jones-Evans, 2000).

With the increasing importance of knowledge transfer activities carried out by academics, a large number of investigations (Davey et al., 2016) began to use entrepreneurship...
models to study the engagement of academics in entrepreneurial endeavour, which was conceptualized as an academic entrepreneurship. In spite of the growing commitment of universities towards entrepreneurial academic activities and the popularity of the term “entrepreneurialism” (Rothaermel et al., 2007), this concept has been, according to Audretsch et al. (2002), poorly defined in the academic context, causing controversy over acceptance between the academic community and challenging what really constitutes an entrepreneurial activity.

According to Davey et al. (2016), academic entrepreneurship has been limited and broadly defined. These authors define academic entrepreneurship according to a narrow and a broad interpretation of the concept. In its narrow interpretation, academic entrepreneurship is synonymous with the commercialization of intellectual property originated from university resources (Etzkowitz, 2001) through the creation of university spin-offs (Meyer, 2003) and academic start-ups. Under this definition, the commercialization of knowledge generated by the university through new ventures is often considered a way of achieving national competitiveness (McMullan and Vesper, 1987) and innovation (Lam, 2005). In a broad definition, other authors (Klofsten and Jones-Evans, 2000) have used the term of academic entrepreneurship to represent a broader set of knowledge transfer activities, such as the academic commitment to entrepreneurial activities, in addition to their normal academic tasks, such as the introduction of novelties in teaching (Etzkowitz and Leydesdorff, 2000) and research (Louis et al., 1989). This broader definition recognizes the dynamism and heterogeneity of academics and their motivations for undertaking different entrepreneurial activities (Davey et al., 2016).

Expectations regarding the engagement of academics in entrepreneurial endeavour, in addition to their major role in teaching and research, have increased in recent years (Davey et al., 2016). At the level of government policy, the production and use of knowledge are increasingly crucial factors for the growth and competitiveness of economies (Jones-Evans, 1997; Lundvall, 1999; Spencer, 2001).

Over time, literature has been revealing a set of factors influencing the level of academic entrepreneurship. Recently, several studies (Davey et al., 2016; Wright et al., 2006) have focussed on several dimensions of the environment in which academic entrepreneurship occurs, such as the organizational context, institution of political, financial, regional strategies or structures mechanisms (Klofsten and Jones-Evans, 2000), culture (Kenney and Goe, 2004) and high-level commitment (Galvão et al., 2017). These studies coincided with an undeniable increase in the entrepreneurial behaviour of academics (Davey et al., 2016; D’Este and Perkmann, 2011).

In this context, university business links are stimulated through a wide range of financing options available for such cooperation (Wright et al., 2006). This puts additional pressure on universities to realize these opportunities in their environment, bridging the gap between industry and universities (Mowery and Shane, 2002) and to generate additional economic returns (Shane and Stuart, 2002).

Audretsch (2014) argues that the role of universities extends beyond the generation of technology transfer (e.g. patents, spin-offs and start-ups) to broader roles such as contributing and providing leadership to create entrepreneurial thinking, institutions and entrepreneurial capital. A recent work of Pugh et al. (2018) emphasizes that the network relationships in which university members engage and their ties within regions can play a significant role in building business activities and better positioning of regions in global arenas. University–industry (U–I) collaboration is a core element of territories’ innovation strategies (Villani et al., 2017).

Currently, there is no consensus on the methods measuring the entrepreneurial university. Markuerkiaga et al. (2018) identified two different study streams from a literature review to measure the entrepreneurial university: studies that measured the entrepreneurial university
from the level that the university developed the factors that describe the entrepreneurial university (Etzkowitz, 2004); and studies that described a set of indicators to measure the entrepreneurial university (Guerrero and Urbano, 2012; Wong et al., 2007).

Many authors point out that the ENTRESCALE (Knight, 1997), despite its widespread use, to measure the entrepreneurial orientation (EO) of private sector firms has a limited applicability in the public or non-profit sectors (Box, 1999). In response to this problem, Todorovic et al. (2011) have developed the ENTRE-U scale to measure the EO of university departments.

There is a clearly compelling evidence to seek a valid and empirically justified means for classifying types of entrepreneurial universities (Siegel et al., 2007). Generally, it is observed that some universities are better at commercialization of research, facilitating entrepreneurial interactions with companies and/or spinning out in new ventures than others (Etzkowitz, 2001).

However, there is still an incipient body of research that attempts to classify the types of entrepreneurial university, thus having the urgent need to develop an empirically justified taxonomy for entrepreneurial university researchers. This research directly responds to a gap in the literature relating to entrepreneurial academics and consequently, it aims to attend this call by developing an individual EO taxonomy, which is empirically validated, thus showing the innovative nature of the study. Therefore, the research question of this study is as follows:

**RQ1. What are the different configurations of EO of academics?**

Accordingly, the main goal of this paper is to develop a taxonomy of academics based on their individual EO. Only few studies have focussed on EO of universities, and fewer at the individual level, considering different national and regional contexts. To fulfil this purpose, a Latent Profile Analysis (LPA) was conducted, and the results allow us to group 1,790 researchers into five different profiles: downers, achievers, followers, defenders and rebels.

Our study contributes to the literature in several ways: building a taxonomy of individual EO by academics, as well as highlighting the role played by scientists/academics as the engine of this EO; seeking to provide a greater understanding of the environment or context in academic entrepreneurship and the method of evaluating academics’ EO in a higher education sector; and extending the data gathering from different geographical areas and/or a different academic context, such that future studies could apply other LPA to make the comparison of the results possible. To the best of our knowledge, this is the first empirical study that develops a taxonomy of academics from HEI, based on their individual EO.

### 2. Literature review

#### 2.1 Theoretical background: is there a gap in academic entrepreneurship profile?

The natural environment of an academic is the university; however, as universities are closely intertwined with their national and supranational environment, it is possible to argue that the national and regional environment also influences the entrepreneurial activities of academics (Davey et al., 2016). This premise is supported either by the concept within a region (regional innovation system) or within a country (national innovation system) (Freeman, 1995; Nelson, 1993). Porter et al. (2002) also support this argument by building the National Innovative Capacity Index, which illustrates how a national environment influences innovation and entrepreneurship and also how countries differ across the world.

Along the same lines, the Global Competitiveness Index recognized the importance of these interactions by affirming that an environment conducive to innovative activity is supported by a wide collaboration in research and technological developments between universities and industries by public and private institutions, in particular, by the extensive
collaboration in research and technological developments between universities and industry (Davey et al., 2016). Such theoretical concepts suggest that since entrepreneurship is considered a context-dependent social process, the perception of determinants and barriers to academic entrepreneurship will be affected by national environments and the specific institutional conditions that foster this type of activity (Davey et al., 2016).

The entrepreneurial university is an academic institution whose vision, goals and strategy put knowledge transfer and entrepreneurship at the focus of its organization (Drivas et al., 2018). Numerous case studies on entrepreneurial universities (Klofsten and Jones-Evans, 2000; Link and Scott, 2005) have provided valuable insights into the ways of these universities towards entrepreneurship and its results.

According to Young (2007), the main factors that should be taken into account when a university decides to launch a technology transfer office are the quality of the research, its volume, as well as its focus on applications of economic/social relevance, whereas other authors (Cartalos et al., 2018; Friedman and Silberman, 2003; Hayter, 2013) draw attention to university culture towards entrepreneurship, as well as regional entrepreneurial technological enterprises, university links with industry and support measures at the public policy.

However, universities have their own identity and as such present different histories, traditions and organizational structures, fostering different ways of becoming entrepreneurs (Martinelli et al., 2008). In this sense, environments conducive to the development of academic entrepreneurship (entrepreneurial ecosystems) predominantly dominated the existing research (Lopes et al., 2018).

It is clear that scholars have previously used ecosystem perspectives to understand industrial dynamics (Moore, 1993). Although conceptualizations have first emerged in management literature (e.g. Iansiti and Levien, 2004) and economic geography (Kenny and von Burg, 1999), ecosystem perspectives have recently been applied in the context of entrepreneurship, for instance, to examine the structure and effectiveness of support programmes (Hayter et al., 2018; Clarysse et al., 2014; Swamidass, 2013).

From a systematic literature review, Rothaermel et al. (2007) identified four areas of research that capture the main currents of research on university entrepreneurship: entrepreneurial research university; productivity of technology transfer offices; new firm creation; and environmental context including networks of innovation.

According to O'Shea et al. (2007) and Davey et al. (2016), the characteristics of each actor as well as the nature of their interactions have been identified as determinants for success or failure of academic involvement in entrepreneurial ventures. Thus, the emergence of the entrepreneurial university proposes the encouragement of an entrepreneurial culture within the academia wherein business activities become part of the university’s mission rather than an activity reserved for a special class of applied science universities (Etzkowitz, 2001).

The entrepreneurial university is focussed on fulfilling its missions of teaching, research and entrepreneurial activities simultaneously (Etzkowitz, 2004). This new university mission of entrepreneurialism is focussed on its contribution to social development and economic growth (Schulte, 2004). Entrepreneurship departments are, for Pugh et al. (2018), considered regional actors in their own right and also part of the broader entrepreneurial university, interacting directly and indirectly with the region through a broader university structure.

Vick and Robertson (2018) identified four central measures related to U–I collaboration: motivations, activities, barriers and outcomes. According to D'Este and Perkmann (2011), concerning academics’ motivation for engaging with industry, the literature is composed of a group of authors emphasizing that academics collaborate with industry to pursue commercialization, whereas other authors believe that academics collaborate with industry to support their research. Based on an UK sample of researchers in the physical and engineering sciences, D'Este and Perkmann (2011) found four motivations for academics to engage with industry: commercialization (commercial exploitation of technology or knowledge); learning
Informing academic research through engagement with industry; access to funding (complementing public research funds with funding from industry); and access to in-kind resources (using industry-provided equipment, materials and data for research). Regarding U—I activities, Perkmann and Walsh (2009) identified four types of U—I activity: problem solving, technology development, ideas testing and knowledge generation. Barriers to U—I collaboration were identified at the individual level, university level and industry level. Francis-Smythe (2008) concluded that the lack of time and incentives were individual barriers. The lack of reward/incentive/investment and bureaucracy represent university-level barriers (Francis-Smythe, 2008; Hughes and Kitson, 2012). A major barrier for businesses is that they consider lacking the internal resources to run interactions with universities and academics (Hughes and Kitson, 2012). Finally, U—I collaboration outcomes may be beneficial (at the economic, institutional and social levels) but may have drawbacks, like digression from core objectives, quality issues, conflicts or risks (Ankrah et al., 2013). Based on a sample of 4,990 U—I collaboration projects in the UK, Scandura (2016) concluded that project participation has a positive effect on the R&D expenditure per employee of firms and a positive and significant impact on the share of R&D employment in the two years after the end of the project. Baba et al. (2009), studying 455 Japanese firms engaging in research collaborations, concluded that a collaboration with "Pasteur scientists" (having a publication record and a patenting activity above the average) resulted in an increased number of registered patents, whereas collaborating with "Star scientists" (with a publication record above the average, but a patenting activity below the average) exercised a little impact on firms' innovative output. These results reinforce the claim that not all U—I linkages are equally helpful (Giuliani and Arza, 2009).

As universities are becoming increasingly entrepreneurial, attention is also increasingly focussed on academic entrepreneurship (Guerrero and Urbano, 2012; Mosey et al., 2012; Seguí-Mas et al., 2018). According to Seguí-Mas et al. (2018), an entrepreneurial university actively seeks to develop its activities in innovative ways, thus promoting continuous changes in its culture and general organizational character. Attempts to understand the diversity of academic entrepreneurial behaviour are not new. Some categories of academic entrepreneurship are evidenced in the literature (Lopes et al., 2018). Louis et al. (1989) identified five institutional academic entrepreneurship activities: securing large publicly funded research projects; deriving supplemental income, mainly through consulting; soliciting private research funding from industry; patenting the results of research and forming university spin-offs based on the results of research.

Despite the diversity of categories of academic entrepreneurship, Holley and Watson (2017) consider that they can all be grouped into two main topics: institutional activities and individual academics. Based on an in-depth qualitative analysis of 30 life sciences scholars in Australia, these authors identified the presence of four distinct categories of academic entrepreneurial behaviour: non-entrepreneurial, semi-entrepreneurial, pre-entrepreneur and entrepreneur. Their empirical evidence suggests that academic entrepreneurial behaviour is not necessarily driven by the recognition of opportunities and it suggests that research on the topic should consider factors other than the individual academic such as the project and funding mechanisms.

Also Lopes et al. (2018) developed a study with resource to bibliometric analyses and classified the field of academic entrepreneurship in a regional perspective into seven major emerging perspectives: entrepreneurial universities; U—I interactions; U—I knowledge transfer; U—I innovation networks; university entrepreneurship; U—I industrial property and innovation ecosystems.

Grimaldi et al. (2011) found that an academic's willingness to accept entrepreneurship as part of the university's mission increases the likelihood that academics will engage in an academic entrepreneurship. Also Errasti et al. (2018) set out to discover the extent to which universities were fulfilling their third mission, that is, to what extent they were developing the elements that
characterise an entrepreneurial university, whether all these elements have reached an adequate level of maturity or whether some are developed more than others. The results show that although the context around the institution and the resources available do not seem to be very favourable elements in support of the entrepreneurial university, the institutions took a proactive position to develop processes of entrepreneurship training from the support of their management teams, thus reflecting the formulation of its policy and strategy.

Much of the empirical literature uses ENTRESCALE to measure the EO of private sector firms (Covin and Slevin, 1988; Knight, 1997). However, many authors have pointed out that ENTRESCALE has a limited applicability in the public or non-profit sectors, and the significance of being entrepreneurially oriented within public or non-profit sectors is just beginning to be explored (Box, 1999; O'Shea et al., 2005, 2007). In response to this problem, Todorovic et al. (2011) developed the ENTRE-U scale to measure the EO of university departments. For these authors, the entrepreneurially oriented university departments are distinguished from those that are less entrepreneurially oriented, by the extent of their research mobilization activities, unconventionality, industry collaboration and perception of university policies.

By understanding the entrepreneurial institutions of higher education, society will be able to better appreciate, support and benefit from the resources they bring to the knowledge economy.

2.2 Individual entrepreneurial orientation

There is a general understanding that EO influences the performance of organizations (Miller, 1983; Covin and Slevin, 1988). Stewart et al. (2016) consider that if the individual characteristics of the entrepreneur are associated with an organization EO, this combination can achieve gains regarding the strategies adopted by the firm.

Although studying the EO of an organization is important to understanding the business environment on a larger scale, it is said that nurturing an organization’s culture, recruiting employees who fit the culture and employing management that can embed value systems into the organization, is the key to build a strong firm performance in the business world (Joardar and Wu, 2011). This corroborates the study of Yong and Panikkos (2010), according to which entrepreneur individual characteristics appear in several critically important roles in terms of behaviour and company performance.

For Lau et al. (2007), entrepreneurial firms are natural extensions of entrepreneurs; therefore, it is important to understand that measuring EO on an individual level might allow us to gain a deeper understanding of the business world and its factors contributing to an individual’s success, as well as the individual’s contribution to the success of a firm or organization.

Lumpkin and Dess (1996) and Zahra (2005) have shown that EO can impact company performance both directly and indirectly, depending on the different environments in which they operate and entrepreneurial actions, along with individual characteristics highlighted by individual’s personality and attitudes that can be affected by external and social influences.

Nowadays, something essential in HEI is seeking to be entrepreneurial (Mowery and Shane, 2002), human resources with entrepreneurial characteristics. Their success will depend on the performance of its human resources, but little is known about the EO of academic departments and its human resources, and how such an orientation might foster commercialization activity (Todorovic et al., 2011). It is from its own resources and core competences that a company can transform the conditions of the environment and build its own innovative paths (Prahalad and Hamel, 1990). Research in entrepreneurship should continue to explore the links between individual-level and firm-level perspectives to better explain entrepreneurial behaviour (Hitt et al., 2007; Hmieleski and Corbett, 2008).
Therefore, only few studies have focussed on individual EO of teachers and researchers, considering different national and regional contexts, and none have developed a taxonomy of academics from HEI, based on their individual EO.

3. Methods

3.1 Participants
The population in study was composed of teachers and researchers from worldwide universities, polytechnics, colleges or specialized schools, from 37 European countries, Brazil, the USA, and from other countries, such as Morocco, South Africa, Azerbaijan, Pakistan, India, Malaysia and Hong Kong. The questionnaire was administered online to a total of 166 and 223 individual e-mails were sent to population members.

The contacts of European HEI were collected online, based on a list created by Bonaccorsi et al. (2010). First, the general e-mails (information, communication, international relations or rectory contacts) were gathered. In the case of countries with more than 110 HEI, 90 HEI were chosen randomly. In the case of European countries that do not belong to the European Union, only 20 HEI were chosen randomly, since searching for the contacts of all the HEI would create some problems in terms of time constraints. Then, in a second phase, the programme Atomic E-mail Hunter was used to gather the e-mails contained in the websites of the HEI.

With regard to the non-European countries, initially, we intended to get e-mails from more North and South American countries; however, due to time constraints, we only gathered contacts of HEI in Brazil and in the USA. Those contacts were based on Scimago Institutions Rankings World Report 2012: Global Ranking, so we used the programme to get e-mails from the HEI listed in the ranking.

3.2 Measures
With ENTRE-U scale being the most suitable to measure the EO of university departments, which is the context of the given analysis, it was considered and decided to use the I-ENTRE-U scale (Felgueira and Rodrigues, 2013), an adaptation of ENTRE-U (Todorovic et al., 2011), to identify entrepreneurial-oriented individuals (teachers and researchers) in HEI. This scale is composed of 23 items divided into 4 dimensions: research mobilization (6 items), unconventionality (8 items), industry collaboration (5 items) and university policies (4 items).

The first dimension, research mobilization, fits within the broader concept of “knowledge mobilization”. It implies a shift from systems that support knowledge creation and innovation at the individual level to groups, organizations or communities.

The second dimension, unconventionality, focusses on research, especially looking for new opportunities and making sure that research is useful and benefits stakeholders. The items also suggest doing things that are unconventional and/or innovative but do not directly refer to sources of risk (or what is at risk, e.g., reputation, resources or career advancement).

The third dimension, industrial collaboration, refers to the teacher or researcher, department, faculty and student engagement with the related industry.

The fourth factor, teacher and researcher perception of university policies, also appears to have a role in encouraging university EO. The key items relate to the general culture of the university, especially being “responsive to new ideas and innovative approaches”, having a “bottom-up” approach to policy development, and being a good fit between university policies, department objectives and teacher and researcher objectives.

Such an instrument clarifies individual accountabilities and specifies measurable routines that add competitive value. This scale provides a method to assess differences between individuals within a HEI, enabling empirical research on differences between types of institutions, departments, roles, training and other characteristics that may influence the extent to which an individual performs entrepreneurial-oriented behaviours. Thus, it is a valid instrument to evaluate teachers and researchers with EO in HEI.
3.3 Latent Profile Analysis

We conducted LPA (Fraley and Raftery, 2007) using the mclust package (Scrucca et al., 2017) with R version 3.5.1 (R Core Team, 2018) to identify profiles of researchers with similar values in the four EO dimensions.

LPA is a latent variable technique aiming at the same goal as cluster analysis – to identify clusters of observations with similar values on cluster variables – but with the difference that LPA is model based and cluster analysis is not (Pastor et al., 2007). Thus, LPA has the advantages of accommodating data with a variety of forms; using more rigorous criteria to decide the final model, including fit measures; and using the model parameter estimates of one sample to compute the posterior probabilities and assign cluster membership to observations in other samples (Pastor et al., 2007).

4. Results

4.1 Descriptive statistics

Table I presents mean, standard deviation, distribution and correlation across I-ENTRE-U dimensions. Nor age nor career length correlates with any of the four dimensions. Research mobilization, unconventionality and industry collaboration correlate moderately among themselves, whereas university policies correlate weakly with the other three dimensions. All the dimensions’ means are positive (above the neutral value of 4 in a Likert-type scale with 7 points). Research mobilization has the highest mean (5.22) and university policies has the lowest (4.16). Industry collaboration is the more heterogeneous dimension, with a standard deviation of 1.34.

As shown in Table II, most respondents came from public institutions (82.8 per cent), from the European Union (69.2 per cent) and were male (60.3 per cent). Women present a higher research mobilization than men and a lower industry collaboration, but there are no significant gender differences in the individual EO. These results differ from other studies that found gender differences in EO, with men showing higher entrepreneurial levels than women (Lim and Envick, 2013; Quaye et al., 2015; Covin and Miller, 2014; Ladd et al., 2018; Abreu and Grinevich, 2017).

Researchers from South America show a higher research mobilization, whereas the ones from North America show a higher unconventionality. However, university policies are higher in researchers from other regions, such as Eastern Europe or Asia. Individual EO shows no differences per region, but the heterogeneous nature of entrepreneurship across countries (Terjesen et al., 2016) may be smooth when heterogeneous countries are combined into larger regions.

Researchers from private institutions show a higher research mobilization than the others, contrasting with the results of Abou-Warda (2015), who found that private institutions show a lower research mobilization that public ones.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Histogram</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>1,707</td>
<td>49.27</td>
<td>10.73</td>
<td></td>
<td>0.044***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Academic career (years)</td>
<td>1,790</td>
<td>21.73</td>
<td>15.82</td>
<td></td>
<td>-0.001</td>
<td>-0.026</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Research Mobilization</td>
<td>1,790</td>
<td>5.22</td>
<td>1.22</td>
<td></td>
<td>0.071*</td>
<td>0.015</td>
<td>0.679*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Unconventionality</td>
<td>1,790</td>
<td>4.78</td>
<td>1.00</td>
<td></td>
<td>0.048**</td>
<td>0.014</td>
<td>0.641*</td>
<td>0.657</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Industry Collaboration</td>
<td>1,790</td>
<td>4.43</td>
<td>1.34</td>
<td></td>
<td>0.083*</td>
<td>0.063*</td>
<td>0.277*</td>
<td>0.290*</td>
<td>0.346*</td>
<td></td>
</tr>
<tr>
<td>6. University Policies</td>
<td>1,790</td>
<td>4.16</td>
<td>1.28</td>
<td></td>
<td>0.063*</td>
<td>0.022</td>
<td>0.826*</td>
<td>0.816*</td>
<td>0.854*</td>
<td>0.628*</td>
</tr>
</tbody>
</table>

Notes: *p<0.01; **p<0.05; ***p<0.1
4.2 Model estimation and selection
Profiles of researchers with similar values in the four EO dimensions were identified with LPA. A total of five models were estimated with LPA using maximum likelihood, ranging from three to seven profiles.

We used three criteria to find the optimal latent profile solution (Ning, 2017). First, we examined fit statistics (Table III), like the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Smaller values of AIC and BIC suggest a better model fitting. Second, we considered an overall uncertainty in posterior classification, assessed by entropy (Ramaswamy et al., 1993). Entropy ranges from 0 to 1, with larger values indicating a better latent class separation (Celeux and Soromenho, 1996) and values above 0.8 indicating a clear separation of the profiles (Stronge et al., 2016). Third, we considered the Lo–Mendell–Rubin (Lo et al., 2001) likelihood ratio test (LRT) and the bootstrap likelihood ratio test (BLRT) with \( p < 0.01 \). When the BLRT is significant, the model with \( k \) profiles should be preferred to the \( k-1 \) profile model (Morin et al., 2016).

Both AIC and BIC show the highest decreases from the model with four profiles to the model with five. The five-profile model shows a low overall uncertainty in posterior classification, with entropy = 0.836. The Lo–Mendell–Rubin (Lo et al., 2001) LRT showed that the model with five profiles was better than the model with four (LRT = 16.49, \( p = 0.02 \), see Table III) and six profiles (LRT = 39.02, \( p < 0.00 \)).

4.3 Classification accuracy of the model
The probabilities of correct classification of observations are shown in the main diagonal of Table IV, ranging from 0.872 to 0.995.

### Table III.
Model fit for the different profile solutions

<table>
<thead>
<tr>
<th>Solution</th>
<th>AIC</th>
<th>BIC</th>
<th>Entropy</th>
<th>LRT</th>
<th>BLRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three profiles</td>
<td>20,363</td>
<td>20,462</td>
<td>0.891</td>
<td>88.53</td>
<td>0.001</td>
</tr>
<tr>
<td>Four profiles</td>
<td>20,346</td>
<td>20,472</td>
<td>0.856</td>
<td>77.47</td>
<td>0.001</td>
</tr>
<tr>
<td>Five profiles</td>
<td>20,134</td>
<td>20,287</td>
<td>0.836</td>
<td>16.49</td>
<td>0.020</td>
</tr>
<tr>
<td>Six profiles</td>
<td>20,043</td>
<td>20,224</td>
<td>0.781</td>
<td>39.02</td>
<td>0.001</td>
</tr>
<tr>
<td>Seven profiles</td>
<td>20,026</td>
<td>20,235</td>
<td>0.763</td>
<td>13.05</td>
<td>0.090</td>
</tr>
</tbody>
</table>

**Notes:** AIC, Akaike information criterion; BIC, Bayesian information criterion; LRT, Lo–Mendell–Rubin likelihood ratio test; BLRT, bootstrap likelihood ratio test; VEE model (\( \lambda DAD^{T} \)) – Ellipsoidal Distribution, Variable Volume, Equal Shape, Equal Orientation. Bootstrap with 1,000 replications.
To further assess the correct classification of observations, we conducted a supervised classification with eigenvalue decomposition discriminant analysis (Bensmail and Celeux, 1996). A model was fit with a randomly chosen training subsample, then it was used to classify data in the testing subsample, with data being assigned to the profile corresponding to the model with the highest posterior probability (Fraley and Raftery, 2007).

The classification accuracy of the testing subsample was 97 per cent, as shown in Table V. Classification accuracy is much greater than one-fourth of the achieved by chance (Hair et al., 2009) while considering the maximum chance criteria (Morrison, 1969) of 37 per cent. The value of Press’s $Q = 2010.3 (N = 537, n = 523, K = 5)$ is greater than 6.63 (critical value from the $\chi^2$ distribution with one degree of freedom and confidence interval of 99%), thus confirming that results exceed the classification accuracy expected by chance (Hair et al., 2009).

### 4.4 Profiles’ description

The means for each entrepreneurial dimension, as well as the global I-ENTRE-U and profile size, are plotted by profile in Figure 1. Profiles are described in the following sub-sections.

**Profile 1 – downers.** Profile 1 is the second largest group, representing 23.9 per cent of the researchers ($N = 428$). This group scores negatively (less than 4) in all dimensions (Table VI); hence, its members are called downers.

Of all five profiles, downers are less oriented towards research mobilization and have the smaller unconventionality; however, this is the dimension with the larger mean for this group. The poorest result for downers is industry collaboration. The largest differences among downers refer to university policies, and this group is the most heterogeneous of the five, showing the highest standard deviations in all four dimensions.

Downers are the only group not primarily driven by research mobilization.

**Profile 2 – achievers.** Profile 2 is the smallest group, representing 10.4 per cent of the researchers ($N = 186$). This group shows the largest means in all four dimensions; hence, it is named achievers.

Achievers are clearly the more entrepreneurial researchers, with all the means above 5.5. Besides, the group is pretty homogeneous, with all dimensions presenting relatively small standard deviations. Their main focus is in research mobilization, and unconventionality is their lesser concern.

<table>
<thead>
<tr>
<th>Profile</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.995</td>
<td>0.000</td>
<td>0.005</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.000</td>
<td>0.872</td>
<td>0.128</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>3</td>
<td>0.003</td>
<td>0.003</td>
<td>0.994</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
<td>0.046</td>
<td>0.000</td>
<td>0.007</td>
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<tr>
<td>5</td>
<td>0.009</td>
<td>0.000</td>
<td>0.027</td>
<td>0.000</td>
<td>0.965</td>
</tr>
</tbody>
</table>

**Table IV.** Average latent profile probabilities for most likely profile membership (row) by latent profile (column)

<table>
<thead>
<tr>
<th>Profile</th>
<th>Predicted in training set ($n = 1,253$)</th>
<th>Predicted in testing set ($n = 537$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>294</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>119</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table V.** Results of the supervised classification

Notes: Main diagonals contain correct classifications. Classification error in the training set is 3.4 per cent and 2.6 per cent in the testing set.
Profile 3 – followers. Profile 3 is the largest group, representing more than one-third of the researchers (36.3 per cent, N = 186). This group’s mean pattern mimics the pattern of achievers (see Figure 1), but in a lower level, and for that reason, the group is named followers.

The most important orientation is research mobilization, followed by industry collaboration, unconventionality and university policies. Only followers and achievers have positive means in all four dimensions. The biggest differences among followers are in their lowest scoring dimension and university policies.

Profile 4 – defenders. Profile 4 represents 17.2 per cent of the researchers (N = 307). This group narrows its orientation to research mobilization and unconventionality, showing negative means in the other two dimensions. This narrow focus is similar to the strategic type identified by Miles and Snow (1978), and that is why the group is called defenders. They score lower in industry collaboration and are the second most heterogeneous group.

Profile 5 – rebels. Profile 5 is the second smallest group, accounting for 12.3 per cent of the researchers (N = 220). This group has the second highest means in all dimensions but in university policies, it scores negatively. It seems to resist organizational rule, and consequently it is named rebels.
5. Discussion and conclusion

5.1 Summary of findings
This research aimed to develop a taxonomy of academics from HEI, based on their individual EO and tried to directly respond to a gap in the literature relating to entrepreneurial universities and an urgent need to develop an empirically validated entrepreneurial researcher taxonomy. No evidence was found in the literature of papers reporting this approach, supporting the innovative nature of the study. By exploring a large sample of international universities, the I-ENTRE-U scale was used, which was adapted to the individual level from the ENTRE-U, to identify entrepreneurial-oriented individuals (teachers and researchers) in a university context. The typology of five profiles of scientists/academics was identified: downers, achievers, followers, defenders and rebels. Based on these profiles, a number of entrepreneurial characteristics and roles were highlighted (research mobilization, unconventionality, industry collaboration and university policies), which have been underexplored in past studies of individual EO. It is not only in entrepreneurship sectors that third mission and knowledge exchange activities have been overlooked (Audretsch, 2014), the same is true for other contexts and social sciences disciplines (Pugh et al., 2018).

5.2 Theoretical and practical implications
Academic entrepreneurship has become a major challenge for HEI across the world, having evolved from individual non-interconnected activities developed by academic institutions to a more structured and systematic need. Generally, entrepreneurial activities are in place throughout world, but efforts are fragmented and often driven by external players, rather than by the education system itself. Few universities in Europe have academic entrepreneurship activities based on an entrepreneurial strategy with clear goals and measurement that really focus on local needs and context (Markuerkiaga et al., 2018). Therefore, HEI require an adequate and cohesive framework that encompasses the various dimensions of EO.

This study can help to gain some insights into the role of scientists/academics' characteristics in modelling the individual EO. There is a specific focus on the teachers and researchers from worldwide HEI. This makes the present study differ from prior studies, as previous studies that have tried to analyse the EO usually consider firm-level or organizational context. In contrast, this study extends the individual EO by introducing a LPA and creates a taxonomy of academics’ EO. By forming groups of researchers with similar EO, this taxonomy allows increased precision about the behaviour of the members of profiles (Bobko and Russell, 1991), and to study the relationship between profile membership and other variables such as performance (Luz Martín-Peña and Díaz-Garrido, 2008).

This study contributes to extant literature that tries to explore the role played by scientists/academics as the driver of EO in an HEI sector.

Methodologically, the contribution is twofold: it comes both from the conducted LPA and used the I-ENTRE_U scale, which is believed to be novel in this study context and from the description of the process followed, which can allow for replications in other contexts and/or sectors. Our study provides a new perspective and methodology to identify elements that promote the individual EO and can be thus used as an important starting point for other researchers and practitioners hoping to evaluate academics’ EO in a HEI sector.

The study has the limitation of being cross-sectional and of using data from only one sample. Given the nature of the LPA, which is model based, future studies could apply other LPA techniques and compare the results. In addition, further contributions may be added by extending the data gathering from different geographical areas and/or different academic contexts. Longitudinal studies may study the method by which an individual entrepreneurship evolves with time or career advancement. It would be interesting to relate profile membership with individual performance.
References


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Abstract

Purpose – The purpose of this paper is to measure the relationship between entrepreneurial orientation (EO) and performance of small- and medium-sized enterprises (SMEs). The aim is to contribute to the extant literature about the role of EO for SMEs development, and more specifically to identify implications that can inform knowledge-based initiatives of entrepreneurship universities focussing on the development and diffusion of the entrepreneurial culture and capacity.

Design/methodology/approach – This research paper adopts a quantitative approach to investigate a conceptual framework linking EO to SME’s performance. The central postulated hypothesis is that EO positively affects performance of SMEs. This hypothesis has been tested by using a system of partial least squares of structural equations modelling, adopting the SmartPLS® 3.0 software (Ringle et al., 2015). The empirical context analysed 170 SMEs operating in the Bajio Region (México) in the leather–footwear sector.

Findings – The results provide evidence that Mexican companies that manifest EO have a positive effect on their firm performance. Similarly, findings emphasise that both risk taking and innovativeness are currently the central axes of EO for the analysed companies. Accordingly, entrepreneurial universities should be engaged in the development of EO of students, academic staff and companies by focussing on knowledge-based actions that can foster the improvement of some specific features of the EO.

Practical implications – The results provide insights about the relationships between EO and the performance of SMEs indicating that potentials initiatives of entrepreneurship universities aiming to support the development capacity of SMEs as well as of students and academic staff should be focussed on the critical dimensions characterising EO.

Originality/value – This paper provides insights into the role of EO for SMEs performance. It provides three main contributions. First, derived from literature research, it proposes a working definition of EO. Second, the empirical research findings support an understanding of the relationship between EO and Mexican SMEs performance and propose a multiple and reflective dimension of EO’s model. Moreover, finally, this research provides some implications for entrepreneurship universities aiming to create and diffuse an entrepreneurial culture and capabilities by fostering the development of the EO.

Keywords Performance, SMEs, Entrepreneurial orientation, Entrepreneurship universities

Paper type Research paper

Introduction

Increasingly in today’s turbulent and fast-changing business landscape in which companies are challenged to face the growing pace of innovation to enhance business performance, entrepreneurship universities play a fundamental role as key enablers to support the development of the entrepreneurial capacity, particularly, of small- and medium-sized enterprises (SMEs) which in turn simultaneously contribute to regional economic development dynamics (Etzkowitz, 2016; Etzkowitz et al., 2000; Etzkowitz and Leydesdorff, 2000). Indeed, one of the main features distinguishing the role of an entrepreneurship university, engaged in
the effective delivery of the “third mission” (Fayolle and Redford, 2014; Philpott et al., 2011) is the implementation of knowledge-based actions aimed at diffusing entrepreneurial culture and capabilities in a wide range of stakeholders ranging from students, start-ups and SMEs (Fayolle and Redford, 2014; Guerrero et al., 2015; Van Looy et al., 2011). By this view, entrepreneurship universities as knowledge agents can contribute to the promotion of strengthening the management capacities of local SMEs (OCDE, 2015). This supports the adoption among SMEs of new technologies and knowledge transfers practices (Shapiro, 2009), and it helps to understand how the SMEs’ value creation capabilities can be enhanced by the incorporation of an entrepreneurial strategy (Wiklund et al., 2009). One of the key dimensions on which an entrepreneurship university, acting as an entrepreneurial hub or knowledge agent, can focus the attention on is the development of entrepreneurial orientation (EO). The EO distinguishes an organisational behaviour by reflecting the capacity and the style of the organisation’s governance, i.e. entrepreneurs and managers, orientation about risk taking, innovation processes, opportunity recognition, approach to the market and decision making. The EO can be considered as a driver affecting both the survival and the growth of SMEs. This is particularly important in those local systems that are characterised by delay of development and in which universities can play a critical role not only as education and knowledge creation hubs but also through knowledge transfer practices and being a catalyst for innovation and entrepreneurial capacity.

This paper aims to shed light on the relationships between EO and SMEs’ performance with the scope of identifying the key dimensions defining EO and their relationships with the performance of SMEs. The understanding of these relationships is essential for drawing managerial implications useful for an entrepreneurship university aiming to support the incorporation of entrepreneurial strategies in SMEs to facilitate local economic development (Arshad et al., 2014; Ferreira and Garrido Azevedo, 2008) as well as to design and implement knowledge-based initiatives aiming to shape a diffuse an entrepreneurial culture in students and academic staff.

The paper has three main sections. First, introduces a working definition of EO and, then, proposes a model to explore the relationships between EO and SMEs’ performance. The specific practical interest of this research is the understanding of the characteristics of EO and their relationships with SMEs’ performance, specifically in the context of developing regions and countries in which the third mission of entrepreneurship universities has relevance for wealth creation, sustainability and the development of innovative entrepreneurs. Accordingly, in the second section, this paper describes the research methodology and adopts the results of an empirical investigation carried out in Mexico and, specifically, for the regions of Guanajuato and Bajio that are characterised by high concentration of SMEs specialised in the leather and footwear industry. Therefore, this study, acknowledging the extant literature and the gathered empirical evidence, suggests that EO plays a critical role in the improvement of firms’ business performance (Covin and Miller, 2014; Garcia-Villaverde et al., 2014; Lumpkin and Hess, 1996, 2001; Miller, 1983; Wach, 2015; Wiklund and Shepherd, 2003) and it can be considered as a catalyst for the development of an entrepreneurship capacity. Therefore, in the third section, the attention is paid on the managerial implications that can be useful for an entrepreneurship university to plan knowledge-based management actions in countries and regions characterised by specific cultural backgrounds and economic conditions such as Mexico (Covin and Miller, 2014; Ferreira et al., 2015; Knight, 1997; Miller, 2011).

Entrepreneurial orientation as a driver of firms’ performance
During the last years, entrepreneurship research as a field of strategic management has focussed its attention on how entrepreneurship is affecting business performance and, in turn, how entrepreneurial culture diffusion is driving the development of regional and national economies (Bruton et al., 2008; Ferreira et al., 2015; Gündoğdu, 2012).
Entrepreneurship is related mostly with launching new products or services, while the notion of entrepreneurial posture can be considered as some practices and behaviours that strengthen the act to be entrepreneurial. An entrepreneurial behaviour, is deeply related to an orientation that the company follows, mainly by the founder; this posture, in literature, is named as “EO” and can be considered as the strategic posture that affects business performance (Edmond and Wiklund, 2010; Miller, 1983; Miller and Friesen, 1978). Acknowledging the relevance of EO, in the last years, different studies have proposed alternative interpretations of the notion of EO and have explored how it connects with companies’ competitiveness (Covin and Slevin, 1988; Lumpkin and Dess, 1996; Miller, 1983; Mintzberg, 1973). Starting from Miller’s (1983) first approach, the research on EO has attempted to clarify to what extent this notion differs from entrepreneurship. The focus has been on obtaining new insights about entrepreneurial behaviour in diverse cultural contexts (Miller, 2011). The understanding of how entrepreneurship and EO are comparable, and how they differ is essential to get a full comprehension of the dimensions of EO (Covin and Miller, 2014; Miller, 2011). The proposed conceptual approaches for both notions, respectively, describe the “what” and “how” a company can create a new entry into the market (Lumpkin and Dess, 1996). In particular, entrepreneurship is mainly focussed on the “what” and consists in launching a novel form of a product or service created for a specific market, or in its absence, the creation of a new one.

On the other hand, EO refers mainly to the “how”, i.e. the entrepreneurship’s process; so, it focusses on questions such as: How did you get to that entrepreneurship? Alternatively, what was the “cooking recipe”? For both constructs, the figure of the “entrepreneur” and “manager” is fundamental as the central “detonator” of innovations, through new designs of products, markets or in the way of producing merchandise and services.

It is essential to identify some standard features of “Entrepreneurship” and “EO”. Both share some key elements, such as they involve the creation, either of an entity, business or business network. They consider the necessity to take risks, such as financial risks in the hope of a benefit, making decisions on uncertain environmental conditions; they acknowledge that entrepreneurs are characterised by a strong will and determination to execute actions and operations, in which they visualise potentials for markets (Lumpkin and Dess, 1996; Miller, 1983).

Some authors (see Lumpkin and Dess, 1996; Miller, 1983, 2011) point out that entrepreneurship is guided by three essential factors: the size of the organisation, the personality of an entrepreneur and aspects related to the structure and processes of the company. These factors, also, distinguish and reveal an “entrepreneurial behaviour”, or an “entrepreneurial posture”, or as postulated by Miller (1983, 2011) the EO. Accordingly, three dimensions characterise EO, as follows: innovativeness (IN), risk taking (RT) and proactivity (PR). These dimensions are known as the basis of an organisation’s EO (Edmond and Wiklund, 2010).

Although the Miller’s EO interpretation is broadly accepted in the management literature, alternative approaches suggest incorporating other distinctive dimensions that better reflect the rapid changes in the economic environment (Edmond and Wiklund, 2010; Wiklund and Shepherd, 2005). In particular, Lumpkin and Dess (1996) model of the EO proposed two more dimensions: competitive aggressiveness (CA) and autonomy (AT). These two dimensions characterise and distinguish an essential entrepreneurial process, which includes the capacity of acting autonomously and the tendency to behave with aggressiveness towards competitors to get first any market opportunity. In summary, such model considers that if an organisation aims to act with an entrepreneurial posture should develop five dimensions: innovativeness (IN), risk taking (RT), proactivity (PR), autonomy (AT) and competitive aggressiveness (CA).

Both models, i.e. the three-based Miller’s dimensional model and the five-based Lumpkin–Dess’s dimensional model, offer different approaches as well as measures. Researches on EO do not provide a consensus about whether EO’s dimensions should be
measured together or not (Kreiser et al., 2002). The three-dimensional Miller’s (1983, 2011) model remains as one of the most adopted (Edmond and Wiklund, 2010). However, Miller’s model analyses EO from a one-dimensional conception, this means that the three dimensions (IN, RT and PR) are combined each other to give higher indicator values of EO (Covin and Wales, 2012). This could be “a lock” for some interpretations and contexts, since if one of the dimensions does not co-vary with the remaining two; we cannot describe the presence of an EO. Thus, Miller’s model considers EO as a formative concept. While the Lumpkin–Dess’s model adopts multiple dimensional approaches suggesting that EO’s dimensions do not need to co-vary (IN, RT, PR, AT and CA), therefore, the EO’s dimensions could vary independently from each other. This approach gives an opportunity to interpret new findings in different cultural and industrial contexts, meaning that the absence of one or two dimensions does not affect the analysis of EO.

For this reason, Lumpkin–Dess approach provides three practical advantages as follows: the EO is considered as a reflective construct, and the dimensions are interpreted as the EO manifestation (not the cause itself). Reflective measures allow evaluating aspects separately. One or more original dimensions could not appear in the final results, but this phenomenon will not affect the analysis of EO.

Although the EO can be measured by using both approaches, Miller’s approach provides a formative measure (co-vary), while the Lumpkin–Dess’s approach offers a reflective measure (not co-vary). The “reflective measures of EO can often be viable or a superior alternative to the formative measurement” (Covin and Wales, 2012, p. 685). Both approaches are identified in the literature as the principal ways to investigate the EO (Covin and Slevin, 1989, 1993; Lumpkin and Dess, 1996; Miller, 1983, 2011), but they reflect different ways of interpreting the EO (Covin and Wales, 2012; Edmond and Wiklund, 2010). By integrating the most frequent and relevant elements of EO and adopting the five dimensions Lumpkin–Dess’s reflective model the following working definition of EO is proposed. The EO can be interpreted as an organisational behaviour that reflects the capacity and the style of the management of an organisation (performed by the “general manager” or by the “attendant of the managerial practice”). It is mainly manifested by five independent orientations, as follows: a decision-making orientation with a meditated risk; an orientation towards investment in innovation processes; a clear orientation towards proactive activities that provide new opportunities; an aggressive orientation to compete in the market; an autonomy orientation, both in decisions when launching a product or service and in personnel management. Considering this definition of the EO, the elements related to the manager’s capacity and style are fundamental in shaping the entrepreneurial culture because they affect the organisational behaviour (Mintzberg, 2009; Pearce et al., 2010). However, in SMEs due to their structural conditions and their family-based business nature, it is not common to find a position labelled as “general manager”, and generally the governance and “managerial practice” (Mintzberg, 2009) is exercised by the family members and the closed collaborators of the firms’ owners.

The EO is a critical dimension to explain the entrepreneurial and innovation capacity of an organisation. However, the understanding of a company’s sustainability and growth potentials are fundamentally related to its performance. For this reason, a better understanding of the relationships between EO and companies performance represents a relevant issue, particularly when analysing the possible knowledge-based actions that can be taken into account when exploring the contribution that entrepreneurship universities can give to the growth and consolidation of SMEs, as well as to the local economic development dynamics.

In the last decades, the notion of performance has been the focus of various studies, however, despite the number of contributions, there is not a homogeneous and universal definition (Davidsson et al., 2010; Davidsson and Honig, 2003). For Peter Drucker (1958) survival is the fundamental purpose of the firm and improving performance is the way to do so.
According to Mintzberg (2009), the continuous search of a performance’s improvement must be accompanied by a series of management tactics that support this capacity and expansion. Meanwhile, some companies are worried about just growing; many others are oriented to measure processes to increase the internal conditions to generate growth sustainably as discussed by Penrose (1959). This performance management view refers to the search for an organisation of measuring and managing their efficiency and effectiveness to be sustainable and more competitive in the market (Neely et al., 1995). The performance measurement and management are essential dimensions of the governance of any firm. They primarily represent critical dimensions for the continuous performance improvement and growth of SMEs (Rezaei et al., 2011).

While performance indicators basically explain the company’s success over time, researchers have extended measures beyond just financial issues, pointing out the fundamental importance of taking into account all forms of indicators that explain an organisational capacity (Barker, 1995), such as management styles (Bititci et al., 2006), potential development of knowledge of personnel (Mardani et al., 2018), management of innovation actions (Walker et al., 2015) and trust in improvements derived from company’s personnel (Brown et al., 2015).

So, growth and performance development are “two sides of the same coin” (Venkatraman and Ramanujam, 1986). Adopting this view is possible to adopt Quinn and Rohrbaugh’s (1983) model, which proposes 14 elements to assess a firm’s business performance. Quinn and Rohrbaugh’s (1983) methodology has been widely used to explore the relations between organisations’ performance and the correlation with firms’ competitive variables, such as innovation (Van Auken et al., 2008), knowledge transfer (Rodríguez Orejuela, 2007) and organisational culture (Hartnell et al., 2011). The Quinn–Rohrbaugh’s methodology is then proposed to investigate the relationships between EO and performance of SMEs.

Entrepreneurship universities as a catalyser for the development of EO
Commonly entrepreneurship and EO are concepts related to a business environment. However, a modern educational paradigm is growing which acknowledges the relevance of higher education institutions in developing an entrepreneurial and innovativeness culture. Accordingly, Universities and Educational Centres are developing a capacity to shape an university-based context for the formation and development of start-ups. Moreover, they are increasingly engaged in the creation of links with local companies to develop projects, joint-curricula and educational programmes oriented to enhance entrepreneurship among students and professors (Taucean et al., 2018) and shape a collective intelligence system (Secundo, Del Vecchio, Schiuma and Passiante, 2016; Secundo, Dumay, Schiuma and Passiante, 2016), where the intellectual assets are oriented to work together to enhance regional development and social commitment. The progressive creation of an entrepreneurial mindset of universities involves different initiatives ranging from the creation of incubators and accelerators, to the promotion of courses and a wide range of initiatives aiming to develop an EO of students and academic staff (Bikse et al., 2016; Hofer and Potter, 2010) and increase entrepreneurial competencies for technology entrepreneurship (Ndou et al., 2018).

The entrepreneurial strategies originated mainly in companies’ environments are now becoming part of the educational strategies of the universities that increasingly are recognising their role as a promoter of the development and diffusion of an entrepreneurial culture and capabilities with a positive impact on regional economic and socio-cultural dimensions (Sánchez-Barriolungo and Benneworth, 2019). As a result, entrepreneurship universities are becoming a key element of the development of today’s knowledge-based economy (Zaharia and Gibert, 2005), especially those that encourage entrepreneurial learning processes oriented to diffuse an entrepreneurial mindset both inside and outside university (Secundo, Del Vecchio, Schiuma and Passiante, 2016; Secundo, Dumay, Schiuma and Passiante, 2016).

Acknowledging that universities have to play a new role as catalysers of entrepreneurship, the notion of EO acquires a central position. Indeed, the crucial role of universities is not to create
enterprises but rather than to enable and support the development of EO both students and academic staff as well as more generally of all stakeholders. For this reason, the understanding of the notion of EO and its link to enterprises’ performance has a focal relevance. Practices of EO development should orient entrepreneurship universities and nurture new ideas, skills and competencies to react entrepreneurially to local and global changes, facilitate collaboration between small and medium entrepreneurs with undergraduate and postgraduate students (Bikse et al., 2016).

To be entrepreneurial, universities not only should embed an entrepreneurship posture at their core, but they need to engage with the entrepreneurial posture of local companies. This means that entrepreneurship universities should play a fundamental role in developing companies’ EO. This entrepreneurship paradigm invites to reshape one of the core values of traditional university, commonly named as social link-up. Even though entrepreneurship increases the potential of a university, the primary challenge is the co-creation and growth of regional SMEs businesses (Tipple et al., 2012), which with an EO strategy are susceptible to consolidate in the market (Ferreira and Garrido Azevedo, 2008; Mthanti and Ojah, 2017).

Exploring the relationships between EO and SMEs’ performance
The existence of a relationship between the EO’s construct and the organisations’ performance has been discussed in the management literature (Covin and Slevin, 1989; Ferreira and Garrido Azevedo, 2008; Keh et al., 2007; Lumpkin and Dess, 1996; Schepers et al., 2014; Soininen et al., 2012; Wiklund, 1999; Wiklund and Shepherd, 2003, 2005; Zahra, 1993; Zahra and Covin, 1995). Most of the studies prove the existence of a positive EO–performance relationship. However, in the case of highly uncertain and turbulent economic environments a negative correlation has also been detected (Pratono and Mahmood, 2015). Some researchers have identified a non-linear EO–performance relation (Kreiser et al., 2013). The results of the previous research works show that the ties between EO and company’s performance have diversified effects (Arshad et al., 2014), depending on the characteristics of the sectors and the adopted measurement approaches.

To shed light on the relationships between EO and companies’ performance, a research framework, depicted in Figure 1, is proposed. It considers the EO’s five dimensions of the reflective measuring model and the 14 dimensions that characterise the company’s performance, as addressed by Quinn and Rohrbaugh’s model. The empirical context of analysis is Mexico, a developing economy in which the recent crises have strongly affected SMEs survival capacity. More specifically, the investigation was carried out for the SMEs located in the region of Bajío. The production specialisation of this region is in the leather and footwear industry and represents one of the main generators of employment in Mexico; as well as a strategic supplier of popular consumption articles of Mexican families. However, in the last years, this sector has shown a lack of competitiveness regarding updating the production systems, the capacity of attracting and retaining talents, the difficulties of improving business performance and competitiveness, particularly, through the adoption of new managerial strategies fostering international export. To understand the links between EO and SMEs’ performance, an exploratory investigation of the relationships between EO and performance of Mexican SMEs companies in the Bajío region was carried out and, the following hypothesis was tested:

H1. EO has a positive effect on the performance of SMEs in the leather–footwear sector, in the Bajío Region, Mexico.

Research methodology
To verify the existence of a relationship between EO and SMEs’ performance, a Structural Equations Model by partial least squares— (PLS-SEM) approach has been adopted
This statistical model belongs to multivariate analysis tools of the second generation that allows simultaneously measuring the associations (Hair, Hult, Ringle and Sarstedt, 2014). The PLS-SEM provides a series of advantages over other methods as flexibility regarding data requirements; it is useful for complex models and the specification of model relationships (Sarstedt et al., 2014).

The variables building the model are: a latent variable of second order: the EO; detaching from it, observable variables according to Lumpkin–Dess’s reflective model: innovativeness (IN), proactivity (PR), risk taking (RT), autonomy (AT) and competitive aggressiveness (CA), which are measured by 18 items adapted from Hughes and Morgan (2007) EO’ scale; and the organisation’s performance as a dependent variable of first order, which is measured by 14 items adapted from Quinn and Rohrbaugh’s (1983) model.

Data about these variables were collected through a survey, which was issued to SMEs managers in the cities of Bajio region with the highest density of enterprises in the leather–footwear sector (CONACYT, 2014; INEGI, 2014). To obtain representative data, was used a random stratified sampling method, divided by company size, locations and suburbs using geolocation software (INEGI, 2016). In total, a sample of 170 valid instruments was obtained during fieldwork (see Table I). In the sample obtained, around

![Figure 1. Research theoretical model](image)

<table>
<thead>
<tr>
<th>Size</th>
<th>Frequency</th>
<th>Percentage</th>
<th>Valid percentage</th>
<th>Accumulated percentage</th>
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<tr>
<td><strong>Valid</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Medium</td>
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<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Small</td>
<td>161</td>
<td>94.7</td>
<td>94.7</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>170</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table I. Frequency by firm size
55 per cent of the SMEs are companies between 5 and more than 25 years of seniority in the market. Nearly 72 per cent of companies are family-based organisations. Regarding manager characteristics, approximately 80 per cent are men and more than 50 per cent of managers manifest to have basic education level. In Mexico, the basic education level is an initial educational step that corresponds to the first six years of school. About the manager’s age, nearly 55 per cent are in the range of 31–50 years, and almost 20 per cent have less than 30 years. And approximately 63 per cent of managers interviewed manifested that they are founders of the company (see Table II). These data was enough to test H1 using PLS-SEM (Chin et al., 1996; Hair, Hult, Ringle and Sarstedt, 2014) through SmartPLS® software in 3.2.7 version (Ringle et al., 2015).

One of the main objectives of the PLS-SEM approach is to detect the relationships between variables. The use of this technique has gained popularity primarily due to the complexity of the models in the areas of administration and management, the resistance due to insecurity or distrust of managers when surveyed, the saturation of surveys in some sectors and the decreasing rates of response (Sarstedt et al., 2014).

Findings have to be structured around the evaluation model, reliability and validity conditions. In that sense, two main stages were identified (Sarstedt et al., 2014): measurement model evaluation and structural model evaluation. If the theoretical research model passed this two stages, it is possible to determine that there is a significant relationship between a predicted and predictors variables (Fornell and Bookstein, 1982) and it is possible to develop the conceptual and empirical discussion about findings. PLS-SEM has proved to be useful in theory testing (Hair et al., 2011) and theory development (Hair, Hult, Ringle and Sarstedt, 2014; Hair, Sarstedt, Hopkins and Kuppelwieser, 2014).

### Table II. Data from sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seniority of the company</td>
<td>Less than a year</td>
<td>31</td>
<td>18.24</td>
</tr>
<tr>
<td></td>
<td>Between 1 and 4 years</td>
<td>43</td>
<td>25.29</td>
</tr>
<tr>
<td></td>
<td>Between 5 and 24 years</td>
<td>57</td>
<td>33.53</td>
</tr>
<tr>
<td></td>
<td>More than 25 years</td>
<td>39</td>
<td>22.94</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>170</td>
<td>100.00</td>
</tr>
<tr>
<td>Company’s foundational origin</td>
<td>Not answer</td>
<td>15</td>
<td>8.82</td>
</tr>
<tr>
<td></td>
<td>Familiar</td>
<td>122</td>
<td>71.76</td>
</tr>
<tr>
<td></td>
<td>Not familiar</td>
<td>33</td>
<td>19.41</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>170</td>
<td>100.00</td>
</tr>
<tr>
<td>Manager’s gender</td>
<td>Female</td>
<td>36</td>
<td>21.18</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>134</td>
<td>78.82</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>170</td>
<td>100.00</td>
</tr>
<tr>
<td>Manager’s educational level</td>
<td>Not answer</td>
<td>3</td>
<td>1.76</td>
</tr>
<tr>
<td></td>
<td>Basic level</td>
<td>87</td>
<td>51.18</td>
</tr>
<tr>
<td></td>
<td>High school level</td>
<td>44</td>
<td>25.88</td>
</tr>
<tr>
<td></td>
<td>University level</td>
<td>33</td>
<td>19.41</td>
</tr>
<tr>
<td></td>
<td>Postgraduate level</td>
<td>3</td>
<td>1.76</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>170</td>
<td>100.00</td>
</tr>
<tr>
<td>Manager’s age</td>
<td>Less than 30 years</td>
<td>33</td>
<td>19.41</td>
</tr>
<tr>
<td></td>
<td>Between 31 and 40 years</td>
<td>48</td>
<td>28.24</td>
</tr>
<tr>
<td></td>
<td>Between 41 and 50 years</td>
<td>46</td>
<td>27.06</td>
</tr>
<tr>
<td></td>
<td>Between 51 and 60 years</td>
<td>32</td>
<td>18.82</td>
</tr>
<tr>
<td></td>
<td>More than 60 years</td>
<td>11</td>
<td>6.47</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>170</td>
<td>100.00</td>
</tr>
<tr>
<td>Company’s founder</td>
<td>Not answer</td>
<td>2</td>
<td>1.18</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>106</td>
<td>62.35</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>62</td>
<td>36.47</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>170</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Findings
Adopting the proposed conceptual framework (Figure 1), a research model Type I reflective was developed (Becker et al., 2012) and the PLS-SEM algorithm was analysed by using the SmartPLS® 3.2.7 software for 170 observations. Figure 2 provides the representation of the model adopted in the study.

Measurement model evaluation
It is fundamental to mention that in reflective models, evaluation starts with the loading’s assessment obtained by checking each indicator such as IN1, IN2 and IN3. Loadings more significant than 0.70 indicate that the construct explains at least 50 per cent of the indicator variance, if they do not get that loading, remove indicators is a recommended path to improve the model fit. In this case, competitive aggressiveness (CA) indicators CA2 and CA3 showed loadings with 0.490 and 0.428, respectively, so they were eliminated. Although CA1 (0.917) had a significant loading, however with one indicator was not possible to perform the reliability and validity test for the dimension (Hair, Hult, Ringle and Sarstedt, 2014; Hair, Sarstedt, Hopkins and Kuppelwieser, 2014), so it was removed from the final model.

A low orientation of competitive aggressiveness (CA) is a significant discovery. This can be explained by the close familiar proximity of the Mexican SMEs in the leather–footwear sector. In other words, companies tend to cooperate and co-compete but supporting each other. Regarding the proactivity (PR) dimension, the PR3 indicator (0.572) was eliminated. Thus, two indicators were left (PR1 and PR2).

Figure 2.
Path model in SmartPLS®

Source: Obtained using SmartPLS® software (Ringle et al., 2015)
In the performance construct, a Hair, Hult, Ringle and Sarstedt criterion (2014) criterion (2014) was adopted where the researcher can examine the effects on the composite reliability and the validity of the construct before eliminating indicators that loadings are below of 0.70 (Hair, Hult, Ringle and Sarstedt, 2014; Hair, Sarstedt, Hopkins and Kuppelwieser, 2014). It is necessary to mention that after the analysis, those indicators below the standard value continued to respect the general parameters of the corresponding model and therefore continued to be part of the dimension (see Figure 3 and Table III).

The next validation step was the analysis of internal consistency reliability of the model. For this reason, the use of PLS-SEM is determined through composite reliability, which establishes margins of 0.60–0.70 as acceptable, while parameters between 0.70 and 0.95 are considered satisfactory and excellent, and those greater than 0.95 are problematic. The EO and firms’ performance dimensions obtained scores higher than 0.85 but less than 0.95 (see Table III).

The next step was the evaluation of the concurrent validity of reflexive constructs. Convergent validity is determined by the average variance extracted (AVE) of all items associated with each construct (Sarstedt et al., 2014). The AVE value was computed by the mean square of loads of all indicators associated with the construct (Sarstedt et al., 2014). An acceptable AVE corresponds to 0.50 or higher; the construct explains at least 50% per cent of the variance of its items. In this sense, the elements of the EO and performance constructs have an AVE higher than 0.50, thus manifesting convergent validity (see Table III).

After the reliability and convergent validity of the reflective constructs, it was necessary to determine the discriminant validity of the constructs. The discriminant validity determines how a construct differs from others in the model. The most conservative way to do so, is by using the Fornell–Larcker criterion (Hair, Hult, Ringle and Sarstedt, 2014; Hair, Sarstedt, Hopkins and Kuppelwieser, 2014; Sarstedt et al., 2014) and it is carried out by

![Figure 3. Adjusted path model in SmartPLS®](source: Obtained using SmartPLS® software (Ringle et al., 2015))
comparing the square root of the AVE of each construct in order to assess if it is higher than the correlations with the other constructs. As reported in Table IV a discriminant validity was satisfied.

### Structural model evaluation

Subsequently, an evaluation was performed of the structural model. For this kind of analysis, it is necessary to consider the following criteria: the coefficient of determination ($R^2$), the cross-validated redundancy ($Q^2$) and the path coefficients (Sarstedt et al., 2014). The indicator $R^2$ is a measurement relative to the variance explained on each dependent construct, so it is assumed to be a predictive measure of the model. The interpretation ranges that have to be considered are: higher than 0.67 it is considered as a substantial value; moderate explanatory value with the range 0.66–0.33 and a weak value with a range of 0.32–0.19.

The results indicate that EO’s dimensions corresponding to risk taking (RT), innovativeness (IN) and proactivity (PR) have values that allow a reasonable explanation of the construct. This result has practical implications since it provides interesting insights into the possible strategies that Mexican SMEs in the leather–footwear sector can adopt (see Table V).

Another way to evaluate the predictive relevance of the model is the $Q^2$, which is described as a predictive measurement, where values greater than 0 indicate an acceptable predictive value (see Table V). The cross-validated redundancy is used to obtain the $Q^2$ value (Hair, Hult, Ringle and Sarstedt, 2014; Hair, Sarstedt, Hopkins and Kuppelwieser, 2014; Sarstedt et al., 2014). The results indicated the model’s predictive value. Subsequently, the strength and significance of the path coefficients were evaluated by the relations established in the model.
and the hypothesis constructed from it. Using SmartPLS® Software (Ringle et al., 2015), there were five relationships obtained of the variables (see Table VI).

From the results obtained, it can be highlighted that EO is reflected in a positive and significant relationship, first, by the risk taking (RT) dimension with 0.809 coefficient path and, second, by the innovativeness (IN) aspect with 0.798. In addition to these results, it can be highlighted a significant and positive relationship between the EO and performance (0.427) of the Mexican SMEs of a leather–footwear sector of the Bajio region (see Table VI and Figure 3).

**Discussion of the empirical investigation**
The investigation of the relationships between EO and SMEs’ performance provides interesting insights. On the one hand, considering the specific empirical context, i.e. Mexico, the study sheds light on the centrality of EO for the competitiveness of firms in Latin American (Ferreira et al., 2015). On the other hand, the understanding of how the EO is

<table>
<thead>
<tr>
<th>Relation</th>
<th>Coefficient path</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO → IN</td>
<td>0.798***</td>
<td>22.781</td>
</tr>
<tr>
<td>EO → RT</td>
<td>0.809***</td>
<td>24.5494</td>
</tr>
<tr>
<td>EO → PR</td>
<td>0.671***</td>
<td>12.5007</td>
</tr>
<tr>
<td>EO → AT</td>
<td>0.557***</td>
<td>10.2304</td>
</tr>
<tr>
<td>EO → R (Hypothesis)</td>
<td>0.427***</td>
<td>5.453</td>
</tr>
</tbody>
</table>

**Notes:** Bootstrapping tests were carried out with a 5,000 subsamples by experiment (Hair et al., 2011). ***p ≤ 0.001

**Source:** Obtained using SmartPLS® software (Ringle et al., 2015)

<table>
<thead>
<tr>
<th>Relation</th>
<th>Coefficient path</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO → IN</td>
<td>0.890</td>
<td></td>
</tr>
<tr>
<td>IN</td>
<td>0.823</td>
<td></td>
</tr>
<tr>
<td>RT</td>
<td>0.356</td>
<td></td>
</tr>
<tr>
<td>PR</td>
<td>0.087</td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>0.068</td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.325</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Obtained using SmartPLS® software (Ringle et al., 2015)

<table>
<thead>
<tr>
<th>Relation</th>
<th>Coefficient path</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO → IN</td>
<td>0.637</td>
<td></td>
</tr>
<tr>
<td>IN</td>
<td>0.635</td>
<td></td>
</tr>
<tr>
<td>RT</td>
<td>0.655</td>
<td></td>
</tr>
<tr>
<td>PR</td>
<td>0.450</td>
<td></td>
</tr>
<tr>
<td>AT</td>
<td>0.310</td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>0.182</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Obtained using SmartPLS® software (Ringle et al., 2015)
linked to firms’ performance has implications for the definition of a knowledge-based agenda of initiatives for entrepreneurship universities.

This research proposes an empirical approach to measuring EO and its relationship with firms’ performance using a methodological design incorporating PLS-SEM in a reflective model. The findings outline the entrepreneurial gap between manifest EO dimensions and those whose effect is less or not at all significant.

The research findings confirm the existence of an association between EO and business performance, which corroborates previous studies (Arshad et al., 2014; Miller, 1983; Schepers et al., 2014; Zahra and Covin, 1995). Although five dimensions of EO were considered, i.e. innovativeness (IN), risk taking (RT), proactivity (PR), autonomy (AT) and competitive aggressiveness (CA), the empirical investigation has highlighted that risk taking and innovativeness are the critical dimensions explaining the EO of SME’s performance of the Mexican firms in the Bajio region. The two dimensions, risk taking and innovativeness, are mostly related to timing and seizing market opportunities (Ben-Menahem, 2013), to employee creativity (Joo and Bennett, 2018) and open-innovation (Burcharth et al., 2017).

The empirical investigation seems to suggest that universities embracing the entrepreneurship paradigm and aimed to implement a knowledge-based agenda to enhance regional entrepreneurial culture and capabilities should mainly focus their attention on the dimensions of innovativeness and risk taking. For this reason and with the aim to provide some recommendations, it is important to highlight two main managerial implications that can be considered valid for both SMEs and Universities:

1) “Full-entrepreneurial-jacket”: the study revealed a low influence of the competitive aggressiveness (CA) dimension on EO. It is worth mentioning that the leather and footwear industry is a SMEs familiar-based industry in the Guanajuato region; this foundational characteristic could restrict the appearance of an aggressive posture among competitors. In fact, during the fieldwork, some industry managers interviewed manifest their preference for having competition, but not that one whose objective entails the disappearance of other entrepreneurs in the region. This means that entrepreneurship universities should take into account three practical implications: may favour the creation of non-competitive networks for exploring opportunities of co-creation and co-development; support the creation of entrepreneurship agendas linked with managers that enhance EO with academic programmes; and use the publicity to engage different industrial sector (regional and international) in the university as a centre of promotion of entrepreneurship culture, innovation and technological transfer (Moortel and Crispeels, 2018).

2) “EO Gap-Entrepreneurship University Shot”: it is worth mentioning that the appearance of the autonomy (AT) dimension in OE’s manifestation (see Table VI and Figure 3) represents a finding that has practical implications for managers. However, it also reveals an opportunity area to improve the global effect of EO and performance relationship. In other words, there are two major areas of opportunity recommended for SMEs managers to improve EO-performance effect: strengthening the autonomy actions of managing personnel and designing marketing strategies to foster competitive aggressiveness in the market. These two adjustments could positively increase the influence of EO on the performance of an industry. These elements constitute an opportunity for an entrepreneurship university that can be named “a shot”. This equals to the design of academic programmes aimed to develop capabilities or skills of SMEs’ managers and to obtain updated information about how and why EO happens or not in a specific sector, or various sectors, in the studied region. This provides strategic elements to develop an “entrepreneurship agenda for a university” (Dalmarco et al., 2018).
Additionally, these findings further support the idea of the need to enhance entrepreneurial capabilities in business, due to rapid changes in the economic environment (Wiklund and Shepherd, 2003). Even though, these results can differ as suggested by Pratono and Mahmood (2015), who pointed out the negative relationship of “environmental turbulence” on the effect between EO and performance. The research findings show the relevance of developing risk taking and innovative capabilities, as postulated by other studies (Edmond and Wiklund, 2010).

One of the issues that emerge from these findings is how to develop such identified EO dimensions. In this regard, entrepreneurship universities could reinforce three main issues: “Attract new talents” – the development of new learning experiences that complement new managerial behaviours profiles could attract new students, as future managers; “Financial support” – the extension of an “outboard” organisational design to attract new business profiles and get financial support for future collaborative projects with local industry (Christensen and Eyring, 2011), –“Linking SMEs-University” – these actions could attract current managers of SMEs to develop new entrepreneurial competencies in “Laboratories of Managerial Experience” inside University Campuses. Universities, for instance, may develop these EO dimensions linking SMEs with students, as suggested by Taucean et al. (2018), and develop new academic programmes incorporating entrepreneurship, as a core dimension. Universities may define new strategies that develop the risk taking dimension, by providing more learning experiences where students and SMEs practitioners could transfer knowledge and technology together. This is, in accordance, with Kalar and Antonic (2015) could increase the perception of being entrepreneurially oriented changing harmful traditional assumptions of technology and knowledge transfer towards a new collaborative culture between industry and university with the aim to shape a “continuous knowledge ecosystem” (Stiglitz and Greenwald, 2014) engaging local SMEs and an entrepreneurship university.

Also, universities with strategic government support (Alexander and Evgeniy, 2012) may orient to build an entrepreneurial culture enhancing a more open environment where new ideas are welcome and prized, from students and SMEs practitioners. In this scenario, the potential of proactivity, autonomy and innovation dimensions can be well developed among professors, students and administrative personnel.

Conclusion
The present research was designed to determine the effect of EO on the performance of SMEs in the leather–footwear sector, in the Bajio Region, Mexico. To derivate implications to advance current studies exploring the links between EO and firms’ performance, and to get implications and applications that can inform the actions of entrepreneurship universities aiming to develop and diffuse an entrepreneurial culture and capabilities through an institutional agenda (Maas and Jones, 2017). The results have shown a significant positive effect of EO on SMEs’ performance. In general, therefore, it seems that developing capabilities, such as risk taking, proactivity, innovativeness, autonomy and competitive aggressiveness would enhance SMEs’ performance.

Entrepreneurship universities can play a fundamental role in sparking EO and this, particularly for emerging economies such as Mexico, has a critical role in the development of SMEs (OCDE, 2015). So the enhancement of the synergy between academia and industry (Alexander and Evgeniy, 2012) can consider the EO as one of the critical dimension to consider and focus on.

The development of EO can be considered as a critical driver to support employability, socio-economic growth and innovation interaction in diverse sectors (Alexander and Evgeniy, 2012; Davidsson et al., 2010). In this perspective, entrepreneurship universities have to extend their traditional focus on technology transfer, incubators and stakeholder collaboration, by
supporting the integration of entrepreneurial strategies in SMEs that are aimed at fostering the development of EO in managerial practices.

This empirical investigation carried out for the SMEs operating the Bajio region of Mexico, in the leather–footwear sector, provides insights about how possible strategies can be implemented aimed to support SMEs competitiveness by developing EO as a critical driver to enhance business performance. This investigation contributes to advance the conceptual understanding of the relationships between EO’s dimensions and business performance. For theory building, the findings provide evidence of EO’s settings in an emerging and Latin-American economy in a specific SMEs sector, which contributes to set differences between dimensions and understanding an entrepreneurial behaviour (Miller, 2011). The results of the research extend the insights collected in other emerging economies contributing to explain how EO can present different manifestation in diverse industries and cultural contexts (Covin and Miller, 2014). Indeed, Arshad et al. (2014) studying Malaysians technology-based industries have found that proactivity (PR) and innovativeness (IN) were the dimensions mostly reflected in the firm’s EO management style. On the other hand, Kreiser et al. (2013) found a non-linear manifestation of innovativeness (IN), proactiveness (PR) and risk taking (RT) in a different level of performance and EO.

This study points out that entrepreneurship universities in the context of Latin-American emerging economy, such Mexico, should design interventions aimed to strengthen specific entrepreneurial and managerial skills in students and local managers such as innovativeness and risk taking as well as on autonomy (AT) and competitive aggressiveness (CA). While EO and performance have shown a positive relationship, and they have been studied in different contexts (Arshad et al., 2014; Ferreira and Garrido Azevedo, 2008; Schepers et al., 2014; Soininen et al., 2012; Wiklund and Shepherd, 2003), identifying the behaviour of each EO dimension in a local sector provides information that allows designing specific practical strategies, especially for those oriented to improve the collaborations between university and industry. For example, the design of an “Entrepreneur Manager Educational Program” between regional entrepreneurs and local universities including the three pillars of an entrepreneurship university: “education, research and socio-economic development” (Dalmarco et al., 2018). Findings of this investigation provide evidence about the benefits of designing entrepreneurial universities actions for the development of SMEs’ entrepreneurial capacity.

Finally, from a methodological point of view, although the study has reached its aims, there were some unavoidable limitations. First, because the contact with managers was through a survey and although it captures their point of view about the EO strategy, such instrument does not enable the evaluation of how these strategies were carried out inside the company. For this reason, the results obtained cannot be considered as definitive. Therefore, further longitudinally studies and ethnographic methods should be conducted in this sector. The second limitation is related to the interpretation of items, despite the grammatical translation and Spanish cultural adequacy, it is correct to assume that some interviewed managers could probably not fully understand the meaning of questions. For this reason, replicate this Mexican cultural adaptation of the instrument in other industries context is considered relevant for further research.

Regarding future research, it is possible to identify some research gaps through these research findings. Future research would benefit from taking into account the following factors. It would be beneficial to include categorical moderators – variables, such as managers demographics data (age, studies, gender, etc.) and company data (location, age and size) to assess how these affect to EO-performance positive relationship. Additionally, it would be useful, to analyse the individual effect of each EO’s dimension directly on performance, and to analyse and discuss an EO-performance model in other international industrial sectors, in order to assess the EO effect in those SMEs cultural contexts. This information gets a strategic value for agendas of entrepreneurship on both business environments as well in university applications, to build an entrepreneurial behaviour or culture, particularly for local development.
An analysis of the structured relationship between EO and performance requires the adoption of an approach that clearly defines its characteristics and dimensions on an empirical context. This also needs to consider an accurate detection of crucial dimensions in EO and innovative conceptual approaches of EO. Therefore, in this research, a PLS-SEM approach was used to allow measuring of the structural relationships between dimensions.

References


(The Appendix follows overleaf.)
## Appendix

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Item</th>
<th>Spanish indicator</th>
<th>English indicator</th>
<th>Coefficient path (adjusted model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative</td>
<td>IN1</td>
<td>En la empresa, introducimos activamente mejoras e innovaciones</td>
<td>In the company, we actively introduce improvements and innovations</td>
<td>0.861 0.858</td>
</tr>
<tr>
<td></td>
<td>IN2</td>
<td>Nuestra empresa es creativa en sus métodos de operación</td>
<td>Our company is creative in its methods of operation</td>
<td>0.897 0.900</td>
</tr>
<tr>
<td></td>
<td>IN3</td>
<td>Nuestra empresa está en constante búsqueda acerca de nuevas formas de hacer el trabajo</td>
<td>Our company is constantly searching about new ways of doing work</td>
<td>0.912 0.912</td>
</tr>
<tr>
<td>Risk taking</td>
<td>RT1</td>
<td>El concepto de &quot;tomador de riesgos&quot; es considerado un atributo positivo para la gente en nuestra empresa</td>
<td>The concept of “risk taker” is considered a positive attribute for people in our company</td>
<td>0.781 0.775</td>
</tr>
<tr>
<td></td>
<td>RT2</td>
<td>La gente en nuestra empresa está motivada a tomar riesgos calculados con ideas nuevas</td>
<td>The people in our company are motivated to take calculated risks with new ideas</td>
<td>0.889 0.890</td>
</tr>
<tr>
<td></td>
<td>RT3</td>
<td>Nuestra empresa enfatiza tanto la exploración como la experimentación de oportunidades en el mercado</td>
<td>Our company emphasises both the exploration and the experimentation of opportunities in the market</td>
<td>0.797 0.800</td>
</tr>
<tr>
<td>Proactiveness</td>
<td>PR1</td>
<td>Siempre tratamos de tomar la iniciativa en cada situación (Sea con competidores, proyectos con otros socios o proveedores)</td>
<td>We always try to take the initiative in every situation (Be with competitors, projects with other partners or suppliers)</td>
<td>0.848 0.887</td>
</tr>
<tr>
<td></td>
<td>PR2</td>
<td>Sobresalimos entre nuestros competidores por la detección de oportunidades</td>
<td>We stand out among our competitors for the detection of opportunities</td>
<td>0.827 0.853</td>
</tr>
<tr>
<td></td>
<td>PR3</td>
<td>Iniciamos acciones a las cuales otras organizaciones del ramo responden más tarde</td>
<td>We initiate actions to which other organisations in the industry respond later</td>
<td>0.596</td>
</tr>
<tr>
<td>Autonomy</td>
<td>AT1</td>
<td>A los trabajadores de la empresa se les tiene permitido actuar sin intervención directa del patrón</td>
<td>The company’s workers are allowed to act without direct employer intervention</td>
<td>0.785 0.787</td>
</tr>
</tbody>
</table>

Table AI. Indicators by Dimension (Spanish and English) (continued)
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Item</th>
<th>Spanish indicator</th>
<th>English indicator</th>
<th>Coefficient path (adjusted model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT2a</td>
<td>A los trabajadores de la empresa se les permite investigar y desarrollar mejoras en la forma en la que ejecutan sus tareas cotidianas</td>
<td>The company’s workers are allowed to investigate and develop improvements in the way they perform their daily tasks</td>
<td>0.891 0.886</td>
<td></td>
</tr>
<tr>
<td>AT3a</td>
<td>A los trabajadores de la empresa se les es conferida libertad e independencia para decidir por si mismos acerca de cómo están realizando sus actividades</td>
<td>The company’s workers are given freedom and independence to decide for themselves about how they are doing their activities</td>
<td>0.882 0.882</td>
<td></td>
</tr>
<tr>
<td>AT4a</td>
<td>A los trabajadores de la empresa se les es conferida libertad para comunicarse sin interferencia alguna</td>
<td>The company’s workers are given the freedom to communicate without any interference</td>
<td>0.698 0.701</td>
<td></td>
</tr>
<tr>
<td>AT5a</td>
<td>A los trabajadores les es conferida autoridad y responsabilidad para actuar por sí mismos, si ellos piensan que están protegiendo los intereses de la empresa</td>
<td>The company’s workers are given authority and responsibility to act for themselves, if they think they are protecting the interests of the company</td>
<td>0.863 0.859</td>
<td></td>
</tr>
<tr>
<td>AT6a</td>
<td>A los trabajadores de la empresa se les otorga acceso a toda la información vital del negocio</td>
<td>The company’s workers are granted access to all vital business information</td>
<td>0.730 0.739</td>
<td></td>
</tr>
<tr>
<td>Competitive aggressiveness</td>
<td>CA1</td>
<td>Nuestra empresa es intensamente competitiva</td>
<td>Our company is intensely competitive</td>
<td>0.887 –</td>
</tr>
<tr>
<td></td>
<td>CA2</td>
<td>En general, en nuestra empresa se toma un agresivo acercamiento con los competidores del mercado</td>
<td>In general, our company takes an aggressive approach with the competitors of the market</td>
<td>0.544 –</td>
</tr>
<tr>
<td></td>
<td>CA3</td>
<td>En la empresa tratamos de desarticular y dejar fuera a la competencia del mercado</td>
<td>In the company we try to dismantle and leave out the market competition</td>
<td>0.466 –</td>
</tr>
<tr>
<td>Performance</td>
<td>P3</td>
<td>La calidad del producto</td>
<td>The product quality</td>
<td>0.616 0.661</td>
</tr>
<tr>
<td></td>
<td>P4</td>
<td>La eficiencia de los procesos operativos de producción</td>
<td>The efficiency of production processes</td>
<td>0.698 0.665</td>
</tr>
<tr>
<td></td>
<td>P5a</td>
<td>La organización de las tareas del personal</td>
<td>Organisation of tasks of personnel</td>
<td>0.690 –</td>
</tr>
<tr>
<td></td>
<td>P6</td>
<td>El nivel de satisfacción de los clientes</td>
<td>The level of customer satisfaction</td>
<td>0.615 –</td>
</tr>
</tbody>
</table>

(continued)

Table AI.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Item</th>
<th>Spanish indicator</th>
<th>English indicator</th>
<th>Coefficient path</th>
<th>Coefficient path (adjusted model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P7a</td>
<td>La rapidez de adaptación a las necesidades del mercado</td>
<td>The speed of adaptation to market needs</td>
<td>0.724</td>
<td>0.744</td>
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<tr>
<td>P8</td>
<td>La imagen de la empresa y de sus productos</td>
<td>The image of the company and its products</td>
<td>0.614</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>P9a</td>
<td>El número de los clientes</td>
<td>The number of clients</td>
<td>0.632</td>
<td>0.681</td>
<td></td>
</tr>
<tr>
<td>P10a</td>
<td>La expectativa de las ventas</td>
<td>The sales expectation</td>
<td>0.656</td>
<td>0.724</td>
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</tr>
<tr>
<td>P11a</td>
<td>La rentabilidad de la empresa</td>
<td>The profitability of the company</td>
<td>0.741</td>
<td>0.780</td>
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<tr>
<td>P12a</td>
<td>El nivel de productividad de la empresa</td>
<td>The level of productivity of the company</td>
<td>0.723</td>
<td>0.778</td>
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<tr>
<td>P13a</td>
<td>La contratación de personal para las funciones y planes de la empresa</td>
<td>The hiring of personnel for the functions and plans of the company</td>
<td>0.645</td>
<td>0.658</td>
<td></td>
</tr>
<tr>
<td>P14a</td>
<td>La motivación/ satisfacción de los trabajadores</td>
<td>The motivation/ satisfaction of workers</td>
<td>0.772</td>
<td>0.763</td>
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</tr>
<tr>
<td>P15</td>
<td>La rotación de personal</td>
<td>Personnel turnover</td>
<td>0.487</td>
<td>–</td>
<td></td>
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<tr>
<td>P16</td>
<td>El ausentismo de los trabajadores</td>
<td>The absenteeism of workers</td>
<td>0.421</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *Indicator included in the adjusted model. EO items based on scale of Hughes and Morgan (2007) and Performance items based on scale of Quinn and Rohrbaugh (1983).

Table AI.

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Entrepreneurial universities and strategy: the case of the University of Bari

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Abstract

Purpose – The purpose of this paper is to investigate why entrepreneurial universities choose a particular business strategy focussing on diversification and multi-nationalisation, and the role of intellectual capital (IC) in supporting such strategies.

Design/methodology/approach – The research question is answered through an exploratory case study of the University of Bari, Italy. Data were collected from strategic plans, annual reports, national evaluation reports and semi-structured interviews with the university’s board members and analysed using Secundo et al.’s (2016) collective intelligence framework.

Findings – The authors show how contingency factors, such as economic and historical reasons, justify both the diversification and internationalisation strategies, and how they both rely on IC.

Practical implications – The results of this study can be used by managers to support the development of entrepreneurial university strategies.

Originality/value – The paper is novel because it provides theoretical justification to strategy development in a university setting. Additionally, the findings contribute to the fourth stage of IC research by showing how IC can be used to support diversification and internationalisation in a university and support third mission goals. Finally, the paper provides an empirical application of the Secundo et al.’s (2016) model for understanding IC in universities.

Keywords Diversification, Internationalization, Entrepreneurial university, Intellectual capital, Strategy

Paper type Research paper

1. Introduction

Universities in western countries are facing a general reduction in the number of national students, and as a consequence, many are experiencing increasing pressure to attract international students (Criddle, 2016). Additionally, public sector budget constraints resulting from the global financial crisis have made education a prime target for cuts (Korn and McWhirter, 2017). Universities are also facing pressure to become knowledge-based agents for local value creation to support technology development, innovation and economic growth (Secundo et al., 2017). Hence, universities are facing more competition in their main activities and a need to develop new operating models supported by strategies to attract more students and more research funding to achieve broader social and economic development goals (Observatory of the European University, 2006). The broader goals are forcing universities to move from simply being higher education centres to become entrepreneurial (Etzkowitz and Leydesdorff, 2000).
The entrepreneurial role of universities has been widely discussed by scholars showing contradictory opinions. Pelikan (1992) describes universities as a place for knowledge advancement through research, knowledge transmission through teaching and publishing activities and preserving knowledge in libraries. Additionally, Krimsky et al. (1991) focus on academic and corporate ties in biotechnology and fear that involving universities in entrepreneurial activities could affect research agenda, scientific norms of communication, leading to conflicts of interest. Thus, some authors point out the role of universities as independent creators of knowledge that might be threatened by entrepreneurial activities.

The development of a knowledge economy leads to scholars expressing different opinions. According to Etzkowitz and Leydesdorff (2000, p. 313), entrepreneurial universities encompass a “third mission” of economic development, adding to research and teaching activities an entrepreneurial role. Here, entrepreneurial universities interact with industry and government, shaping a “triple helix” that also contributes to a developing society. This triple helix approach has been further analysed based on a “Mode 3” Knowledge Production System (Carayannis et al., 2016) that pushes universities to perform “basic research in the context of application”. Thus, while some scholars express fear for university independence, more recently scholars have outlined the benefits of an entrepreneurial university for economic and social development.

The understanding of entrepreneurial universities (Etzkowitz, 1983; Clark, 1998; Philpott et al., 2011; Etzkowitz, 2016) is even more relevant today as new university models are emerging, and, as outlined in the call for papers of this special issue, they present a contemporary research opportunity. In response, we investigate the strategy development of new entrepreneurial universities and build on the university’s intellectual capital (IC). More precisely, we analyse the exploratory case study of the University of Bari to examine why the university chooses a particular business strategy to become an entrepreneurial university, and how university IC supported the university’s aim to become a knowledge hub to support the social and economic development in its operating ecosystem (Secundo et al., 2018).

Our analysis particularly focuses on the pursuit of a diversification and multinationalisation strategy adopted by the University of Bari. The aim is to understand the reasons that led the University of Bari to develop and pursue its chosen strategy and the role of its IC in subsequently supporting that strategy. The case is interpreted through Secundo et al.’s (2016) collective intelligence framework for universities. Thus, we examine knowledge asset management through the key dimensions of what, who, how and why to answer the research question, resulting in both theoretical and practical contributions. This framework was selected as it allows for the identification and analysis of how universities strategically manage and measure IC contributing to the social and economic development (Secundo et al., 2018). The findings of this paper include a practical application of Secundo et al.’s (2016) framework and show why the University of Bari chose to pursue a particular business strategy to achieve the three main missions of the university: teaching, research and the third mission (Guan and Zhao, 2013). Contingency factors, such as historical and economic reasons, answer the “why” dimension of the framework and justify the university’s chosen strategy. Thus, our findings build on the literature on university’s strategies (Mintzberg and Rose, 2003) using a contingent approach that highlights the role universities play in the ecosystem (Etzkowitz and Leydesdorff, 2000).

Our findings show how the borders of IC are re-shaped in supporting entrepreneurial university strategies. Thus, results demonstrate how IC is used by the university within the ecosystem in which it operates (Dumay and Garanina, 2013). The selected university leverages on historical and geographical reasons to work in a more global manner. The findings show how considering IC in the context of an ecosystem can include a wider set of ICs that relate to the role universities play in the triple helix (Secundo et al., 2018).
This study is novel since it focusses on the emerging for the development of entrepreneurial universities. Additionally, the study focusses on how IC contributes to supporting the role of universities as knowledge hubs in their ecosystems. Best practices are recognised from the exploratory case study. Therefore, this research contributes to the fourth stage literature on IC which seeks to understand how IC impacts beyond organisational boundaries. Additionally, we outline managerial practices that can be used by university boards to support the transition to entrepreneurial knowledge hubs.

The remainder of the paper is organised as follows: Section 2 examines the relevant literature. Section 3 presents the research methodology. Section 4 presents the findings from the exploratory case study. Finally, Section 5 presents the discussion and conclusions of the paper.

2. Literature review and research question

Within an ecosystem perspective, entrepreneurial universities develop their activities through “collective intellectual innovation” (Buckland, 2009) where internal and external IC is used to develop courses, research programmes and support third mission goals (Cañibano et al., 2016; Secundo et al., 2017). Thus, entrepreneurial universities consider a broader concept of IC that supports all partners in the triple helix when developing courses, conducting research and undertaking activities to support the third mission (Brundenius and Göransson, 2011; Leydesdorff and Etzkowitz, 2001).

The emergence of the fourth stage of IC research provides a new perspective, in which IC is shaped by internal and external resources that interact to support teaching, research and third mission activities (Bisogno et al., 2018). Due to the fiercer competition in all of their main activities (Etzkowitz and Leydesdorff, 2000), universities use their IC to develop consistent strategies to achieve a broader social and economic development (Secundo et al., 2018). Diversification and internationalisation are two relevant strategic themes for a greater understanding of the university setting (Zanoni Beretta and Barzatta, 2011). The following subsections describe the role of IC in the context of diversification and internationalisation strategies from the perspective of the fourth stage of IC research.

2.1 IC and diversification to face new competitive challenges

Through a longitudinal case study on the McGill University, Mintzberg and Rose (2003) find that in order to increase students and revenue, many universities choose to diversify their teaching and research activities through a significant increase in the number of courses offered. Similarly, Teixeira (2014) finds that rather than increasing the number of courses, some universities diversify their revenue by balancing student tuition with funding for research projects. By contrast, universities might choose to specialise in specific fields to increase their effectiveness and efficiency (Agasisti, 2016). Thus, universities can either diversify to increase the number of courses and research activities or specialise in particular courses and research activities (Cattaneo et al., 2015; Donina et al., 2015; Seeber et al., 2016).

To diversify, universities need to leverage their existing knowledge in all aspects of IC. For example, according to Neffke and Henning (2013), human capital undertakes a central role in supporting diversification strategies. Even though human capital can be improved through the labour market, “a diversification strategy should focus on identifying new activities requiring resources that are already possessed, but currently underleveraged by a firm” (Neffke and Henning, 2013, p. 300). Additionally, in the perspective of increasing the number of services provided, universities need to increase their IC. Universities that want to attract new researchers need to disclose their existing human capital to become more appealing to individuals with higher skills and experience (Low et al., 2015). As always, scholars are under increasing pressure to “publish or perish” (Parker and Guthrie, 2016). But scholars that work in a university filled with skilled people are more likely to find high-calibre co-authors that can help to develop research and support the publication process. Thus, new, talented staff,
hired by the university, could improve their career prospects thanks to knowledge acquired from skilled colleagues.

Additionally, structural capital can reduce the production costs of new services (Camison and Villar-Lopez, 2010, p. 122) and is a crucial resource for business success (Wiedenhofer et al., 2017). Universities can leverage their physical structures and procedures to develop new courses and new research projects (Wiedenhofer et al., 2017). Existing structural capital, together with specialised physical and intellectual assets, such as specialised procedures within specialised labs, can help to develop new, focused research and curricula (Observatory of the European University, 2006).

Finally, relational capital supports the diversification process by helping organisations enter new market sectors more easily (Fernández-Olmos and Díez-Vial, 2012; Steenkamp and Kashyap, 2010), or by helping to enhance a university’s brand (Nguyen et al., 2016). Thus, in all three of its capitals, IC supports diversification strategies.

2.2 IC and internationalisation to face new competitive challenges
In a cross-sectional study, Ayoubi and Massoud (2007) report that several UK universities claim to be pursuing an internationalisation process in their institutional mission statements with international branches to serve a worldwide audience. While internationalisation and globalisation are key elements in most university mission statements, the connection with the local context is paramount to ensure the effectiveness of the triple helix (Pineda, 2015). Universities with multiple branches overseas can be described as multinational universities (Guimon, 2016; Maslen, 2012). Within this context, universities could have both a multinational strategy, where a university has international aims operating in multiple countries through overseas branches, and also focus on each local context.

Multinational universities can assume an international role, but stay strongly connected to their local community/ies (Greenholz, 2000). These universities can facilitate the exchange of staff to improve organisational performance “by universally imposing culturally-specific quality and accreditation standards and by transferring so-called ‘best practice’ from one country to another” (Pearce, 2016, p. 44). Similarly, Powell (2014) focusses on the positive knowledge effect that multinational universities can have in local communities, providing new insights and importing knowledge into developing countries through international experiences. However, to achieve this cross-border effect, “teachers undertaking transnational programmes have to be equipped with skill sets marked by high levels of intercultural understanding” (Kosmützky and Putty, 2016, p. 18). According to Kosmützky and Putty (2016, p. 21), the multinational and local paradox “neither results in worldwide homogeneity nor fully preserves national differences, but rather leads to interlacing convergences and divergences”, which fosters the development of human capital. Thus, IC can be used to support multinational strategies that help students and researchers exchange ideas in supporting knowledge mobility (Kazantsev and Zakhlebin, 2014).

Similarly, structural capital requires the development of cross-cultural competence assessment to assure quality standards (Greenholz, 2000). Multinational universities with a local focus can use their structural capital to work with national institutions to find better ways of, for example, exchanging data with national ministries due to shared internal and external procedures (Siboni et al., 2013). Thus, IC in all its forms can support the strategies of universities, helping them to become knowledge hubs and therefore become entrepreneurial universities.

2.3 Research question
Universities aim to produce the “knowledge, know-how, and technology of prosperous societies” (Brundenius and Goransson, 2011, p. v). Additionally, due to their role in the society, they are facing an increasing managerial complexity (Secundo et al., 2018). More and more universities need to manage their IC from an ecosystem perspective (Secundo et al., 2018).
Finally, in developing their strategies, in terms of the courses offered and their impact on the local community, universities need to consider their role as part of the triple helix (Etzkowitz and Leydesdorff, 2000). Thus, understanding why universities choose to compete using the strategies of diversification and multi-nationalisation, and the role IC plays in supporting these strategies is paramount not only for universities but also for the society as a whole (Cheng, 2017).

To gain a deeper insight into why enterprises, including universities, adopt one strategy over another, research into IC is expanding organisational boundaries to encompass countries, cities and communities (Dumay, 2013; Rooney et al., 2017; Dumay and Garanina, 2013). These broader horizons allow for a deeper interpretation of how IC creates bridges within entire ecosystems (Borin and Donato, 2015). For example, a university’s human capital extends beyond the borders of the campus to include alumni (Secundo et al., 2018). Similarly, a university’s relational and structural capital involves external actors in the context in which the university operates (Di Berardino and Corsi, 2018). Interestingly, as members of the triple helix, glocal and multinational universities deal with different contexts, countries, cities and communities that have different needs, which may influence a university’s strategy to diversify or specialise. Thus, the evolution of IC research, and its role in supporting university strategies, drives our research question as follows:

**RQ1.** Why does a university choose a particular business strategy?

### 3. Methodology

To answer this research question, we used Yin’s (2014) case study methodology. Compared to quantitative approaches, the qualitative approach of a case study allows researchers to discover and understand the relationships between variables in complex processes (Shah and Corley, 2006). Additionally, case studies are particularly useful when “a how or why question is being asked about a contemporary set of events over which the investigator has little or no control” (Yin, 2014, p. 14). Given our research question, we relied on an exploratory case study with the aim of extending existing theories on IC in the university’s specific research contexts. The following subsections describe the research context, and the methods used for data collection and analysis.

#### 3.1 Research context

We focus on Italy considering the public sector budget constraints and the need for social and economic development that the country is facing (Jones, 2017). We reviewed the list of the 67 public Italian universities and focus on those that specifically have a strategic plan focussed on the third mission. We focus on the University of Bari “Aldo Moro” (or University of Bari) as it represents a critical and representative case (Yin, 2014). The University of Bari is a public university located in Puglia in the southeast of Italy. Bari decided to pursue a new strategic plan to improve performance. Bari is a multinational university with a branch in Tirana, Albania, and its course range is extensive, encompassing 47 undergraduate courses and 50 master’s degrees (The University of Bari’s Strategic Plan, p. 17). Arguably, the University of Bari is a polar type: Bari is a fully diversified, international institution that adopted a strategy to differentiate itself in a competitive market. Interestingly, within this context the impact of this strategies on IC is transparently observable (Eisenhardt and Graebner, 2007).

#### 3.2 Case study design and Yin’s strategy for ensuring reliability and validity

The first step in the exploratory case study design was to establish a research protocol to ensure reliability (Yin, 2014). A research protocol defines the people to interview,
the average expected length of each interview and the questions to ask. We conducted semi-structured interviews with six board members from the university. According to Qu and Dumay (2011, p. 246), semi-structured interviews involve “prepared questioning guided by identified themes in a consistent and systematic manner interposed with probes designed to elicit more elaborate responses”. Our questions explored: the personal background of each board member; their role in the university; the university’s vision, mission and strategic objectives; and the impact of each university’s chosen strategy on both internal and external stakeholders. Additionally, a specific section of the interview was dedicated to the role of IC in supporting the university’s strategy.

As a supplement to the interview data, we also examined annual reports, the strategic plan and the national evaluation report for both universities. Table I lists the people interviewed and the documents collected.

3.3 Data analysis
To analyse the data, we used Secundo et al.’s (2016) collective intelligence framework. This framework was chosen because it specifically focusses on universities, including their external stakeholders. The key questions of what, who, how and why provide a structure for highlighting IC management and the strategic role it plays in the context of the University of Bari (Secundo et al., 2016):

- “What” outlines the universities’ goals in all three missions – teaching, research and social and regional development.
- “Who” represents the human capital that collectively contributes to the development of strategy.
- “Why” describes the vision?
- “How” examines the set of processes and actions used to achieve mission goals.

All of the case study data were examined and coded using open in-vivo coding in NVivo (Miles et al., 2013, p. 2340[1]). The results were then discussed among the authors to achieve investigator triangulation (Yin, 2014). A first draft of the results was produced and discussed with the people interviewed to validate the results (Yin, 2014). As a last step, a chain of evidence matrix was used to increase reliability (Yin, 2014). Section 4 presents the results of the analysis, followed by a discussion of our findings in Section 5.

<table>
<thead>
<tr>
<th>Source</th>
<th>Bari University</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>University documents</td>
<td>Strategic plan</td>
<td>SP2</td>
</tr>
<tr>
<td>Interviews with governance board</td>
<td>Interview 1</td>
<td>I21</td>
</tr>
<tr>
<td></td>
<td>Interview 2</td>
<td>I22</td>
</tr>
<tr>
<td></td>
<td>Interview 3</td>
<td>I23</td>
</tr>
<tr>
<td></td>
<td>Interview 4</td>
<td>I24</td>
</tr>
<tr>
<td></td>
<td>Interview 5</td>
<td>I25</td>
</tr>
<tr>
<td></td>
<td>Interview 6</td>
<td>I26</td>
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</table>

Table I. Sources used for developing the study

<table>
<thead>
<tr>
<th>Source</th>
<th>Bari University</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>National evaluation system documents</td>
<td>National evaluation indicators according to the law DM 345/2011</td>
<td>NE1</td>
</tr>
</tbody>
</table>
4. Results
The following section presents the case study analyses for the University of Bari using Secundo et al.'s (2016) framework to highlight the different aspects of the adopted strategy in answer to our research question:

RQ1. Why does a university choose a particular business strategy?

4.1 The case of the University of Bari
4.1.1 The “what” dimension. The University of Bari is located in the Puglia region in Southeast Italy. Bari is a public university, founded in 1925, with a Euro-Mediterranean focus and a diversified perspective in its course and degree offerings. Over the last year, Bari has developed a wide range of study opportunities that now include 113 classes from undergraduate level to master’s degrees, and some international dual/joint degrees with Tirana Catholic University[2]. Bari boasts more than 1,400 professors, including researchers and linguistics experts, and 48,000 enrolled students. It also hosts more than 700 Erasmus students. Our analysis of the “what” dimension for the University of Bari is illustrated in Table II.

The results show that the University of Bari performs its three missions through an open model of governance with internal and external stakeholder involvement. Further, Bari contributes to the fourth stage of IC research (Dumay and Garanina, 2013) in the context of the ecosystem in which it operates (Secundo et al., 2016, 2018). The goals of the University of Bari are fixed and explained in its strategic plan as a diversified, international strategy.

4.1.2 The “who” dimension. Bari’s internal and external stakeholders are listed in Table III.

Bari’s main internal stakeholders are professors and researchers, its strategic task force, employees and administrative offices, and national and international students. The professors and researchers are involved in Bari’s mission to support the internationalisation process. Participation in the Erasmus programme is strongly encouraged. A strategic task force consisting of a rector, vice-rectors and departmental deans helps to define its

<table>
<thead>
<tr>
<th>Aim</th>
<th>Literature</th>
<th>Description in the strategic plan</th>
<th>Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Becoming a diversified university with a multinational perspective that leverages internal and external IC</td>
<td>Literature on diversification strategies Mintzberg and Rose (2003) Agasisti (2016) Literature on multinational university strategies Pearce (2016) Kosmutzky and Putty (2016)</td>
<td>As a diversified university, Bari supports and promotes scientific and human knowledge cooperation, pursuing actions aimed at interaction and osmosis among scientific sectors, entities and organisations, and research groups working on several knowledge areas. It intends to develop research of international standards specialised in recognised high-quality fields that transfers functional knowledge, first through teaching, directed to develop the territory and the country (Source: Bari University’s Strategic Plan, p. 8)</td>
<td>[...] The diversified university as Bari university (with 120 classes of study) boasts so much experiences also in the teaching and scientific perspectives [...] (Interview code: I21)</td>
</tr>
</tbody>
</table>

Table II. The “what” dimension: the University of Bari’s aims
institutional relationships and promote Bari’s brand internationally. Employees and administrative offices are responsible for Bari’s education programmes and an organisational restructuring process to increase the university’s efficiency.

As the internal stakeholders, national and international students participate in the Erasmus programme, training and teaching offer aligned to the market opportunities extending existing theory (Teixeira, 2014) of the attraction of international students keeping national branches or opening new markets with branches abroad. Additionally, shared degree programmes support cultural exchanges between international branches.

Bari’s main external stakeholders are the professional institutions in the Puglia region who collaborate to develop post-degree courses that increase professional competences. These institutions also collaborate with Bari to promote cultural, social and economic development throughout the territory. These results provide new evidence on how multinational universities contribute as part of the triple helix to the development of cross-border cultural programmes (Pearce, 2016).

4.1.3 The “why” dimension. Strategic intent, mission statements, strategic visions, corporate strategies and strategic plans reveal an organisation’s internationalisation process supported by several actions (Ayoubi and Massoud, 2007). Some examples include the adoption of the Erasmus programme, the development of an international branch in collaboration with the Tirana Catholic University, the enhancement of an open culture supported by multiple collaborations with institutions of the Puglia region and geographical position near to other nations such as Tirana, Kosovo and the Balkan area. These results show how the University of Bari represents an example of an Italian university with a multinational strategy. Interestingly, these motivations contribute to the existing theories that show how contingency elements, such as position, existing relationships, culture and history can influence the development of multinational strategies (Pearce, 2016).

Furthermore, Bari’s strategy pursues a diversification strategy thanks to several actions and activities aimed at increasing the number of students and revenues by growing the

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Involvement goals</th>
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<tbody>
<tr>
<td>Internal</td>
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<tr>
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<td>International and national students</td>
<td>Definition of institutional relationships and identity acquisition in the international context</td>
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<tr>
<td>Strategic task force (rector, vice-rectors, departments deans)</td>
<td>Education is a relevant task to increase efficiency as well as restructuring</td>
</tr>
<tr>
<td>Employees and administrative offices</td>
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<tr>
<td>Training and teaching offerings aligned to market opportunities</td>
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Table III. Main stakeholder involvement in the University of Bari’s strategy

Institutional relationships and promote Bari’s brand internationally. Employees and administrative offices are responsible for Bari’s education programmes and an organisational restructuring process to increase the university’s efficiency.

As the internal stakeholders, national and international students participate in the Erasmus programme, training and teaching offer aligned to the market opportunities extending existing theory (Teixeira, 2014) of the attraction of international students keeping national branches or opening new markets with branches abroad. Additionally, shared degree programmes support cultural exchanges between international branches.

Bari’s main external stakeholders are the professional institutions in the Puglia region who collaborate to develop post-degree courses that increase professional competences. These institutions also collaborate with Bari to promote cultural, social and economic development throughout the territory. These results provide new evidence on how multinational universities contribute as part of the triple helix to the development of cross-border cultural programmes (Pearce, 2016).

4.1.3 The “why” dimension. Strategic intent, mission statements, strategic visions, corporate strategies and strategic plans reveal an organisation’s internationalisation process supported by several actions (Ayoubi and Massoud, 2007). Some examples include the adoption of the Erasmus programme, the development of an international branch in collaboration with the Tirana Catholic University, the enhancement of an open culture supported by multiple collaborations with institutions of the Puglia region and geographical position near to other nations such as Tirana, Kosovo and the Balkan area. These results show how the University of Bari represents an example of an Italian university with a multinational strategy. Interestingly, these motivations contribute to the existing theories that show how contingency elements, such as position, existing relationships, culture and history can influence the development of multinational strategies (Pearce, 2016).

Furthermore, Bari’s strategy pursues a diversification strategy thanks to several actions and activities aimed at increasing the number of students and revenues by growing the

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<th>Stakeholders</th>
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Furthermore, Bari’s strategy pursues a diversification strategy thanks to several actions and activities aimed at increasing the number of students and revenues by growing the
number of curricula provided by the university. As the University of Bari’s Strategic Plan (p. 8) states, “Among the commitment on the research, teaching and high education, the contribution to the scientific, cultural and civil growth of local, national and international community is essential”. Thus, results show that Bari opted for a diversification strategy, in an international context, to increase revenue opportunities but also to contribute in a broader sense to the development of the communities it is geographically and historically connected to.

4.1.4 The “how” dimension. This dimension focusses on the actions and the impact of IC in light of Bari’s diversified, international strategy. The results of this analysis are shown in Tables IV and V.

Our findings show that Bari relied on enhancing existing competences to diversify graduate and postgraduate courses, along with specific professionalisation courses with the aim of consolidating shared values with the territory and internationally. According to topics on the relevance of human capital by Neffke and Henning (2013), the University of Bari valorises its professors and employees by investing in their education improvement and proposing teaching programmes with generalist paths to increase students’ education and permitting the admission of students to several classes. Within this context national and international human capital assumes a central role in supporting diversification strategies. Interestingly, these results extend the findings of Secundo et al. (2018) by providing a new perspective on external human capital in multinational universities.

Additionally, a relevant role is revealed for the University of Bari as a promoter of values in all of the territories in which it operates and in its external collaborations with institutions in the Puglia region by enhancing the professional knowledge of its post-degree students. Additionally, broader involvement by all of Bari’s stakeholders originates mainly from the promotion of its partnerships and collaboration networks to external organisations in the Puglia region, such as the Bari Municipality. These partnerships seek to achieve social, cultural and economic growth extending existing theories (Fernández-Olmos and Diez-Vial, 2012; Steenkamp and Kashyap, 2010) through the opportunities of the university to enter new markets and collaborate with them exchanging knowledge and value.

Thus, the aim of the University of Bari is to increase synergies with labour and professional organisations to develop its third mission activities and to become an urban campus following the Chicago model. Interestingly, the multinational dimension of Bari’s strategy enhances these opportunities since multinational projects can easily be developed by supporting historical and economic connections. Thus, these results contribute towards extending existing theories on the fourth stage of IC (Dumay and Garanina, 2013) by showing the role of multinational universities.

As a crucial resource in its success, Bari leverages its existing procedures and structures to supports its activities (Wiedenhofer et al., 2017). Hence, with the aim of achieving quality objectives in a diversified strategy, Bari established several regulations, research indicators and research valuation committees inside its departments. The regulations govern a range of areas, such as teaching and the PhD school; the research indicators include national research evaluations (VQR), and so on. In addition, Bari has initiated an innovative process to disseminate student opinions on teaching, using the University’s website as the main strategic tool to move beyond a national context.

The education of people by sharing core values, attracting students and exporting values are also relevant insights. Passing on knowledge to the international scientific community involves a massive increase in the knowledge its human capital currently holds, which has largely been accomplished through international course offerings and mutual exchanges with overseas students and professors (e.g. the Erasmus programme and visiting scholars). Additionally, Bari consolidated its relationships with other universities to increase
### Table IV. Bari’s diversification strategy – actions

<table>
<thead>
<tr>
<th>Action</th>
<th>Literature</th>
<th>Description in the strategic plan</th>
<th>Interviews</th>
<th>Impact on IC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing the diffusion of knowledge at the national and international level</td>
<td>Human capital is relevant to organisations (Neffke and Henning, 2013)</td>
<td>Valorising professors follows economic, efficiency, and efficacy criteria (p. 21). Employee education is a relevant task (p. 36; p. 38)</td>
<td>“Several high quality scientific fields exist in all university sectors […] The diversified university as Bari university (with 120 classes of study) boasts so much experiences also in the teaching and scientific perspectives […]” (Interview code: I21)</td>
<td>Enhance existing competencies</td>
</tr>
<tr>
<td>Increasing the recognition of research outcomes at the national and international level</td>
<td>Strategic intent, mission statement, strategic vision corporate strategy and strategic plan allow for the recognition of internationalisation process. (Ayoubi and Massoud, 2007, p. 329) The variety of scientific fields is synonymous with differentiation (Beretta Zanoni and Borzatta, 2011, p. 102)</td>
<td>Bari University’s diversified strategy aims to develop research of an international standard, specialised in recognised high-quality fields (p. 8)</td>
<td>“A changing process has been developed especially if we think to an university as Bari in which there was a resistance to change […]” (Interview code: I24)</td>
<td>Multidisciplinary</td>
</tr>
<tr>
<td>Consolidating shared values with the territory</td>
<td></td>
<td>Bari University assumes the role of democracy, equality, and growth courier (p. 8)</td>
<td>We’ve activated professional consultants with professional institutions in the Puglia region […] (Interview code: I21)</td>
<td>Core values</td>
</tr>
<tr>
<td>Developing collaborative relationships with strategic partners and institutions in the Puglia region</td>
<td></td>
<td>One of the activities is the activation of collaborations with professional institutions of post-degree courses to increase professional competencies (p. 34)</td>
<td>Professionalisation after completing a university degree</td>
<td>Professionalisation</td>
</tr>
<tr>
<td>Increasing synergies with institutions, and labour and professional organisations to develop the third mission</td>
<td>Universities should have a dialogue between science and society and also contribute to regional development, and the development of cultural capital for social cohesion (Secundo et al., 2017, p. 3)</td>
<td>Collaboration with institutions, labour and the professional world promotes cultural, social, and economic development (p. 8) and establish synergies with research actors (pp. 29:30)</td>
<td>“External stakeholders are local actors of social and economic system from city and region […] so they are professional organisations and industrial institutions with which we have a relationship based on two reasons: third mission and social partners consultation to qualify degrees” (Interview code: I24)</td>
<td>Broader involvement of all the stakeholders</td>
</tr>
<tr>
<td>Action</td>
<td>Literature</td>
<td>Description in the strategic plan</td>
<td>Interviews</td>
<td>Impact on IC</td>
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<tr>
<td>Increasing collaborations with private and public entities, such as</td>
<td>Third mission activities comprise dimensions performed by universities in relation to external environments: technology transfer and innovation, continuing education, and social engagement (Secundo et al., 2017, p. 3)</td>
<td>Wide collaborations with private and public entities, both in research and the third mission, exist (p. 16) as well as the sensibility of regional and local interlocutors and social entities to university issues (p. 17)</td>
<td>“Key stakeholders are category organisations, professional entities, and institutions, such as the regional and Bari municipality […] then, there are other partners, such as foundations and societies included in Bari University like Technopolis “We have the university campus project, which presents us an urban campus following the Chicago model to the municipality […] as an integrated university in the city that facilitates city growth” (Interview code: I24)</td>
<td>Broader involvement of all the stakeholders</td>
</tr>
<tr>
<td>Bari Municipality, the Puglia Region, and Technopolis Presenting the</td>
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<td>university campus project as an urban campus following the Chicago</td>
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<td>model</td>
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<tr>
<td>Incorporating national research evaluation results in the quality</td>
<td>Universities’ governing bodies are responsible for the management of the institution and for planning its future development (Low et al., 2015, p. 780)</td>
<td>Results of national research evaluation (VQR) are used to define quality objectives aligned to ministry incentive mechanisms (p. 17)</td>
<td>The National Agency for the Research Valuation ANVUR has given four blue stickers to our university […] (Interview code: I21)</td>
<td>Use of existing procedure and structures connected with supporting activities</td>
</tr>
<tr>
<td>objective processes of Bari University</td>
<td></td>
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<tr>
<td>Developing innovative processes to disseminate students opinions on</td>
<td>The indicators used provide visual outputs for each strategic objective (Secundo et al., 2016, p. 309)</td>
<td>One of the indicators used is the evolution of measurement parameters of teaching quality for teaching programs and classes (p. 24)</td>
<td>We collect students opinions and publish them on our website […] (Interview code: I22)</td>
<td>Use of existing procedure and structures connected with supporting activities</td>
</tr>
<tr>
<td>teaching activities through the university website as a strategic tool</td>
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<td>to move beyond national context</td>
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Table IV.
<table>
<thead>
<tr>
<th>Actions</th>
<th>Literature</th>
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<th>Interviews</th>
<th>Impact on IC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realisation of double and joint degrees with foreign universities teaching and joint research initiatives between the University of Bari and Tirana Catholic University</td>
<td>The adoption of a strategy of diversification for teaching and research activity with growth of the number of curricula provided (Mintzberg and Rose, 2003)</td>
<td>Opening the international scientific community and promoting the knowledge, technological progress, and cultural and professional growth of people (p. 8)</td>
<td>This academic year we're offering six degrees of international nature among which marketing, information security, physic, medic and pharmacy at Tirana with a double degree [...] (Interview code: I22)</td>
<td>Educate people: core values</td>
</tr>
<tr>
<td>Stipulation of agreements and development of relations with foreign universities for the Erasmus programme</td>
<td>Several factors supporting an international strategy exist, such as international teaching programmes, partnerships, students and staff exchanges, and research activities (Ayoubi and Massoud, 2007, p. 330)</td>
<td>Existence of the Erasmus and Erasmus Plus programmes (p. 17)</td>
<td>This year we celebrate 30 years of Erasmus activity [...] tomorrow we will be holding two meetings to promote the Erasmus competition promotion [...] stimulating students participation [...] (Interview code: I25)</td>
<td>Attract students</td>
</tr>
<tr>
<td>Stipulation of agreements with foreign universities to develop reciprocal placement actions Development of relations with strategic geographic areas: Albania</td>
<td>University internationalisation includes joint educational projects, postgraduate levels, student and staff exchange, curriculum matters, and administrative cooperation (Ayoubi and Massoud, 2007, pp. 330-331)</td>
<td>The proposition of a wide and varied training and teaching offering aligned to market opportunities (p. 16)</td>
<td>We’ve activated degrees in the English language and conventions with international universities, such as Tirana University [...] (Interview code: I23)</td>
<td>Attract students</td>
</tr>
<tr>
<td>Increasing the opportunity to develop international teaching and research through visiting professors positions</td>
<td></td>
<td></td>
<td>We’ve planned to reserve money for visiting professor [...] to guarantee to our colleagues have this international experience [...] (Interview code: I22)</td>
<td>Export values</td>
</tr>
<tr>
<td>Launch of scholarships to increase knowledge in the international context</td>
<td>Educating students is a relevant focus for university measuring through students satisfaction (Low et al., 2015, p. 786)</td>
<td>Developing intra- and extra-regional attraction indicators of students (p. 24)</td>
<td>Government bodies (following rector indication) have started to invest in scholarships with the aim of guaranteeing students the possibility to develop their thesis abroad [...] (Interview code: I22)</td>
<td>Attract students</td>
</tr>
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<tr>
<td>Increasing the opportunities to develop international teaching and research</td>
<td>The adoption of a strategy of diversification for teaching and research activity with growth in the number of curricula provided (Mintzberg and Rose, 2003)</td>
<td>To support knowledge directed to developing the local context and the nation is necessary to highlight teaching programs and research of an international standard (p. 8)</td>
<td>[...] opening the university to the local context with an international dimension (Interview code: I21)</td>
<td>Educate people; core values</td>
</tr>
<tr>
<td>Developing relations with strategic geographic areas: Albania and Kosovo</td>
<td>Internationalisation is a good strategy for increasing market profile, international image, diversification, and opportunities for new income (Ayoubi and Massoud, 2007, p. 331)</td>
<td>Consolidated research relationships with high quality international centres (p. 16)</td>
<td>Bari University has had a relationship with Tirana University since 2004 [...] I’m gathering the challenge that the rector has promoted is intensifying the collaboration with this university [...] we’ll have a meeting to discuss [...] a business opportunity between Albany and Kosovo [...] (Interview code: I25)</td>
<td>Consolidate relationships to increase project opportunities</td>
</tr>
<tr>
<td>Consolidation of collaborative relationships with Tirana Catholic University</td>
<td></td>
<td>Bari University needs to participate in scientific international competitions to increase competencies and find ideas to transform into specific projects</td>
<td>At the Tirana University [...] it has been activated as an Advisory Board of the faculty connected to territorial companies or with other institutions, such as foreign trade institutions (Interview code: I25)</td>
<td>Consolidate relationship to increase project opportunities</td>
</tr>
<tr>
<td>Creation of a skilled committee to support research project activities</td>
<td></td>
<td>Institution of a research team work and departmental committee supporting research projects, open competition participation and research activities</td>
<td></td>
<td>Use of existing procedures to be replicated</td>
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</tbody>
</table>
international project opportunities, for example, by establishing collaborations with the Tirana Catholic University and research centres in strategic geographical areas contributing to the existing theory (Kosmützky and Putty, 2016) of intercultural understanding through knowledge sharing, human capital valorisation and increasing relationship.

According to the theory of knowledge mobility supported by Kazantsev and Zakhlebin (2014), the University of Bari proposes to achieve international research standards by promoting basic and applied research and fostering international partnerships. The development of cross-cultural assessing competence to assure quality standards (Greenholz, 2000), the use of existing university procedures (e.g. assistance in the project definition; meetings organisations with external stakeholders to share researches results) needs to be replicated especially in research projects and activities directed to the international scenario. Establishing a skilled committee has resulted in useful procedures to be adopted in the above context. Further, Bari has developed a database of research projects on a smart IT platform.

5. Discussion and conclusions
This paper presents a case study, analysed using the collective intelligence framework for universities developed by Secundo et al. (2016). The University of Bari in Italy is interpreted through the framework’s key dimensions of what, who, how and why to answer the question:

RQ1. Why does a university choose a particular business strategy?

The results of the analysis provide both theoretical and practical contributions to the literature as presented in the following subsections.

5.1 Practical contribution
The practical contribution of our research begins with the research question. In analysing why an entrepreneurial university chooses a particular strategy, the results reveal that the University of Bari adopted a strategy in pursuing teaching, research and third mission goals (Etzkowitz, Leydesdorff, 2000) in the light of the production, the application and the promotion of knowledge and technology (Leydesdorff and Meyer, 2006). The University of Bari choses a diversified approach (Guan and Zhao, 2013).

To show the diversified approach, we identify contingency factors, such as historical and economic reasons, in the “why” dimension of the framework to justify university decisions. For example, the University of Bari developed a diversified strategy due to its perceived role in shaping cultural values and supporting the broader development of society. These findings build on findings concerning the benefits of diversification strategies (Mintzberg and Rose, 2003). We outline how different approaches increase the university’s effectiveness and efficiency (Agasisti, 2016). Additionally, our findings support the development of a contingency approach that highlights the role that universities play in the triple helix context to explain a university’s strategy (Etzkowitz and Leydesdorff, 2000).

Additionally, our findings show how the borders of IC are being re-shaped to support entrepreneurial university strategies. The multinational strategy of the University of Bari is focussed on intercultural understandings derived from: student and academic exchanges (Kosmützky and Putty, 2016), consolidating relationships to develop project opportunities with other universities and research centres in strategic geographic areas, and developing cross-cultural competence assessments to ensure that quality standards are met and maintained.

Overall, our findings show how IC is used by the University of Bari within an ecosystem (Dumay and Garanina, 2013). For example, the strategic plan of the University of Bari
focusses on the development and transfer of shared cultural values through a multinational approach to education. Stakeholders support the development of new courses and new research projects in both universities. The University of Bari leverages history and geography to operate on a more global level. Our findings show how the University of Bari uses its entire IC ecosystem to include a wider set of intangible assets that relate to the role that universities play in the triple helix (Secundo et al., 2018).

Interestingly, our results can be used by university boards and policymakers in developing the role of universities as knowledge hubs. We show the importance of contingency factors and argue that these factors must be evaluated in entrepreneurial universities. IC needs to be re-shaped and measured before starting an entrepreneurial transition in universities.

5.2 Research contribution
The paper analyses specific strategies developed by the University of Bari to test the model developed by Secundo et al. (2016). These cases provide a practical application for Secundo et al.’s (2016) model and contribute by analysing why this university chose the particular strategy it did. More specifically, the results of our analysis are summarised in Table VI and further outlined in the following subsections. These results provide evidence of the model's application with descriptions of each dimension and a comparison of the strategy adopted by the University of Bari.

5.2.1 Contribution and future “what” research. This paper investigates the strategies of diversification and multi-nationalisation through an exploratory case study. The results show how the University justifies its choice based on a long-term aspirational view of their role in the community. IC is considered to be a key element in defining the “what” dimension, therefore, building on the fourth stage of IC research in the university setting as we examine the ecosystems in which the university operates (Bisogno et al., 2018). Further research might explore whether there are other relevant strategic variables to investigate. For example, future research works might analyse closed vs open enrolment strategies or online vs onsite strategies to see how these strategies combine.

5.2.2 Future “who” research. The “how” dimension shows internal and external stakeholder involvement in the mission of the University of Bari (e.g. professors, international and national students, strategic task force, labour and professional institutions). Our findings build on Secundo et al. (2016), showing that the relationships with external and internal stakeholders are relevant issues in understanding their influence on the community. Interestingly, the findings also show how the university refers to different audiences based on its specific strategy. These findings might be used by other universities to compare stakeholder’s involvement. Further, subsequent research could focus on the involvement of differences in applying various strategies (e.g. online vs onsite).

5.2.3 Future “why” research. The “why” dimension analyses the reasons and motivations supporting the university’s vision in local community, and collaborations with territorial organisations and internationalisation processes, international branches and diversifying courses and research activities in the case of the University of Bari.

<table>
<thead>
<tr>
<th>Results</th>
<th>University of Bari</th>
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<tbody>
<tr>
<td>What</td>
<td>Diversification and multinational strategy</td>
</tr>
<tr>
<td>Who</td>
<td>All institutions in the territory</td>
</tr>
<tr>
<td>Why</td>
<td>Internationalisation process</td>
</tr>
<tr>
<td>How</td>
<td>Multidisciplinary projects (e.g. professional competence projects, synergies with labour and professional organisations)</td>
</tr>
</tbody>
</table>

Table VI. The University of Bari: results comparison
Interestingly, the findings confirm the role of IC in supporting the collaboration of the University of Bari with its local communities as part of an ecosystem in which the university survives (Secundo et al., 2016, 2018). Thus, these findings can be used by other universities to compare strategic motivations.

5.2.4 Future “how” research. Our findings describe the “how” dimension through the specific action undertaken by the University of Bari to develop its strategy and the role IC played in supporting it. The University of Bari developed teaching programmes with generalist paths and has increased its synergies with labour and professional organisations. It also developed a database of research projects on a smart IT platform. These results extend the findings of Secundo et al. (2018) by providing a new perspective on external human capital in a university setting. Further, they provide some insights for universities when adopting similar strategies to leverage and/or improve their IC within an ecosystem approach contributing towards the creation of strong connections with local communities (Greenholz, 2000) and to achieve a social, cultural and economic growth. Finally, results highlight the actions and strategies directed to increase the role of IC for developing strategy, especially through the use of an ecosystem approach based on the Secundo et al.’s (2016) analytical framework.

5.3 Limitations
The limitations of the paper derive from the analysis of only one exploratory case study in the public sector in Italy. Future research might apply Secundo et al.’s (2016) framework to other entrepreneurial universities in different countries to help understand their particular strategies. Additionally, different models can be applied to extend our findings.

Notes
1. According to Miles et al. (2013), in-vivo coding “is one of the most well-known qualitative coding. NVivo coding uses words or short phrases from the participant’s own language in the data record as codes”.

2. The full name is Catholic University “Nostra Signora del buon consiglio” of Tirana.

References


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The role and function of cooperative research centers in entrepreneurial universities

A micro level perspective

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Matthias Menter
Faculty of Economics and Business Administration, Friedrich Schiller University Jena, Jena, Germany, and

Caroline McGregor
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Abstract

Purpose – The purpose of this paper is a micro-level examination of the role and function of cooperative research centers (CRCs) in entrepreneurial universities from a principal investigator (PI) perspective.

Design/methodology/approach – This study uses a qualitative research design and is based on 38 semi-structured interviews with PIs who are publicly funded at the Centre for Research in Medical Devices (CÚRAM) based in Ireland. CÚRAM has a multiple mission focus of supporting scientific excellence, industry engagement, educational and public engagement that supports the Irish medical device sector.

Findings – The findings reveal that CRCs’ role and function at the micro level constitute a necessary and functional organization architecture that supports PIs who are required to meet multiple scientific, commercialization, educational and public engagement objectives. Specifically, from the micro-level PI perspective, the role and function of CRCs focus on research quality enhancement, brokerage, networks and collaborations, addressing research impact and resource enhancement and appropriation.

Practical implications – This research emphasizes the importance and necessity for the creation of CRCs as part of the entrepreneurial architecture of entrepreneurial universities that provides the necessary appropriate local environmental conditions and enhanced supports to enable micro-level actors to fulfill multiple mission objectives with respect to research excellence, industry, educational and public engagement and impact.

Originality/value – This study contributes to the limited literature on new institutional configurations that support entrepreneurship and addresses recent calls for further research. In taking a micro-level focus, the authors identify the role and function of CRCs from a PI perspective in an entrepreneurial university setting.

Keywords Entrepreneurship centres, Entrepreneurship, Entrepreneurial universities, Principal investigators, Entrepreneurship research centres, Cooperative research centres

Paper type Research paper

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1. Introduction
The growing body of empirical research related to entrepreneurial universities has provided a richer understanding of how universities are responding and coping with an evolution in their core missions, i.e. education, knowledge creation, knowledge transfer and commercialization. According to Urbano and Guerrero (2013, p. 43), the entrepreneurial university is “a natural incubator providing support structures for teachers and students to initiate new ventures: intellectual, commercial, and conjoint.”

Empirical studies have further shed light on how entrepreneurial universities are meeting the increasing external and internal demands and expectations of students, staff, industry, government and society. For example, based on a UK study, Guerrero et al. (2015) have showed that entrepreneurial universities’ activities do have an economic impact across all missions. For universities to adopt an entrepreneurial university philosophy, they have to be entrepreneurial with respect to culture, structures, strategies and processes (see Cunningham, Guerrero and Urbano, 2017).

One way that entrepreneurial universities have responded to these challenges is by scaling its entrepreneurial architecture through establishing dedicated entrepreneurship centers (ECs), entrepreneurship research centers (ERCs) or cooperative research centers (CRCs) to effectively and sustainably address socio-economic demands and expectations (see Boardman and Gray, 2010; Cassia et al., 2014; Katz, 1991; Maas and Jones, 2017). These new institutional configuration units seek to support entrepreneurship activities along other mission objectives and this is reflected by the scope of their activities. ECs have a focus on students and on established businesses (see Menzies, 2000) and promote what Del-Palacio et al. (2008) describe as “entrepreneurial attitudes” throughout the university and beyond. The core focus of ECs is on applied entrepreneurship activities, which are aimed at supporting new venture creation among university stakeholders. ERCs on the other hand have a broader remit and scope, which combines research and applied entrepreneurship activities with other various activities, and is financially supported by different internal and external stakeholders such as government (see Sandberg and Gatewood, 1991). CRCs are organized differently to promote entrepreneurship and they are focused on achieving social and economic outcomes by supporting and enhancing science and technology. Boardman and Gray (2010, p. 450) defined CRCs as “an organization or unit within a larger organization that performs research and also has an explicit mission (and related activities) to promote, directly or indirectly, cross-sector collaboration, knowledge and technology transfer, and ultimately innovation.”

Set against this background, and reflecting the spirit of Bowers and Alon’s (2010) observation of these differences with respect to creation paths and functions of these institutional configurations within universities to support entrepreneurship, the purpose of this paper is to examine at the micro level the role and function of CRCs in entrepreneurial universities from a principal investigator (PI) perspective. Entrepreneurial activities are part of CRCs’ mission and activities, however their embodiment and creation path is through responding to industry needs and/or government policies (Boardman and Gray, 2010). Our study thus contributes to the limited literature and responds to recent calls for further research focused on different institutional configurations that support entrepreneurship within an entrepreneurial university setting (see Maas and Jones, 2017). Our paper thereby makes contributions to the extant literature on these new institutional configurations with respect to the role and function of CRCs supporting entrepreneurship. Taking a micro-level focus from a PI perspective, we identify the role and function of CRCs. Our findings reveal that CRCs’ role and function at the micro level constitute a necessary and functional element of the entrepreneurial architecture that supports PIs that are required to meet demanding scientific, alongside other commercial and impact objectives that are necessary to enable entrepreneurship, innovation and technology transfer. Specifically, at the micro-level PI perspective, the role and function of CRCs...
focus on research quality enhancement, brokerage, networks and collaborations, addressing research impact and resource enhancement and appropriation.

The remainder of the paper is structured as follows. The next section provides a literature review of entrepreneurial universities, ECs, ERCs, CRCs and PIs. The subsequent section outlines the methodological considerations and describes our data collection procedure and analysis. Section 4 explains the main findings, whereas Section 5 discusses the results in relation to the extant literature. A final section concludes with some implications for policy, practice as well as suggests some future avenues of research on CRCs.

2. Literature review

Entrepreneurial universities

Entrepreneurial universities have been the focus of increasing research attention within the entrepreneurship and innovation literature. This growing interest reflects the expanded university mission to encompass third mission activities that include knowledge and technology transfer (Cunningham and Harney, 2006; Meyers and Pruthi, 2011). The philosophy of entrepreneurial universities is to pervade and embrace a culture of entrepreneurialism (see Thorp and Goldstein, 2013) to overcome some of the traditional barriers to entrepreneurship such as hierarchical structures, controls, rules, procedures as well as limited entrepreneurial talent (see Kirby, 2006). Therefore, as Guerrero et al. (2015, p. 751) argued, entrepreneurial universities need to adapt and change in order to “provide adequate environments for their students, academics and staff to explore/exploit entrepreneurial activities.” Furthermore, Röpke (1998, p. 2) suggested that “the university itself, as an organization, becomes entrepreneurial” and Schulte (2004, p. 187) posited that universities “operate in an entrepreneurial manner.” To capture the complexity of this entrepreneurial orientation, Kirby et al. (2011) developed a framework for entrepreneurial universities that links formal and informal factors to outcomes with respect to teaching, research and entrepreneurial activities such as technology transfer. One of the formal factors of relevance for this study that Kirby et al. (2011) identified focuses on flexible organizational and governance structures enabling the effective bridging of university, industry and government boundaries. Citing relevant literature, they suggest that limited hierarchy and “horizontal coordination is advocated as a means to promote intellectual, financial and physical resources” (Kirby et al., 2011, p. 304).

The theme of organizational structure within entrepreneurial universities is further reflected by Clark (2004) who noted the presence of an increasing number of units operating in universities that are clearly not traditional or discipline-centered departments. These units particularly take the form of interdisciplinary and trans-disciplinary research centers focused on a wide range of societal problems. Such configurations have implications for knowledge management within and outside the university boundaries. This brings into the focus how entrepreneurial universities structure and organize their entrepreneurial architecture to support entrepreneurship throughout the university communities and beyond (see Hallam et al., 2014; Morris et al., 2014; Vorley and Nelles, 2009). Taking this entrepreneurial architecture perspective of entrepreneurial universities, Nelles and Vorley (2011) provided examples of formal organization mechanisms such as programs, incubators and technology transfer offices (TTOs) and suggest that internal factors play a role in the success of these formal structures, particularly culture and leadership. They also suggest that in taking this conceptualized entrepreneurial architecture focus the embeddedness of technology transfer actors and supports into any structural form is crucial in an entrepreneurial university context. In building what Sporn (2001, p. 129) described as “adaptive universities,” structure was identified as a critical factor. She hence suggested that universities create competence fields around differentiated internal units that have autonomy in terms of activities and focus but are accountable to the university. Therefore, the knowledge management that universities
adopt with such units and institutional configurations requires that they are flexible with their knowledge management systems and processes to meet the needs of internal and external stakeholder communities. In summary, in supporting entrepreneurship, entrepreneurial universities have created new institutional configurations that are described and discussed in the following section.

Entrepreneurship centers, entrepreneurship research centers and cooperative research centers

ECs, ERCs and CRCs are different institutional configurations within the entrepreneurial architecture of entrepreneurial universities to support entrepreneurship. These institutional configurations directly and indirectly contribute to creating and developing entrepreneurial trajectories within and beyond the academic context. In creating these centers, institutions need to take account of contextual factors – institutional and regional – to ensure an alignment to the respective needs and opportunities (Maas and Jones, 2017). There has been limited research disentangling ECs from ERCs and CRCs. ECs have a core focus typically around students and faculty. Maas and Jones (2017, p. 12) defined their remit as follows: “Entrepreneurship centers should play a direct (e.g. presenting their own programmes and activities) and indirect role (e.g. undertake joint programmes/activities with other faculties) in promoting enterprise and entrepreneurship activities.” In their study of US ECs, Bowers et al. (2006) found that their core activities were focused on education and their activities consisted of seminars, courses for credit, business plan competitions and networking events. ECs collaborating with university-based TTOs can also enhance entrepreneurial attitudes and activities as well as technology transfer (Boh et al., 2016). In their concluding remarks of their international study of ECs, Bowers and Alon (2010, p. 124) called for further research on this topic and note that “the paths to creation and function of these centers differ.”

There has been a significant growth in another institutional configuration as part of the universities’ entrepreneurship architecture that supports entrepreneurship activities, that is ERCs. There is such diversity of ERCs that Sandberg and Gatewood (1991, p. 20), based on their US study, concluded that ERCs are “a diverse, eclectic group.” In the USA, Finkle et al. (2006) estimated that there were over 1,600 ERCs and found that beyond qualified faculty, access to funding seems to be a pivotal factor directly related to the performance of ERCs. More recently, Cassia et al. (2014) classified ERCs into three groups – pure ERCs, educational ERCs and multi-service ERCs. Cassia et al. (2014, p. 383) defined a multi-service ERCs as a center that “dedicates its effort in equal shares in to research, education and transfer activities” and pure ERCs as centers “dedicating more than 50% of their effort to research.” Moreover, in their study of 46 ERCs, Cassia et al. (2014) concluded that knowledge transfer of ERCs does enhance their research performance.

In taking inspiration from Cassia et al.’s (2014) ERC multi-service definition and Bowers and Alon’s (2010) observation of these differences with respect to creation paths and functions of ECs, another institutional configuration that entrepreneurial universities use to infuse entrepreneurship activities, attitudes and outcomes are CRCs. The growth of CRCs is driven by the multidisciplinary nature of scientific discovery, the need to commercialize such discoveries through entrepreneurship and innovation and the demonstration of the socio-economic impact and benefits to firms, society and government (see Boardman and Gray, 2010). While there are different definitions of CRCs, Boardman and Gray (2010, p. 451) identified three common characteristics: engagement in research, exhibition of organizational formality and promotion of organizational and cross-sector collaboration and transfer. They also posit that CRCs can be involved in other activities such as facilitating business formation. Studies of CRCs have focused on issues such as CRCs’ contribution to regional development (Clark, 2010), their economic impact (Roessner et al., 2010), firms’ motivational factors in joining CRCs (Hayton et al., 2010) and trust (Davis and
Bryant, 2010). In order to achieve these value creating outcomes and foster collaboration across disciplines, trust as well as an ongoing exchange between university administrators, scientists, industry and government entities needs to be created and ensured (see Davis and Bryant, 2010). To date, no research has specifically focused on the role and function of CRCs. Thus, the creation of an understanding of the role and function of CRCs at the micro level is crucial to understand how this institutional configuration facilitates the creation of new entrepreneurial trajectories.

From a faculty or scientist perspective, Garrett-Jones et al. (2010) found in their study of Australian CRCs that scientists benefitted from membership through skills development, career development, knowledge acquisition with respect to IP and commercialization and industry engagement. Moreover, in their concluding thoughts on CRCs and faculty satisfaction, Coberly and Gray (2010, p. 563) noted that their results “suggest that a faculty member’s subjective evaluation of their involvement is the product of a complex set of contextual factors and individual factors related to institutional support, personal rewards and a psychological contract with their external partners. Unless these factors are supportive, faculty satisfaction and potentially organizational commitment may suffer.” CRCs are facilitators of collaborations between stakeholders and CRCs need to constantly align stakeholder interests to survive and thrive (Lind et al., 2013). Therefore, the design of such centers is critical to their survival and performance as Simeone et al. (2017, p. 58) suggest that the “design can play a relevant role in fostering entrepreneurial activities and value creation in academia, by supporting the translation of the different needs and interests of stakeholders into a shared meaning that allows a coordinated way of working.”

The institutional configuration origins of ECs, ERCs and CRCs in how they support entrepreneurship and more broadly the exploitation of knowledge are different. CRCs’ origins are more externally instigated and are instruments of government policy and/or industry needs (Boardman and Gray, 2010). They are configured to achieve multiple missions that are usually aligned to specific industry needs. ECs’ and ERCs’ origins tend to be more internally instigated and reflect the intellectual trajectory of the entrepreneurship field (Katz, 2003). They are a response to the needs and demands of internal stakeholders particularly students and faculty.

**Principal investigators**
CRCs are typically supported in the initial stages through publicly funded research that requires scientists undertaking research programs to demonstrate tangible entrepreneurship and innovation benefits for industry partners. Consequently, this means that scientists in CRCs take on the role of being a PI. Cunningham et al. (2016, p. 72) defined PIs as “scientists who orchestrate new research projects, combine resources and competencies, deepen existing scientific trajectories or shape new ones that are transformative in intent, nature and outcome that can be exploited for commercial ends and/or for societal common good.” The growing body of empirical research on PIs at the micro level has focused on themes such as strategic behaviors, managerial challenges, technology transfer mechanisms, gender, time allocation, barriers, etc. (see Cunningham et al., 2018, 2019; Del Giudice et al., 2017; Kastrin et al., 2018; Kidwell, 2014; Mangematin et al., 2014; Menter, 2016; O’Kane, 2018; Romano et al., 2017). However, within this body of empirical research, there have been no studies in relation to how they understand the role and function of CRCs they are members of to support their expanded role as a PI.

PIs are at the forefront of knowledge creation (Kidwell, 2014) and interact with various stakeholders to create new knowledge, enhance value and push the scientific boundaries (Cunningham et al., 2018, 2019). Their role also means that they are at the forefront of the exploitation and commercialization of knowledge and play a key role in establishing and managing networks within CRCs and beyond. In particular, membership of CRCs accrue
symmetry benefits with industry (see Coberly and Gray, 2010). Consequently, PIs seek organizational settings that enable them to fulfill their role as Kidwell (2014, p. 33) noted that PIs actively sought organizational alignment that allowed them “to make things happen while keeping harmony between the university and enterprise.” Furthermore, Baglieri and Lorenzoni (2014) in their study of scientist-user PIs active in biotechnology, medical devices and nanotechnology concluded that institutional environments can dissuade PIs from undertaking technology and knowledge transfer.

Furthermore, studies have revealed the hidden complexities of this role and where PIs, through their boundary spanning engagement, create and enhance value through technology and knowledge transfer and push the scientific and knowledge boundaries (Cunningham et al., 2018, 2019). They are involved in knowledge management of their scientific discoveries through their own institution and this is also influenced by their industry partners (Cunningham et al., 2015). In particular, one of the reported managerial challenges of PIs focus around IP and the lack of dedicated technology transfer support (Cunningham et al., 2015). PIs are perceived as scientific entrepreneurs who shape and reshape new paradigms and boundaries, broker science and innovate by bridging the gap between science and industry (Casati and Genet, 2014). Boehm and Hogan (2014) described PIs as a “jack of all trades” who create and enhance collaborative networks in scientific knowledge commercialization. Moreover, scientists in the PI role learn on the job whereby the lack of dedicated institutional support is a barrier for PIs (see Cunningham et al., 2014; O’Kane et al., 2017; O’Reilly and Cunningham, 2017). The institutional and environmental context that PIs choose to be located matters in fulfilling the PI role, meeting and exceeding the expectations of stakeholders, particularly external stakeholders with respect to entrepreneurship outcomes. In summary, scientists in the PI role need the CRC institutional configuration, given their core and boundary spanning role of creating and exploiting scientific knowledge (see Mangematin et al., 2014). Consequently, given their role, position and needs, PIs are best positioned to offer insights at the micro level with respect to the role and function of CRCs.

3. Methodology considerations, data collection and analysis
The research question for our study is a micro-level examination of the role and function of CRCs in entrepreneurial universities from a PI perspective. To address this question we undertook a qualitative case study approach of CURAM, the Irish Centre for Research in Medical Devices, as a CRC, investigating it from the micro-level perspective of CURAM PIs. This micro-level perspective of PIs was chosen due to the influential and boundary spanning position and role of PIs as outlined in our literature review. This qualitative methodology can be categorized as a single, holistic case study that is exploratory in nature, in line with the study of Yin (2003), with CURAM as the typical-case, single-case study and PI interviews as the main data source. Yin (2003) outlined how a case study methodology allows for the study of contemporary phenomena within real-life context, and described this methodology as particularly useful in studying programs and people, which aligns with the aim of this study. Yin’s case study methodology also allows for prior development of theoretical propositions, as presented in this paper, in order to direct data collection and analysis processes. The primary data source are semi-structured, open-ended interviews carried out with 38 PIs based at CURAM who are involved in medical device research in Ireland. The interview data, alongside archival records, was analyzed using a flexible thematic analysis as outlined below (see Hair et al., 2011).

Study context
CURAM, the Irish Centre for Research in Medical Device, is co-funded by the European Regional Development Fund and the Science Foundation Ireland (SFI), Ireland’s statutory
body with responsibility for funding basic and applied science, technology, engineering and mathematics research. CÚRAM is one of SFI’s 16 CRCs, hosted at various Irish academic institutes, an “academic-industry-clinical ‘super center’ designing the next generation of ‘smart’ medical devices” (CÚRAM, 2018). The creation of these centers, including CÚRAM, was instigated by mandated government research prioritization policies to “develop a distinctive industry-focused culture” (DBEI, 2012, p. 15), promoting multidisciplinary research activities and industry-academic collaborations, with medical device research constituting one of the identified priority areas of focus for taxpayer investments. As an agent of government, a key objective of SFI’s strategic plan, Agenda 2020, was to develop these centers to provide major economic impact for Ireland, creating partnerships between academia and industry to address crucial research questions and contribute to the Irish economy. To this end, CÚRAM received an initial investment of €49m over six years from SFI and industry. As such, CÚRAM can be viewed as an instrument of recent government policy to develop CRCs with integrated goals of research, entrepreneurship, education and outreach. Thus, CÚRAM PIs have a clear remit to foster industry partnerships and engage in boundary spanning, technology and knowledge transfer and commercialization activities, alongside the traditional roles of education and research.

The medical device sector in Ireland is recognized as one of the five global emerging hubs, with nine of the top 10 medical device companies globally having their bases in Ireland, and alongside this growth, medical device research has become a key national research priority (Cunningham et al., 2015; Giblin, 2011; Giblin and Ryan, 2012). CÚRAM as the national center for medical device research places particular focus on chronic ailments such as heart disease, wound healing, diabetes and musculoskeletal diseases, and thus works across a wide variety of disciplines, including biomaterials, drug delivery, tissue engineering, regenerative medicine, device design and glycoscience. The center has thereby secured over €135m in total grant value (€25.2m CÚRAM team share) through previous EU Framework programs. Through European funding, SFI and industry co-funding, CÚRAM currently employs over 500 researchers, with 61 academic leads (PIS) and eight clinician collaborators. While led by National University of Ireland Galway, CÚRAM’s academic partners include University College Dublin, University College Cork, Trinity College Dublin, University of Limerick and Royal College of Surgeons Ireland. The center has partnered with a network of ten national academic institutions in total, including six Irish universities, and has established 28 industrial partnerships, made up of 18 SMEs and 10 MNCs (CÚRAM, 2018). Multinational industry partners include Boston Scientific, Medtronic, Novo Nordisk and Arch Therapeutics. Alongside supporting research excellence, the center also supports product development and the creation of spin-out companies. To date, CÚRAM has supported the creation of over 100 industrial contracts/engagements, 10 spin-out companies, 15 licensed technologies, and over 40 approved patents (see Table I). CÚRAM has also completed a first-in-human clinical trial, one of the key goals of the center.

As a CRC, CÚRAM supports these various lines of research, technology and knowledge transfer and commercialization activities through a variety of initiatives and programs related to scientific excellence, industry engagement and education as well as public engagement, to promote innovation, technology and knowledge transfer, and training in medical device research and clinical application. CÚRAM offers a network of national and international academic, industry and clinical collaborators, intending to enable rapid translation of research results to clinical applications. CÚRAM’s Industry Program Team is focused on establishing “long-term strategic relationships” with industry (CÚRAM, 2018), providing PIS with knowledge and expertise in IP, facilitating academic–clinician–industry interactions, determining the type of funding and IP model, supporting the definition and allocation of resources and budget, and identifying further activities and future projects to advance the technologies. The center also offers a wide range of guest lectures and
seminars, industry workshops and networking events for PIs, and researchers in general, to enhance industry and clinician engagement, and to support greater levels of knowledge transfer. For example, in February 2019, CÚRAM was one of seven SFI research centers to receive funding, as part of a UK-Ireland joint initiative, for doctoral training for future innovation leaders through the establishment of lifETIME: an Engineering and Physical Sciences Research Council Centre for Doctoral Training in Engineered Tissues for Discovery, Industry and Medicine. Additionally, CÚRAM’s Education and Public Engagement program seeks to better engage primary and secondary students, teachers and the general public in medical device science, through three core residency programs for artists, filmmakers and teachers. This program was designed to support SFI’s Agenda 2020 objective of “having the most scientifically informed and engaged public.”

**Data collection**

Data collection is based on semi-structured interviews with 38 PIs. The group for this study was selected due to their involvement with CÚRAM, as publicly funded PIs in charge of medical device related publicly funded research projects. All CURAM-supported PIs were systematically contacted by e-mail to invite them to partake in a semi-structured interview on their experiences to date as a PI and their views on impact and the role and function of CRCs in entrepreneurial universities, with a total of 38 respondents (of a total of 56 CURAM-funded investigators identified at the time and contacted). The majority of PIs interviewed were male (29 compared to 9 female PIs), with 22 PIs holding professorships (19 males, 3 females). Domain areas of PIs varied widely across health-related disciplines, from basic science domains such as cell biology and anatomy, through to applied and translational disciplines, for example biomedical engineering and biostatistics (see Table II for a summary of PIs’ title, position, gender, type of research and experience). The PI interviewees in this study worked across five Irish academic institutes, with the vast majority (27) located in NUI Galway, with the other eleven interviewees being spread across five other Irish universities and academic institutes.

The interviews were conducted either in person or over the phone, with interviews lasting between 25 min and over 1 h, averaging 33 min, carried out between September 2017 and February 2018. The interview transcriptions amounted to over 250 pages of interview data, averaging 4,300 words per interview transcription. The interview schedule, aligned to
core themes of the literature review outlined above, employed open-ended questions on the respondent’s experience to date as a PI, looking specifically at their motivations for taking on the role of PI and the challenges involved, their main undertakings as PI, and then investigating how each respondent views the impact of their research and the efforts they make to realize that impact as well as the role and function of CÚRAM in supporting their activities. All interviews were semi-structured and open-ended in design.

**Data analysis**

Following data collection, interviews were transcribed by the authors, and then analyzed using the NVivo 11 software package. NVivo was chosen as an appropriate qualitative analysis software due to the possibility to powerfully manage the large amount of data gathered, as well as to identify patterns and themes from the data, to prevent information overload and make more sense of the data (Miles and Huberman, 1994). Braun and Clarke’s (2006) model of thematic analysis was the method chosen for analyzing the data, first and

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<td>F</td>
<td>Basic</td>
<td>&gt; 15</td>
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<tr>
<td>PI30</td>
<td>Prof</td>
<td>Associate Professor</td>
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<tr>
<td>PI31</td>
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<td>PI32</td>
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<tr>
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</tr>
<tr>
<td>PI38</td>
<td>Prof</td>
<td>Senior lecturer</td>
<td>M</td>
<td>Applied</td>
<td>5-15</td>
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Table II. Interviewee participant summary overview
foremost due to the flexibility of the model. This approach involves five stages of data analysis beginning with data familiarization (Phase 1; primarily involving the verbatim transcription of interview data and active reading and rereading of the transcriptions) and the systematic generation of initial codes, collating data relevant to each code (Phase 2). Following best practice guidelines as outlined by Braun and Clarke (2006), the members of the research team collated codes into potential themes (Phase 3). Phase 4 involved reviewing these themes in relation to each coded extract and across the entire data set. Finally, themes were defined and named by the authors, analyzing the specifics of each theme and the overall story the analysis provided (Phase 5). For the purpose of this paper, the focus was placed on codes and themes specifically related to the roles and functions of CRCs among our PI interviewees (see Figure 1 for the sample of relevant first order codes and the identified themes relating to our research question, as identified through thematic analysis of the collected data).

4. Findings
Through the qualitative case study methodological approach outlined above and the process of thematic analysis of interview data, key themes were identified relating to the key roles and functions of CURAM as a CRC from the micro-level PI perspective: research quality enhancement, brokerage, networks and collaborations, addressing research impact (including technology transfer) and resource enhancement and appropriation (see Figure 1). Findings related to these key themes as well as some interrelated subthemes identified are presented in the following sections. It is worth noting that, although for some of the findings presented below there are only a small number of PIs supporting the themes, the high level of PI experience of our respondents and level of detail of certain responses was taken into account.

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**Figure 1.** Visualization of Braun and Clarke’s (2006) model of thematic analysis as applied to our PI interview data collection.
In particular, for those subthemes identified below with less than five respondents, it was agreed upon by members of the research team to include these subthemes depending on the experience level of the respondents involved, as well as by the quantity and quality of individual first order codes under analysis.

Research quality enhancement

Ten PIs interviewed in this study highlighted the role CÚRAM played in supporting their research activities and in enhancing the quality and scientific and knowledge transfer impact of their research. One method identified by five PIs to enhance the quality of their scientific exploits was through engaging in multidisciplinary research, which was supported through CÚRAM’s role as a mediator and promoter of multidisciplinary research projects:

The main thing, and I think it is being cultivated in CURAM, I really think a multidisciplinary team is a really good team. (PI35)

CÚRAM was also identified by two experienced PIs as influential in terms of building research teams in a more general sense, leading to more successful research projects, with one PI (PI30), strongly emphasizing the importance of the research team to enhance the research they carried out and for effective knowledge transfer; “[…] together, that’s where that success rate comes from.” Furthermore, PI01, a Professor focused primarily on basic science with over 25 years of experience as PI, mentioned the “stimulating” environment created through CÚRAM, “the interface with engineers, physicists, chemists […]” as beneficial to their research success, with the center’s emphasis on multidisciplinary research being important for publication in “the very successful big impact journal papers.” PI12, a Senior Lecturer with over 15 years of PI experience and focused primarily on basic research, also made note of the positive influence of CÚRAM in relation to scientific impact, to “improve and enhance the quantity and quality of research.” It should be noted that the knowledge management formal mechanisms offered by CÚRAM, such as seminars and workshops, were not highlighted by any of the PIs interviewed.

Brokerage, networks and collaborations

Nine PI respondents pointed to CURAM’s brokerage capabilities, as mediators or intermediaries between academia and industry (often single individuals within CURAM acting as mediators) as a valuable function of this CRC. The cooperative focus of CURAM in ensuring scientific excellence alongside translational research often requires greater levels of brokerage with industry and clinicians, developing relationships and networks, connecting and mediating between academia and various relevant stakeholders, as acknowledged by PI17:

[…] somebody then in the middle being able to put us in the right direction, and put two groups together and say you might be able to help each other on this. (PI17)

Similarly, in relation to brokerage, from the micro-level PI perspective, nine PIs emphasized specifically the positive effect of the center on PIs’ boundary spanning activities, to develop relationships with potential academic, clinical or industry partners and to share knowledge:

That is what I find healthy about the CURAM initiative, though it sounds like a plug for CURAM, but it’s not really. The important aspect of it is don’t stay in your silo, go talk to someone. (PI01)

Furthermore, the strategic platform pushed by the center focused on knowledge brokering and engaging with relevant stakeholders influenced some PIs in their own views of knowledge transfer strategies and activities, creating another benefit for PIs to work with the CRC:

CURAM is part of that, so a positive in that way, the EU projects almost force you to go looking for people in different areas, in companies and other types of partners. (PI24)
One of the selling points offered by CÚRAM is their knowledge of and access to a “unique network of academic, industry and clinical partners” (CÚRAM, 2018). Informal mechanisms offered by the center in relation to networking, as a mechanism for entrepreneurship, were referenced by six PI interviewees as important reasons for becoming and remaining involved with the research center, to connect more efficiently and effectively with the most relevant stakeholders of their research, including industry partners, regulatory bodies, clinicians and patient/public groups. The center’s networking capacity and training support was emphasized by PI24, a professor with over 15 years of PI experience focused on more applied, translational research, as an important mechanism offered by CÚRAM to increase the PI’s technology and knowledge transfer potential:

I think you can really flounder, cold-calling companies and getting nowhere, talking to reps whose job is mostly about selling the product rather than engaging in partnerships, so again it is like a number of other things we talked about, you are not really trained for it, and this is a lot of what CURAM is about, is actually training people in those types of interactions, and supporting them better than they are currently supported. (PI24)

The center’s strategy to promote and support collaboration, particularly industry collaborations, was another common theme identified through thematic analysis, with ten of the 38 PIs interviewed making reference to the influence of the research center on their industry collaboration and engagement activities. Speaking about CRCs in general, PI16, a Professor with 11 years of experience in the PI role, placed significant emphasis on the role of CRCs in creating strong links with companies:

What has been really helpful there has been the [name] center, because they basically have a team that know what I do, they are kind of the front door for companies, and then they really funnel potential partners towards the academics. We’ve a couple of very strong company relationships, they’ve been driven through the center. (PI16)

CÚRAM’s focus on the entrepreneurial mechanism of industry collaboration was mentioned by a number of PIs as influencing their own attitudes on industry-academic partnerships and views on academia in general, and as an advantage for PIs in creating more effective and efficient industry collaborations:

[…] before that we always thought science is there, and at the other end is the big bad industry […] and those barriers have been broken down, and certainly CURAM is a perfect example of that. But that’s made my life easier. From the point of view of, it’s less distasteful now to be seen to be bringing in funding from industry, and there’s many more calls where you can marry those two, co-funding or that, and that makes a big difference. (PI35)

In conclusion, the interrelated themes of brokerage, networking and collaboration were identified by several PIs as important functions of CURAM as a CRC to enhance the translational, or impact potential of their research, serving to more effectively connect PIs with potential academic, clinician and, in particular, industry partners. In general, collaboration was seen by the PIs in this study as vitally important in technology transfer and commercialization activities, such as patenting and licensing, particularly with regard to industry collaborators.

Addressing research impact

As the scope of our study is on how PIs understand impact, and how they approach and action their environment to create impactful research, one of the roles and functions of the CRC identified by several PIs was, perhaps quite naturally, in supporting PIs to better address and understand the impact of their research projects. One of the main focuses of the CURAM team is in encouraging PIs and researchers to reflect on and action the technology transfer and translational potential of their work, the commercial impact, with PI23 pointing
this out specifically, stating “[…] if we have something worth patenting we patent it. If we don’t we won’t.” CURAM was identified and emphasized strongly by three of the PIs as playing a part in their impact orientation in terms of supporting them in developing translational trajectories for their research and developing potential economic, technology and knowledge transfer impacts from their projects:

But I’d like to, sort of, examine that, and CURAM is very good at getting researchers to examine how they can translate impact from the basic science stuff to the more translational piece […] , getting you to look at, well why don’t we file this and then we can talk about licensing and whatnot. (PI31)

Four PIs, two with over 15 years of PI experience, made reference to the benefit of involvement with CURAM in relation to dealing with impact in the writing of “impact statements” within funding applications, for some particularly in relation to helping them identify and develop potential economic outputs, outcomes and impacts:

I probably would have found the industrial/economic impact a bit tricky had it not been for the research centers, they have really helped with that process, so again possibly lucky in that sense that the centers came around and enabled that for me. (PI16)

Another aspect of addressing impact related by seven PIs was that of the current requirements of funding applications for greater levels of patient and public engagement, and societal impact. As outlined above, one of the key strategic goals of CURAM is to promote and support greater levels of patient and public engagement and education. At the micro-level perspective of the PI, five respondents found that the center influenced them in their public and patient engagement strategies:

I am engaging very regularly with those patient advocacy groups. So incentives by CURAM are really important in that they can enable that, like the big EU programs enable that. (PI30)

These findings suggest that, for some respondents, CURAM plays an important role in supporting PIs in addressing the often-complex and misunderstood notion of impact of research, particularly with regard to the increasing emphasis placed by funding agencies and governmental policies on the broader, societal impacts of research, and public and patient engagement in research (see Castaño-Martínez et al., 2015).

Resource enhancement and appropriation
Another key theme identified through the thematic analysis of the interview data was that of resource enhancement and appropriation through involvement with CRCs, particularly in relation to access to appropriating funding for research, researchers (i.e. postdoctoral) and materials. This is particularly important for PIs involved in medical device research, due to the increased costs involved in running a medical device research-related lab. Industry involvement was of particular importance in terms of material resources, for example for “kits, diffusion chambers that are in the lab” (PI06). Four PIs placed emphasis on the benefit of involvement in the center in accessing suitable PhD students and postdoctoral researchers, and funding for these researchers: “the postdocs come very easy” (PI26). The role of the center was highlighted by four experienced PIs as increasing the opportunity and likelihood of success in relation to accessing funding of research. PI38, a Professor and Head of his research unit, emphasized the role of another SFI center in more easily accessing funding:

[Centre C] has been great because what it has done, it does allow you get access to funding, if you are interested in that, probably easier in some ways than having to apply through ERCSET or other forums. (PI38)

Three of our highly experienced PIs (more than 15 years PI experience) mentioned this particular benefit of involvement with a CRC as a specific motivation for becoming and
remaining involved, with the belief that it is easier to get funded when applying through the CRC. Interestingly, two of the less experienced PIs mentioned this as an issue, that attaining funding was only possible through a CRC, particularly for early-stage researchers: “[…] finding it hard to get a project funded unless you were through a center” (PI05). It should be noted that, when PI intervieeweess spoke about funding, this related to funding of research as opposed to funding through commercialization activities such as spin-offs.

5. Discussion
Our findings suggest that CÚRAM, as a CRC, infers some important roles and functions for scientists in the PI role, in this case PIs involved in medical device research, in enhancing research, in brokerage, networks and collaboration activities, particularly with industry and clinician partners, in addressing various aspects of impact, and in resource enhancement and appropriation, specifically in increasing the chance of obtaining and maintaining funding for research.

Our paper makes several contributions. First, our study extends our understanding of the entrepreneurial architecture in an entrepreneurial university setting by specifically examining the role and function of CRCs from a micro-level PI perspective. Our study highlights that different institutional configurations within an entrepreneurial university setting can be used to achieve the common goals of supporting entrepreneurship. In particular, our study extends Maas and Jones (2017) argument for the need of institutions to take account of contextual factors – institutional and regional – in creating such centers. Our study highlights that supporting entrepreneurship can be undertaken by using a different institutional configuration that takes account of contextual factors that form part of the entrepreneurial architecture in a university. In doing so, such institutional configurations meet the actual needs and demands of internal stakeholders at the micro level, while also meeting multiple missions and demands that have been placed on CRCs through their creation path that is instigated by government policy and/or industry needs (see Boardman and Gray, 2010). Moreover, our study suggests that there is a need to consider other institutional configurations beyond EC and ERCs within a university context that are designed to achieve similar entrepreneurial activities, attitudes and outcomes while balancing and delivering other contextual and institutional objectives and outcomes such as public engagement, societal benefits, etc. Furthermore, our study extends the limited literature on CRCs through identifying their roles and function from a micro-level perspective. We also have extended previous studies of CRCs (such as Boardman and Gray, 2010; Hayton et al., 2010) beyond a North American into an Irish context, where CRCs are a new phenomenon.

Second, our findings show that CRCs provide a suitable environment or what Boardman and Gray (2010) described as the “organizational formality” for PIs enabling them to fulfill the various roles, responsibilities and stakeholder expectations as well as reducing some of the traditional barriers to entrepreneurship, knowledge and technology transfer (Kirby, 2006). By focusing on CRCs, we have built on and extended the classification of Cassia et al. (2014) with respect to multi-service ERCs. CRCs, similar to ERCs, have a research mission combined with other multiple missions but, as Bowers and Alon (2010) noted, there are different paths to creating such centers. There is also a unifying commonality of purpose among ECs, ERCs and CRCs of supporting entrepreneurship and entrepreneurial outcomes despite their different institutional configurations as units within the entrepreneurial architecture in an entrepreneurial university. Our study highlights how the role and function of CRCs enhance the environment and supports at the micro level, particularly with respect to brokerage, networks and collaborations all necessary to support entrepreneurship on the demand side. These roles and functions of CRCs are necessary to support entrepreneurship activities particularly with respect to supporting new venture creation.
Furthermore, our study indicates that CRCs provide PIs with the structural holes as part of their wider institutional setting that enables individual actors to pursue multiple objectives and create value (Kidwell, 2013). CRCs provide them with the environment that enables them as Kidwell (2014) stated “to make things happen” and supports more autonomous researchers. In essence, this institutional configuration is aligned to role demands and expectations that scientists have in the PI role.

Third, our study provides some evidence how the role and function of CRCs can provide tangible supports and expertise that address the specific scientific domain, industry, entrepreneurship and impact challenges along with the needs that micro level individual actors experience. CRCs provide PIs with the ability to focus their efforts simultaneously on different activities similar to what Cassia et al.’s (2014) definition of multi-service ERCs. One of the key differences is that the research focus is not on entrepreneurship, but on the roles and functions identified by PIs at the micro level supporting entrepreneurship directly and indirectly. Our study also extends Garrett-Jones et al.’s (2010) study of the benefits of membership of CRCs for scientists such as funding, resources, knowledge acquisition. Specifically, in examining the roles and functions of CRCs from a PI perspective, we found that some of the barriers with respect to technology transfer, industry collaborations and expertise (see Cunningham et al., 2014) can be met through the CRC’s organizational structure. Moreover, the findings of our study also extend the work of Simeone et al. (2017) by highlighting targeted supports and expertise for individual actors – in this case PIs – providing them with an ability to meet different stakeholder expectations. In particular, CRCs’ combination of supports and environment facilitate and provide individual actors with the capacity to develop sustainable collaborations and networks with industry and other stakeholders that are necessary prerequisites for knowledge and technology transfer. For the individual actor at the micro level, CRCs can realize some of the posited macro-level dimensions of entrepreneurial universities (see Etzkowitz, 2003; Formica, 2002; Jacob et al., 2003) as well as contribute at a macro level to the economic impact of an entrepreneurial university (Guerrero et al., 2015).

Fourth, our study extends the current understanding of the different institutional configurations that support entrepreneurship beyond ECs and ERCs (see Bowers and Alon, 2010; Maas and Jones, 2017). Our study also extends the interpretation of Nelles and Vorley (2011) of entrepreneurial architecture in an entrepreneurial university setting by including CRCs as another institutional configuration similar to ECs and ERCs that supports entrepreneurship. Furthermore, our study has shown that CRCs also may confer some competitive advantage for individual actors in pursuing and appropriating resources from a variety of stakeholders, particularly access to funding to pursue scientific discovery with relevant industry partners to support these firms’ corporate entrepreneurship and innovation. We found no evidence in our study that CRCs conferred any funding advantage for PIs with respect to entrepreneurship unlike ECs or ERCs. However, we suggest that this should be a focus for future research.

Fifth, a surprising finding at the micro level is that PIs did not identify knowledge management as one of the key roles and functions of a CRC, particularly as our study’s contextual setting requires effective knowledge management. This is critical and fundamental to the medical device sector with respect to the exploitation of new knowledge. The more formal mechanisms of knowledge sharing as part of knowledge management were not highlighted as a crucial role or function of CRCs by our respondents in this study. This is somewhat counterintuitive as respondents highlighted how the role and function of CÚRAM was research quality enhancement. One possible explanation for this unexpected finding is that in an Irish context, CRCs may have adopted and embedded standardized national arrangements with respect to industry collaboration, IP management and exploitation and knowledge and technology transfer, and as such, PIs may not intrinsically acknowledge or
recognize the more formal mechanisms of knowledge sharing and management taking place as functions of CRCs. In some respects, it would suggest from an organizational structure perspective that knowledge management is part of the everyday of PIs in a CRC. However, we suggest that further investigations in other contexts and CRCs are required.

6. Concluding thoughts and future research avenues
Our study has highlighted the role and function of CRCs, is yet not without limitations. PIs interviewed in this study were all funded through CURAM, and so may have felt the need to positively mention the financial support in the interviews and as well as speaking positively about CURAM. Consequently, there might be some bias that we tried to address through our probing during the semi-structured interviews. Another possible limitation of this study is that we only spoke with those PIs willing to be interviewed, hence there might be a success bias among these PIs. However, given the paucity of research at the micro level on the role and function of CRCs, we chose in-depth interviews to provide new contributions that can build the basis for large-scale studies of CRCs. The use of the single-case study methodology focusing solely on CURAM could also be considered a limitation of the study. Future research could look to undertake a multiple-case study approach of a variety of CRCs to compare roles and functions across different contexts and research areas.

Our research has implications for policy makers, university managers and PIs. Policy makers need to give due consideration to the entrepreneurship outcomes that they envisage through the creation of policy instruments and sustainability of the funding model that establishes CRCs. CRCs, unlike ECs and ERCs, have to manage multiple often more complex missions, agendas and objectives from stakeholders within and outside a university setting. Our study highlights that CRCs provide the necessary supports to their role and function that enable PIs to pursue different forms of entrepreneurship. Some of their entrepreneurial activities does not necessarily end with a new venture formation. This raises an interesting policy question that requires an empirical focus of under what conditions policy makers should use CRCs as an instrument to orchestrate change and support for industry and university stakeholders.

University managers need to appreciate that there is an array of institutional configurations that can be used as part of the entrepreneurial architecture within a university setting to support entrepreneurship and knowledge transfer. These different institutional configurations such as ECs, ERCs and CRCs have a shared commonality of supporting entrepreneurship but achieving this through different means while being clearly focused and aligned to their core stakeholders. Consequently, this variety clearly meets different needs but is essential and complimentary in supporting the entrepreneurial architecture within a university setting. University managers should consider means by which organizational knowledge and know-how is shared among such units within a university setting. Such cross-fertilization could yield even further environmental enhancements and entrepreneurship outcomes (see Leyden and Menter, 2018).

Moreover, our study specifically highlights the specific role and function of CRCs that are aligned with PIs and this could be a useful guide to university managers that seek to create and set up effective CRCs. Moreover, university managers need to consider how realistic or advisable it is to have a co-existence of such institutional arrangements.

For scientists in the PI role, our study provides a tangible guide to better understand if not to evaluate their own participation in CRCs. As CRCs evolve and the demands placed by external stakeholders such as industry and government grow, PIs need to ensure that the role and function of CRCs keep pace with these demands. Moreover, PIs need to evaluate their participation in CRCs to see if their current needs are met particularly with respect to entrepreneurship or if they are better suited engaging with an EC or ERC to realize their entrepreneurship ambitions.

Finally, based on our study, we suggest that future research should focus on the interplay between these differing institutional configurations within the entrepreneurial architecture.
within entrepreneurial universities aimed at fostering the transfer and commercialization of knowledge. In particular, there is a need for comparative studies of the knowledge management practices of CRCs and needs to be extended also to other institutional configurations supporting entrepreneurship. Furthermore, the role of the directors of CRCs needs to be further investigated as only an aligned strategy that manages intellectual capital through a collective intelligence approach promises impactful outcomes (Secundo et al., 2016). Therefore, a broad set of data collection methods should be utilized to capture the inherent complexities within these institutional configurations (Cunningham, Menter and Young, 2017). A deeper understanding of technology transfer mechanisms and processes might thereby be derived from combining a macro-level institutional perspective and a micro-level PI perspective.

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Entrepreneurial university strategies in the UK context: towards a research agenda

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Julienne Senyard

**Abstract**

**Purpose** – Prior research shows that universities differ in the knowledge exchange (KE) activities they pursue, but little is known about universities’ strategies regarding their portfolio of KE activities. The purpose of this paper is to explore the KE strategy of UK universities in specific relation to their portfolio of KE activities with small- and medium-sized enterprises.

**Design/methodology/approach** – Based on the 2015–2016 Higher Education Business and Community Interaction Survey data set, this study employs the Preference Ranking Organisation METHod for the Enrichment of Evaluations to assess the KE activities from 162 UK higher education institutions.

**Findings** – The study reveals that entrepreneurial universities valorise university knowledge assets through five SME-focussed KE activities most beneficial to measuring the entrepreneurial university. It also uncovers four different archetypal categories (groupings) of universities based on their strategic focus of KE activities.

**Originality/value** – This study contributes to the entrepreneurial university literature by considering universities’ overall KE portfolio rather than examining individual KE activity in isolation. It provides a clearer understanding of universities’ KE strategies that help define and delineate entrepreneurial universities regarding their range, focus and the combination of KE activities.

**Keywords** PROMETHEE, Entrepreneurial university, Small- and medium-sized enterprises, Third sector activity, Knowledge exchange strategy, Ranking of university

**Paper type** Research paper

1. **Introduction**

Increased competition exists for universities, as a consequence of decreasing higher education funding from the government (Lambert, 2003; Martin, 2012; Mowery *et al.*, 2015). Simultaneously, universities are increasingly tasked with contributing to the broader development of the economy and society (Perkmann *et al.*, 2013; Sánchez-Barrioluengo, 2014). Under greater pressure to tackle the challenges of the knowledge economy (Charles *et al.*, 2014; Miller *et al.*, 2014), this places increasing importance on the “Entrepreneurial University” concept.

Broadly, entrepreneurial universities have been defined as universities that pursue a third mission beyond their traditional missions of teaching and research (Sam and Sijde, 2014). Defined more narrowly, Etzkowitz *et al.* (2000) define entrepreneurial universities as those that engage in third mission activities to improve regional or national economic performance as well as the university’s own financial position. Third mission activities, also known as knowledge exchange (KE) activities or entrepreneurial activities (Philpott *et al.*, 2011), are in the UK measured under the term third sector activity (TSA). Since these
activities have profound economic and social impacts (Guerrero et al., 2016; Fini et al., 2018), extensive studies have explored determinants of KE activities (D’Este and Patel, 2007; Guerrero and Urbano, 2012; Huggins et al., 2012; Galán-Muros and Plewa, 2016; Hmieleski and Powell, 2018).

Clearly, however, universities are heterogeneous organisations, there being 162 higher education institutions in the UK context for example, differing significantly in background and characteristics. Within the literature analysis of UK universities has tended, however, to follow relatively simple, usually dichotomous, evaluations in regards to the entrepreneurial university. Morgan (2002), for example, classified this dichotomy between “elite” and “outreach” universities, overlapping with Hewitt-Dundas’s (2012) low research intensive (LRI)/high research intensive (HRI) definition in which LRI/outreach universities were engaged in far more human (social) capital development than HRI/elite universities, whilst HRI/elite universities were able to generate far more income from their research and were provided with far more funds for that research. This essentially dichotomous approach has also been adopted in more recent work. Fuller et al. (2017), for example, constructed indexes based on universities existing along (indexed) continuums in terms of the extent to which they can be seen as more entrepreneurial (as defined by focus on a narrower range of activities, more likely primarily for their own benefit) or enterprising (more broadly and balanced in their focus in activities that both benefit themselves but also the economy more widely).

Despite growing interest among academics and policymakers in entrepreneurial universities (Etzkowitz et al., 2000; Audretsch, 2014; Guerrero et al., 2016), the variety and connectivity of their strategies regarding the KE portfolio (i.e. the mix of KE activities universities pursue) has received relatively limited attention (Sengupta and Ray, 2017a). For example, prior studies tend to focus on comparing the individual KE activity separately without considering the portfolio of KE activities pursued by universities (Hewitt-Dundas, 2012; Abreu et al., 2016). Even where multiple KE activities have been analysed together, as in Fuller et al. (2017), this has concentrated on the overall resultant index score and university ranking, rather than analysing the range of ways similar rankings may be achieved by different universities.

This paper argues that examining individual KE activities in isolation, or considering only the overall KE “score”, however constructed, without also considering the overall KE portfolio, gives only a partial picture, because universities engage in sets of KE activities rather than pursuing a single activity alone. Literature has highlighted that universities are heterogeneous institutions varying in objectives and strategic priorities with regards to the types of partners they engage with, as well as the range of TSA they pursue (Kitagawa et al., 2016). Examining universities’ KE portfolio is critical as it can shed lights on the range of activities universities pursue, and thus help to uncover universities’ KE strategy. In other words, universities’ strategic priorities in KE can be identified through examining the combinations of activities they undertake.

The combinations of activities they undertake have a further, specific importance when applied to interactions with SMEs. Giuliani and Arza’s (2009) research shows that the value of universities’ TSA can partly be determined by the knowledge base of those receiving university knowledge, highlighting the key importance of firms’ absorptive capacity (Clifton et al., 2010) in this debate. This is often an issue with regards to smaller firms in particular, because “SMEs find it difficult to engage with HEIs for a host of different reasons, not least the lack of resources to engage, the lack of capabilities to identify the right partners, and a lack of awareness of the benefits” (PACEC, 2012, p. 32). This therefore gives additional importance to the interactions between universities and HEIs that do take place, and increases the importance of analysis of these.

Clifton et al. (2010), analysing contributions of a range of actors in SME innovation creation and dissemination, also highlight that because the level of UK firm–UK university
cooperation was often low, firms also required a certain level of absorptive capacity (through their own innovation activities), to provide legitimacy prior to being able to beneficially cooperate with a university. All of this raises potential important questions of WHO universities engage with through their TSAs, as well as WHAT activities this is focussed through, in helping to better understand the strategies that lie behind the entrepreneurial university concept. Specifically, how is the degree and type of engagement with SMEs relevant in this debate?

To put in context, whilst recent empirical work indicates that universities differ in the KE strategy they adopt, with some universities emphasising a broad range of KE activities while others are more selective on the activities they pursue (Kitagawa et al., 2016; Sengupta and Ray, 2017a), the existing evidence is based only on a small number of universities. We also still lack a holistic understanding of how the strategy of KE portfolio varies amongst universities in the UK specifically. Research suggests that universities make strategic choices by growing certain KE activities while neglecting others (Day and Fernandez, 2015). There is, however, currently little research explicitly about the strategies of universities regarding their KE portfolio in terms of simultaneously analysing the size, scope and focus of this portfolio. This is particularly apparent with regards to universities’ KE strategies with regards to SMEs. In the UK context, this may partly be because SMEs have historically only accounted for a relatively small proportion of the total incomes generated from universities’ KE activities (HE-BCI, 2017).

We focus specifically on universities’ KE activities with SMEs because we believe it to be a better entrepreneurial university-focussed measure of the strategic choices of universities generally than KE activities overall. It simultaneously captures Etzkowitz et al.’s (2000) definition of university activities that simultaneously improve university and regional or national economic performance, whilst also broadly fitting many aspects of the “enterprising university” definition described in Fuller et al. (2017). Another reason to focus on SMEs is that the majority of English universities having established infrastructure to provide support for SMEs (HE-BCI, 2017), implying their extent of engagement with SMEs are more likely to be a function of their strategic decisions. By contrast, it may be more challenging for some universities to attract and collaborate with large organisations due to constraints in resources and capabilities (Kitagawa et al., 2016).

Furthermore, SMEs represents an increasingly important source of revenues for universities (HE-BCI, 2017). SMEs have been identified as the most frequent target for KE activities (PACEC/CBR, 2009). This is not surprising, given that universities are increasingly incentivised to interact with SMEs. For example, the KE incomes generated from SMEs being double weighted in the allocation of third stream funding by the Higher Education Funding Council for England (Rosli and Rossi, 2016). Evidence has also shown that universities interact with SMEs to a greater extent than large firms (Huggins et al., 2012).

Accordingly, the purpose of this study is to explore the KE strategy of universities in the UK in specific relation to their portfolio of KE activities with SMEs. In so doing, this study identifies groups of universities sharing similar KE strategies in their interaction with SMEs, upon which more detailed analysis of the reasons behind these choices can be built. We adopt a holistic approach by using individual universities as the unit of analysis and considering the KE portfolio of universities with SMEs. Based on the 2015–2016 HE-BCIS data set, we identified universities’ incomes from each KE activities they pursue. The incomes are then used as proxy to represent universities’ relative strategic focus on each KE activity. As such, the present study concerns the outcomes from universities’ KE strategy rather than their strategic choices which may or may not be realised.

In order to undertake ranking universities according to a range of KE activities whilst simultaneously identifying and illustrating groups of universities sharing similar portfolios in terms of these outcomes from their KE strategy, it is necessary to use a different approach
to those used in studies such as Fuller et al. (2017). The Preference Ranking Organisation METHod for the Enrichment of Evaluations (PROMETHEE) is a multicriteria method that employs visualisation software that, with few parameters, creates non-technical, user-friendly visualisation of results (Brans, 1982; Brans and Vincke, 1985; Nemery et al., 2012). The evaluation of each criterion can be expressed in their natural units, also eliminating problems relating to scaling, obviating the need for normalisation of scores, avoiding rankings relying on the selected normalisation method (Tofallis, 2008; Ishizaka and Nemery, 2011), or the log based approach highlighted in Fuller et al. (2017). Instead, the decision maker defines a preference function generally characterised by an indifference and preference threshold. PROMETHEE is also able to be linked to graphical analysis for interactive aid (GAIA), allowing a two-dimensional representation of individual decision-maker preferences (Brans and Mareschal, 1994). In this research, all included universities are able to be represented and then compared on a single GAIA diagram, which compares favourably to previous approaches (e.g. Fuller et al., 2017) which require multiple diagrams to undertake the same types of processes.

The rest of the paper is structured as follows. The next section evaluates the existing literature for university KE activities in terms of the different types of activities and partners they can engage with, focussing on the heterogeneous strategies that are possible. From this research, questions are developed. The PROMETHEE methodology is then outlined, followed by the results. These are then discussed and compared with the extant literature. Finally, in the conclusions, contributions are identified, limitations explained and future research opportunities discussed.

2. Literature review

2.1 The heterogeneity of universities and their KE activities

While Etzkowitz et al. (2000, p. 313) assert “the ‘entrepreneurial university’ is a global phenomenon with an isomorphic developmental path”, recent research suggests no best type of entrepreneurial university exists (Bronstein and Reihlen, 2014) because of considerable differences between higher education systems across different countries and even between universities in the same educational system (Bonaccorsi et al., 2007; Philpott et al., 2011; Sánchez-Barrioluengo, 2014). Indeed, based on a meta-synthesis of 27 case studies on entrepreneurial universities across different national contexts, Bronstein and Reihlen (2014) found that universities can be categorised into several different types depending on their primary focus.

Previously, UK universities have been categorised into types such as new vs old, research-oriented vs teaching-led and Russell Group vs non-Russell Group. Research-oriented universities have significantly higher levels of research outputs than those that are teaching-led (Abreu et al., 2016). It can thus be expected that universities have different levels of resources and capabilities that may influence their engagement in KE activities.

Indeed, evidence suggests that universities differ in their engagement in KE activities. For example, Hewitt-Dundas (2012) showed that HRI universities generated higher KE incomes from SMEs in contract research and consultancy but lower revenues in courses for business and community than LRI universities. Likewise, Huggins et al. (2012) showed that older universities have a higher tendency than new universities to interact with different types of organisations for KE activities. Similarly, Abreu et al. (2016) found that research-intensive universities (i.e. the 24 Russell Group universities) differ from teaching-led universities (i.e. 126 non-Russell Group) in the KE type of activities pursued, in particular exhibiting higher levels of licensing, spin-out and contract research activities.

While these studies have contributed to our understanding of how universities differ in KE activities, there are limitations remain to be addressed. In addition to differences between universities in different groups (e.g. Russell vs non-Russell Group), substantial
differences also exist within the same group (Sengupta and Ray, 2017a). Within group differences concerning KE activities, however, are largely unexplored in the literature. Furthermore, prior research often examines KE activities in isolation without considering the KE portfolio. This is problematic because universities often pursue a set of KE activities and need to balance the different KE activities they undertake (Day and Fernandez, 2015). Examining individual KE activities in isolation therefore provides an incomplete picture of the overall KE strategies of universities.

2.2 KE strategies

The KE strategies of universities entail at least four key elements: the range of KE activities they pursue, the relative emphasis they put on each activity within this KE portfolio, the type of partners they engage with and the geography (e.g. regional, national and international) they are focussed on when engaging with partners. As Kitagawa et al. (2016, p. 736) noted, “each university creates its own approaches and models of third mission by targeting different areas of activities, partners and geographical areas”.

KE activities can take place through a wide range of channels including patenting, licensing, spinoffs, contract research, collaborative research, consultancies, continuing professional development (CPD) and facilities and equipment-related services (Perkmann et al., 2013; Abreu et al., 2016). KE channels such as patenting, licensing and spinoffs are often used by universities to exploit the intellectual property (IP) they generated (Abreu and Grinevich, 2013). Since KE activities through these channels are less compatible with the traditional role of academics (Louis et al., 1989), they are often considered more entrepreneurial. Conversely, KE activities through channels such as contract research, collaborative research and consultancies are seen to be more aligned with the traditional academic culture and considered less entrepreneurial (Louis et al., 1989). These boundaries may be, however, increasingly blurring in relation to the entrepreneurial university concept as TSA revenues become more important.

Universities may adopt either a broad or a focussed strategy for KE portfolio (Kitagawa et al., 2016; Sengupta and Ray, 2017a). They may pursue a broad strategy, engaging with external organisations via a wide range of channels, for several reasons. First, a broad KE strategy may allow universities to generate revenues through multiple KE channels. Other things being equal, universities using a broad range of KE channels should be better positioned to address the specific needs of individual organisations and generate greater incomes from diverse sources (Olmos-Penuela et al., 2014; Ramos-Vielba et al., 2016). Second, it allows universities to develop diverse knowledge bases and capabilities to help bridge gaps between scientific research and application (D’Este and Patel, 2007). Third, it enables universities to enhance their research base. Since the knowledge flow between universities–industries interactions tend to be bi-directional rather than unidirectional, universities can also gain considerable insights from interactions with industries (D’Este and Patel, 2007). For example, KE activities such as collaboration and contract research may lead to the development of new knowledge that contributes to universities’ research base. Recent evidence also suggests that universities’ past research output (both quality and quantity) positively impact their knowledge transfer activities (Sengupta and Ray, 2017b).

Conversely, some universities may pursue a narrower KE strategy, where they have comparative strengths to compete effectively in the competitive education sector. For example, universities that focus on KE activities where they have a relative advantage are more likely to achieve above average growth in their KE incomes (Day and Fernandez, 2015). Furthermore, the disciplinary mix of universities may also influence their strategic choices to focus on certain KE activities over others. Since universities may have a very different disciplinary mix as determined by the faculties and schools they are composed of (Bonaccorsi et al., 2007), the educational activities and research outputs should vary between
them. Such a difference can impact the forms and range of KE activities universities pursue. For example, patenting and licensing activities are more relevant to certain academic disciplines (e.g. biosciences) than others (Mowery et al., 2015). The decisions to focus on a smaller set of KE channels may also, of course, partly be the result of constraints on the availability of resources and capabilities. For example, universities that are relatively small in scale may lack the resources and capabilities to pursue a broad KE strategy. Likewise, in comparison with old universities, new universities tend to have a disadvantage in pursuing diverse KE activities because they are much more constrained in terms of internal resources than established universities (Huggins et al., 2012; McCormack et al., 2014) as well as external relationships.

It should be noted, however, that even for universities that adopt a broad KE strategy, the relative importance of each KE channel may differ between individual universities. For example, some universities may generate higher proportions of income from certain channel(s) and lower from others (Day and Fernandez, 2015), demonstrating that not all universities emphasise the same channels in their KE strategy (Sengupta and Ray, 2017a). Evidence also suggests that incomes from patenting, licensing and spinoffs activities represent a relatively small proportion, a large percentage of revenues instead generated through contract research, collaborative research and consultancy (HE-BCI, 2017).

The type of partner universities interact with for KE activities may include SMEs, large firms and other non-commercial organisations. Some universities (often low research intensity) have a greater strategic focus on SMEs, while others (often high research intensity) tend to emphasise large firms (PACEC/CBR, 2009). Evidence has shown that, for both established and new universities, SMEs are the predominant type of organisation they interact with (Huggins et al., 2012). This may partly be because universities generally are less likely to be constrained by resources or capabilities to engage with SMEs (Kitagawa et al., 2016). Indeed, irrespective of their relative size, age and research quality, most universities in the UK have established the infrastructure to engage with SMEs, partly supported by the funding from government initiatives (HE-BCI, 2017). Given that most universities have capabilities to interact with SMEs, it is reasonable to expect their extent of engagement with SMEs to be more a function of their strategic choice than resource-related necessity than it would be for KE activities more generally. As such, a focus on SME engagement therefore has the potential to give a better understanding of the range of Entrepreneurial university strategies.

It must also be acknowledged that the regions the universities are embedded within can also impact their KE strategies. In England, for example, local economic partnerships (LEPs) research has shown that “there are significant variations in the population of SMEs across LEPs both in terms of their number, sectoral composition, productivity and technological intensity” (Bonner et al., 2015, p. 3). This implies that the demand of SMEs for specific KE activities should vary substantially between different regions. This may be for a number of reasons, related to numbers of SMEs within a region, but also their sectoral breakdown and growth ambitions. For example, SMEs in high-technology sectors or knowledge-intensive business services may have a higher demand for collaborative research or contract research (Bonner et al., 2015), whilst higher growth-oriented firms are both more likely to engage in international markets (Mason and Brown, 2013; BIS, 2010), where innovation is more important, and are likely to be more open to business support and collaboration (Bonner et al., 2015). Conversely, regions lacking these types of SMEs may also be the ones where university KE activity is promoted more strongly by government (Cooke, 2003). Indeed, recent empirical evidence suggests that “academics in uncompetitive regions are more intensively engaged in entrepreneurial activities but generate less income from them than their counterparts in competitive regions, suggesting that there are differences in the income-generating capacity of academics across regions” (Zhang et al., 2016, p. 257).
Partly related to this universities will have different strategies in relation to the geographic scope of the partners they interact with for KE: some universities are more likely to engage with business at the regional level, while others are more likely to engage with business at a national or international level.

This review of the literature therefore identifies a need for tools for entrepreneurial universities to better understand and evaluate their own and other universities’ KE activities and consequent strategic profiles, particularly given their need to increasingly focus their engagement strategies in this area as a result of increased competition and constrained resources from other sources. In this research, we are therefore interested in the following questions:

RQ1. How do entrepreneurial universities valorise university knowledge assets in terms of SME-focussed KE activities that can be seen as most beneficial to measuring the entrepreneurial university?

RQ2. What entrepreneurial university models/archetypes can be identified and classified in terms of these SME-focussed KE activities?

RQ3. What are the most relevant KE activities (both singular and in combination) that universities are using, in relation to the entrepreneurial university concept as it relates to interactions with SMEs?

RQ4. Are there specific SME-focussed entrepreneurial university models/archetypes that are more likely to influence regional economic development in terms of shaping entrepreneurial ecosystems?

3. Method

3.1 PROMETHEE

The PROMETHEE has attracted increasing attention in the literature (see Behzadian et al., 2010 for a recent review). For example, prior research has applied it to evaluate business incubators (Schwartz and Göthner, 2009), project selection (Halouani et al., 2009) and, important for this paper, the strategic goals of education institutions (Živković et al., 2017).

Information within a criterion. As with any multicriteria decision problem, we consider a set of m possible actions or alternatives \( A = \{a_1, a_2, \ldots, a_m\} \) which are evaluated on a set of n criteria \( C = \{c_1, c_2, \ldots, c_n\} \). For each criterion, and for each ordered pair of actions, the decision maker expresses his/her preference by means of a preference degree. The preference degree \( P_i(a, b) \) indicates if an alternative \( a \) is preferred or not to alternative \( b \) on the criterion \( c_i \). The preference degree is obtained using the preference function. Several typical shapes are proposed (Brans and Vincke, 1985) for the preference functions like the linear, the step or Gaussian preference function.

Aggregated preference functions. In order to evaluate how much action \( a \) is preferred to \( b \) over all the criteria, the preference index \( \pi(a, b) \) is calculated with a weighted sum (1) of the preference degrees \( P_i(a, b) \). The weights \( w_i \), calculated represent the importance of each criteria in the decision:

\[
\pi(a, b) = \sum_{i=1}^{n} P_i(a, b) \cdot w_i, \tag{1}
\]

where \( P_i(a, b) \) is the score of the preference function, \( w_i \) the weight of criterion \( c_i \) and \( n \) the number of criteria.

Outranking flows. As each action is compared with \( m-1 \) other actions, two flows can be defined with (1).
The positive flow is as follows:

$$\Phi^+(a) = \frac{1}{m-1} \sum_{X \in A} \pi(a, X),$$

(2)

with $m$ being the number of actions of the set $A$.

This score represents the global strength of action $a$ in comparison to all the other actions. It is this score that has to be maximised.

The negative flow is as follows:

$$\Phi^-(a) = \frac{1}{m-1} \sum_{X \in A} \pi(x, a),$$

(3)

with $m$ being the number of actions of the set $A$.

This score represents the global weakness of $a$ in comparison to all the other actions. It is this score that has to be minimised.

**Ranking.** The complete ranking of PROMETHEE II is given by the net flow:

$$\Phi(a) = \Phi^+(a) - \Phi^-(a).$$

(4)

The higher the net flows, the better the rank of an action. A fuller discussion on net flow scores can be found in Brans and Mareschal (2005) and Mareschal et al. (2008).

The score produced for each university is entirely relative to the pool of other universities. The score is relative and sums to 0. This means that if we have say only two universities and one has a score of 0.5, then the second will have a score of $-0.5$.

### 3.2 Visualising the results – GAIA

The aim of the GAIA method is to represent, on a two-dimensional view, as much as possible the decision maker’s preferences and its implications (Brans and Mareschal, 1994). For this purpose, a plane in the hyperspace is found via principal component analysis (PCA) of the matrix $\Phi$. In the PCA, the variance-covariance matrix of the decision problem, denoted by $C$, is first calculated. This matrix can be obtained by using the following relation:

$$nC = \Phi'\Phi,$$

(5)

where $C$ is the variance-covariance matrix; $\Phi'$ the transposed matrix of $\Phi$ and $n$ a positive integer.

Then, two eigenvectors, denoted by $\vec{u}$ and $\vec{v}$, are selected such as they have the greatest eigenvalues $\lambda_1$ and $\lambda_2$. These two eigenvectors are orthogonal ($\vec{u} \perp \vec{v}$) and define the best plane, called the GAIA plane, to use for the projection of the actions (the $a_i$ points) while minimising the loss of information (Brans and Mareschal, 1994).

Every action of the decision problem will be projected in this plane and its coordinates are obtained as follows:

$$\begin{align*}
\frac{|\overrightarrow{Op_i}|}{|\overrightarrow{Oq_i}|} &= \frac{\vec{a}_i'}{\vec{a}_i'} \cdot \frac{\vec{u}}{\vec{v}} \\
\frac{|\overrightarrow{Op_i}|}{|\overrightarrow{Oq_i}|} &= \overrightarrow{a}_i' \times \vec{u} \\
\frac{|\overrightarrow{Oq_i}|}{|\overrightarrow{Op_i}|} &= \overrightarrow{a}_i' \times \vec{v},
\end{align*}$$

(6)

where $\vec{a}_i'$ is the transposed row $i$ of matrix $\Phi$. 

Entrepreneurial university strategies
In order to represent the intra criteria information, each criterion \( f_j \) will be projected to \( c_i \) on the GAIA plane. The angle between the projections of two criteria is a measure of similarity or conflict between the criteria. The smaller the angle, the more similar two criteria are. A large angle means conflicting criteria.

Finally, the information on the weights chosen by the decision maker can be added by finding the projection of the weights vector: \( \vec{w} : (w_1, w_2, ..., w_j, ..., w_k) \). The obtained vector is called a decision stick \( D \), and represents the decision maker’s priorities:

\[
D : \left( \vec{w} \cdot \vec{u}, \vec{w} \cdot \vec{u} \right).
\]

The GAIA plane facilitates the decision aid process as easy conclusions can be drawn visually. Near actions on the plane will often have very similar rows in the variance-covariance matrix \( \Phi \). The decision maker can thus easily identify actions with similar or opposite performances. Moreover, the decision maker can compare criteria since their position on the plane is an indication of their conflicting or correlated behaviour. Their length represents their distinguishing power between actions. A wash criterion has a short length, and a discriminating criterion has a long length.

### 3.3 Data used

This research evaluates the following variables, all taken from the 2015–2016 HE-BCIS data set, expressed in £, for the eight KE variables contained in the data set that were also identified from the literature as relevant to the entrepreneurial university context, and where an explicit focus on SMEs could be identified or implied:

- income from continuous professional development with SMEs;
- income from shares sold in spinouts;
- income from software licence income from SMEs;
- income from non-software licence income with SMEs;
- income from consultancy with SMEs;
- other IP income with SMEs;
- income from contract research with SMEs; and
- income from facilities and equipment-related services with SMEs.

### 4. Results

In terms of the results, these can be presented in a number of ways. The most obvious, and traditional, is in the form of a ranking of University KE Activity with SMEs, based on the PROMETHEE analysis itself, illustrated in Table I, which, for reasons of brevity, shows the first 30 universities in the index.

This ranking generates an order consistent with alternative rankings (albeit in slightly different contexts using different methods) conducted by, for example, Fuller et al. (2017). However, because PROMETHEE is specifically designed to focus on the strategies employed via the way in which the scores are generated, supported by the additional visualisation techniques employed, additional information relevant information is generated as discussed below. For example, the stacked bar chart below (which, for brevity, only shows the first 30 universities in the index) indicates where low performance on one criterion can be totally compensated and masked by higher performance on another criterion.

Figure 1 illustrates the university ranking in decreasing order according to their net score (sum of positive and negative). This ranking is the same as in Table I. It shows a stacked bar
chart of the contribution of each evaluation criterion to the global score. Because PROMETHEE is a partial compensatory method, low scores for one variable cannot be fully compensated by high scores. For example, the Anglia Ruskin (A4) score is very reliant on consultancy income from SMEs and would appear higher in the rankings without PROMETHEE being able to partially compensate for this. Indifference thresholds define the minimum necessary for each criterion to be achieved in order to start to accumulate a positive flow. The preference threshold, at the other end, gives the maximum allowed to be accumulated in the positive flow. This therefore partially compensates in the overall ranking for universities strategically concentrating only or mainly on that measured criteria. A negative score means that they are below average overall, whilst a positive score indicates an above average overall performance.

In general terms this allows identification of the relevant KE strengths (that could be used by university management for marketing promotion) and weaknesses (that can be used for policy development focus) of each university. For example, A12 (Birmingham City University) could improve on the contract research income they could generate and as a result improve their score. Many universities also have a very small bar, which indicates that they need to improve on all evaluation criteria.

The GAIA visual technique provides more information than simple ranking, through the identification of the criteria contributing most to the differences between universities in terms of their rankings, where criteria are more closely correlated with each other, and also a visual means of identifying groupings of universities as defined by similar outcomes from universities’ KE strategies.

<table>
<thead>
<tr>
<th>Rank</th>
<th>University</th>
<th>Positive</th>
<th>Negative</th>
<th>Net flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A104 – The University of Oxford</td>
<td>0.328903</td>
<td>0.016645</td>
<td>0.312257</td>
</tr>
<tr>
<td>2</td>
<td>A150 – University College London</td>
<td>0.241222</td>
<td>0.018694</td>
<td>0.222528</td>
</tr>
<tr>
<td>3</td>
<td>A134 – The University of Southampton</td>
<td>0.190443</td>
<td>0.017574</td>
<td>0.172803</td>
</tr>
<tr>
<td>4</td>
<td>A75 – The University of Leeds</td>
<td>0.192261</td>
<td>0.023024</td>
<td>0.169238</td>
</tr>
<tr>
<td>5</td>
<td>A28 – Cardiff University</td>
<td>0.18752</td>
<td>0.020309</td>
<td>0.16713</td>
</tr>
<tr>
<td>6</td>
<td>A82 – The University of Liverpool</td>
<td>0.175388</td>
<td>0.019949</td>
<td>0.15544</td>
</tr>
<tr>
<td>7</td>
<td>A25 – The University of Cambridge</td>
<td>0.165584</td>
<td>0.016382</td>
<td>0.149202</td>
</tr>
<tr>
<td>8</td>
<td>A93 – The University of Manchester</td>
<td>0.165753</td>
<td>0.018485</td>
<td>0.147088</td>
</tr>
<tr>
<td>9</td>
<td>A42 – The University of Dundee</td>
<td>0.165283</td>
<td>0.029018</td>
<td>0.136264</td>
</tr>
<tr>
<td>10</td>
<td>A1 – The University of Aberdeen</td>
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<td>0.027097</td>
<td>0.128727</td>
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<tr>
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</tbody>
</table>
Figure 2 focusses on the centre of the GAIA plane. Consultancy for SMEs, CPD for SMEs, software licence income, non-software licence income and contract research are the criteria that have the best discriminating power for evaluating universities because they have longer arrows. The other criteria – share in spinouts, other IP income and facilities and...
equipment-related services in contrast—have low discriminating power (short arrow), which indicates that universities have very similar values for these activities. Indeed, many universities are not undertaking these activities at all.

Where the arrows are pointing in the same direction, this indicates that the criteria are positively correlated. The closer the lines are to each other the stronger the correlation. Therefore, other IP income, facilities and equipment-related services, consultancy for SMEs, and CPD for SMEs are correlated with each other. There is another set of correlations between software licence income, non-software licence income, sales of shares in spinoffs, and contract research.

In contrast, the arrow for \textit{CPD for SMEs} is more than 90° different to software licence income, indicating that universities generating strong income performance from CPD activities do much less well in terms of software licensing and vice versa. Another way to look at this is the larger the angles between variables, the higher the degree of potential policy tension between the desired outcomes, with potential trade-offs between these groups of policy aims, since they are less strongly mutually supportive than where variables are more strongly correlated.

5. Discussion
5.1 Archetypes of universities based on SME-focussed KE activities
Specifically focussing on the research questions identified, it can clearly be seen that entrepreneurial universities valorise university knowledge assets through five SME-focussed KE activities most beneficial to measuring the entrepreneurial university, namely, consultancy for SMEs, CPD for SMEs software licence income, non-software licence income and contract research. These are the criteria identified as having the best discriminating power for evaluating universities because they have longer arrows. They also indicate, at an
individual level, a broad range of ways in which universities is generating value from their knowledge assets in relationships with SMEs.

Figure 3 identifies where each university sits on the GAIA plane, both in terms of the activities that it focusses upon and which other universities it is closest to, the precise position of each university being a combination of the strength (or weakness) in overall activities and also the activity/activities it is most strongly associated with. Using Figure 3, four different broad archetypal categories (groupings) of entrepreneurial university models/archetypes can be identified and classified in terms of these SME-focussed KE activities. These are visually identified on the GAIA plane and defined in terms of position on the diagram and by the correlations between the criteria as follows:

- Weak external entrepreneurial income (WEEI) generating activities with SMEs (having negative values). Examples include the University of Winchester and University of Chichester.
- “Teaching Related Focus”: CPD/consultancy/facilities focussed/(e.g. Liverpool (6th)), Salford (ranked 12th), Anglia Ruskin (13th) and York (14th).
- “IP Exploitation Related Focus” software licence income/non-software licence income/contract research and sales of shares in spinoffs focussed (Oxford University (ranked first), University College London (second), Dundee University (ninth), University of Aberdeen (tenth)).

- “Broad Focus” (e.g. Southampton (3rd), Cambridge (7th), Nottingham (11th)).

Identifying the most relevant KE activities (both singular and in combination) that universities are using in relation to the entrepreneurial university concept as it relates to interactions with SMEs, it can be seen that universities with a narrower IP exploitation-related focus (IPERF) are more likely to be found higher up the entrepreneurial university rankings (Oxford University (ranked first), University College London (second), Dundee University (ninth), University of Aberdeen (tenth)). Overall, six of the top 10 places are taken by universities with this type of strategy, compared to three with a broad focus (BF) strategy. The fact that only one university with the narrower “Teaching Related Focus” (TRF) is placed in the top 10 suggests that the success of a narrow focus strategy is also dependent on which activities are focussed on, the focussed grouping having representatives that are much less prevalent in the entrepreneurial university index, at least amongst the top 10.

If one looks at all the universities with positive scores, the picture becomes even more nuanced. Of the 49 universities with a positive score, whilst it is the 15 IPERF universities, which rely on a smaller number of key KE activities for their rankings, that have the highest average score, they have a slightly lower average ranking than the 11 BF universities which generate their results from a wider range of activities. Also, whilst the TRF universities have the lowest average ranking and score, they are also the most prevalent grouping in the top 49, with 23 universities, and between these three groupings the differences in average scores and rankings are not significant.

This result also suggests a blurring of universities’ KE strategies, with contract research in this analysis, previously seen as more broadly linked to academic engagement, in this study being more aligned with research commercialisation. Simultaneously, academic engagement and business and community-related services can be seen as part of one broader group of activities.

In comparison with previous approaches, there are also some interesting contrasts. For example, compared with the approach of Hewitt-Dundas (2012), it can be seen that, whilst, as expected, there is a concentration of the old research-intensive HRIIs from the Russell Group in the IPERF cluster (with 10 of the 15 universities coming from the Russell Group), there are another 7 in the more widely focussed BF grouping (of a total of 12), 4 in the TRF group and 3 in the cluster that would be characterised as WEEI generating in terms of their activities with SMEs. In comparison with Fuller et al. (2017), the indexes of overall rankings are strongly correlated, both with the entrepreneurial university index (0.67) and, even more so, the enterprising university index (0.71). This lends support to the approach used in this study in that it is consistent with previous studies using different techniques, is most strongly related to a broader measure of enterprise supporting activities, but also is able to provide additional information in relation to different strategic foci that underlie the rankings.

5.2 Implications for regional economic development
The final research question, concerning whether there are specific SME-focussed entrepreneurial university models/archetypes that are more likely to influence regional economic development in terms of shaping entrepreneurial ecosystems, is more complex. The results from this study suggest the ways universities engage in strategic choices tend to be within a small number of KE portfolios that vary significantly. In part, this appears likely due to universities that emphasise KE activities aligned with their own internally -driven
advantages will likely achieve better outcomes for the university itself. However, there are also other, more subtle often geographic forces at play. For example, prior empirical evidence has shown a negative correlation between the incomes from contract research and CPD (Day and Fernandez, 2015), suggesting that universities that have high levels of contract research activities are less likely to have high levels of CPD. Previously it has been suggested that this may be due to the potential divide between research-intensive and teaching-led universities. For example, contract research is more research-oriented, suggesting that it is more linked to the research intensity of universities, whereas CPD is more teaching oriented, implying that it is more related to how the university prioritises teaching. Whilst our results partly support this, as these activities are being employed in closely correlated sets of activities for different groupings of universities, HRI Russell group universities can also be found in both groups, as well as less research intensive. There are also the more broadly based universities (including Russell group universities) that undertake both sets of activities more evenly. More generally, the Russell Group universities traditionally defined as being research intensive can be found in all four of the groupings.

It is the universities with a narrower focus on higher research based activities, that are more likely to be ranked in the top 10 of this index, indicating that from the universities’ point of view, it may be that a more niche focussed strategy (particularly research commercialisation which leverages the IP generated within the university) is more likely to be successful from the university’s own point of view. It has also been highlighted previously that research commercialisation activities can contribute to regional economic development through the creation of new ventures and jobs (Fini et al., 2011), spinoffs positively impacting economic development (Guerrero et al., 2015), these KE activities directly contributing to society via the introduction of new products and services (Colyvas, 2007). Given the greater need for these activities to take place within entrepreneurial ecosystems that are able to absorb and use this knowledge then it might be expected that this particular archetype would work best in terms of regional economic development within stronger core regions. Looking at the LEP area covering London, for example, of the 7 universities with a KE focus (another 30 being part of the WEEI cluster), 2 fall within the TRF grouping, 1 within the BF group and the majority, 4, are designated as IPERF in nature.

Conversely, the other focussed grouping, encompassing TRF activities (and universities Salford (ranked 12th), York (14th), Anglia Ruskin (13th) and Liverpool (6th)), includes activities that have received less attention than studies on research commercialisation. Indeed, the study by D’Este and Patel (2007) is among one of the first to consider activities such as contract research and consulting. This grouping also includes KE activities that can be seen as providing business and community related services, designed to support businesses and local communities, such as CPD and facilities and equipment-related services. Through accessing universities’ resources, organisations may consequently save the resources that are required to invest in their own facilities, extremely beneficial for SMEs, given that they tend to be constrained by limited resources. This would suggest, therefore that this particular archetype would work best in terms of regional economic development in more obviously peripheral economic regions. In the South West of England, for example, only two of the six universities have a KE focus (the other four being WEEI) both of these part of the TRF group. For Liverpool, whilst four of the five universities are part of the WEEI group, the one KE focussed university is part of the TRF. In the North East also, whilst two of the universities are in the WEEI category, there are two KE focussed universities, both part of the TRF cluster.

It is between the core-periphery extreme, therefore, that one might expect the broad based entrepreneurial university archetype to be most relevant, but also potentially, more difficult to achieve, and therefore likely to be in more need of stronger internal and external drivers. The evidence here is broadly, but not wholly supportive of this.
In England, the LEP covering Manchester, for example, has one BF university as well as one IPERF and three in the WEEI category. For the LEP covering Leeds also includes a BF university along with four in the WEEI category. In terms of GVA per head in the region in which the universities sit, within the three broad groupings of universities with positive scores, it is those with software licence income/non-software licence income/contract research, and sales of shares in spinoffs focus that have the highest GVA per head average (£28054), with universities taking the CPD/consultancy/facilities focus where the GVA per head average is lowest (£23,985), the broadly focussed university grouping sitting between these two extremes (£27,534).

In terms of external drivers, the government is clearly encouraging businesses to engage with universities. For example, the Higher Education Innovation Fund (HEIF) was specifically devised to encourage and support universities’ engagement in KE activities, the allocation of HEIF based solely on universities’ incomes generated from KE activities (PACEC, 2012), suggesting that universities are incentivised to increase their KE activities. Universities that receive HEIF are also now required to outline their strategies in relation to KE activities (PACEC, 2017). These policy contexts may help explain the broader strategic focus of certain universities, given that a narrower focus would seem to pay greater rewards to the university itself. Universities also, however, clearly have different levels of capabilities to engage in KE activities. Their KE capabilities are likely to be a function of several factors such as universities’ research quality, size, age, specialisation, and past experience. As Sengupta and Ray (2017a, p. 706) noted, “specialized universities limited by the number of research-active disciplines would prefer channels involving AE [academic engagement], whereas those with a broader research focus discriminate between channels of RC [research commercialisation] or AE to a lesser degree”. In other words, the breadth of universities’ research focus determines the range of their KE activities. It has also been found that the presence of more applied disciplines (i.e. engineering or bio-medicine) positively influence universities’ tendency to engage in KE activities (Bekkers and Freitas, 2008) (Table II).

The context of devolution also highlights potential roles of differential government Higher Education policy for the three nations of the UK that can all be considered

<table>
<thead>
<tr>
<th>University grouping</th>
<th>Widening participation</th>
<th>Graduate retention in local region</th>
<th>Supporting SMES</th>
<th>Graduate enterprise</th>
<th>Incubator provision</th>
<th>Attracting students to region</th>
<th>Regional skills needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Weak external entrepreneurial income-generating activities with SMEs</td>
<td>0.4513 (3, 4)</td>
<td>0.1947 (3)</td>
<td>0.2743 (4)</td>
<td>0.1327 (3)</td>
<td>0.0354</td>
<td>0.2124 (3)</td>
<td>0.2301 (3)</td>
</tr>
<tr>
<td>2. CPD/consultancy/facilities focussed</td>
<td>0.3478</td>
<td>0.0435</td>
<td>0.4348 (4)</td>
<td>0.0807</td>
<td>0.1304</td>
<td>0.0807</td>
<td>0.2609</td>
</tr>
<tr>
<td>3. Software licence income/non-software licence income/contract research and sales of shares in spinoffs focussed</td>
<td>0.1333</td>
<td>0.0000</td>
<td>0.2000</td>
<td>0.0000</td>
<td>0.0667</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>4. Broadly focussed</td>
<td>0.0909</td>
<td>0.1818</td>
<td>0.0000</td>
<td>0.0909</td>
<td>0.1818</td>
<td>0.0909</td>
<td>0.1818</td>
</tr>
</tbody>
</table>

**Note:** Figures in parentheses refer to significant at 5 per cent level Tamhane tests
geographically peripheral but who have very different combinations of university types. Looking at Scotland, four of the nine universities with a KE focus are part of the TRF grouping, four in the IPERF, and one in the BF (with the nine others part of the WEEI group). For Northern Ireland, whilst two of the universities are WEEI, one is IPERF and one BF. For Wales, however, whilst five universities are designated as WEEI, one is part of the IPERF group whilst two are members of the TRF cluster, with none in the BF category.

5.3 Strategic priorities for KE activities
This research also raises an important question of whether the large number of universities that have WEEI generating activities with SMEs should be encouraged to enhance such activities. It may be more efficient for them to adopt strategies that prioritise areas that they have a relative comparative advantage, in the geographies that they have the capacity to serve. The results in the table above, for example, indicate that universities with relatively WEEI generating activities with SMEs are significantly more strategically focussed on activities that Morgan (2002) conceptualised as outreach, in terms of human (social) capital development, but only compared to the university group focussed on software licence income/non-software licence income/contract research and sales of shares in spinoffs.

Where universities have a narrow focus but the region they reside within is attempting to transition towards more core and away from peripheral economy status, this may also suggest the need for government policy able to utilise the strengths of universities that focus on different strategic areas, in combination. More generally, these results suggest, however, that at least in terms of strategies with regards to income generation with SME the dichotomy between “elite” and “outreach” universities, overlapping with Hewitt-Dundas’s (2012) LRI/HRI definition is too simplistic, with policy development in this area requiring an in-depth analysis of universities’ strategic focus prior to the development of linking multiple universities together to promote more beneficial entrepreneurial ecosystem outcomes.

6. Limitation and future research
Clearly, this research has a number of limitations, broadly the prescriptive power limited due to the cross-sectional data, though offering a starting point for further research on the topic. More specifically, first, this study is based on one year of data, and a more longitudinal approach would be valuable. Second, this study is within the UK context only, and research into a range of international contexts would also help develop this area. Third, whilst we have been able to map the outcomes of strategic choices in terms of the KE activities focussed on, we have not analysed in detail the individual-level university reasons that might explain this, including underlying strategies. Fourth, the insights that come out from the data are based on a cross-sectional analysis of those universities that currently have income coming from KE, meaning that this approach is neither able to evaluate longitudinal transitional processes towards more entrepreneurial universities, particularly in cases where there is no substantial income from the analysed activities, nor have we undertaken a detailed evaluation of the regional economic context in which the university sits. A more in-depth analysis of the factors underlying universities strategic choices would therefore seem to be the most fruitful area for future research.

7. Conclusions
The research undertaken in the paper examined the outcomes from universities’ KE strategies with specific regards to interaction with SMEs, creating an index and ranking of universities, but also identifying specific groupings of universities defined by different combinations and strengths of the individual KE activities from which the overall rankings are derived. The contribution to knowledge concerning the Entrepreneurial University has
been built, therefore, by extending the existing literature on university archetypes and rankings (most notably Morgan, 2002; Hewitt-Dundas, 2012; Abreu et al., 2016; Fuller et al., 2017) through more detailed, university–SME interactions specific analysis, of a broad range of university KE activities. This allows a more fine grained definition of entrepreneurial universities than previously, by simultaneously being able to evaluate their overall strength, range, focus and combination, allowing the identification of the diverse strategies different universities employ to obtain similar results in terms of outcomes.

Specifically, it identifies that entrepreneurial universities valorise university knowledge assets through concentration on five SME-focussed KE activities most beneficial to measuring the entrepreneurial university, namely, consultancy for SMEs, CPD for SMEs software licence income, non-software licence income and contract research. It finds four different archetypal categories (groupings) of universities on the GAIA plane that can be visually identified from WEEI generating activities with SMEs: CPD/consultancy/facilities focussed; software licence income/non-software licence income/contract research, and sales of shares in spinoffs focussed; and broadly focussed. Identifying the most relevant KE activities (both singular and in combination) that universities are using, in relation to the entrepreneurial university concept as it relates to interactions with SMEs, universities more narrowly focussed on software licence income/non-software licence income/contract research and sales of shares in spinoffs focussed are those broadly with the highest entrepreneurial university ranking.

The results also suggest that the specific SME-focussed entrepreneurial university archetype likely to be beneficial regional economic development in terms of shaping entrepreneurial ecosystems will likely depend on the ecosystem itself. Implications of the findings for key stakeholders include a potential need for government Higher Education policy to take account of the different mixes of university archetypes that exist in a region, when considering how best higher education can support regional policy goals. This is also particularly relevant when considering how to support SMEs, as key stakeholders and developers of regional entrepreneurial ecosystems.

References


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Entrepreneurial activities and models of advanced European science and technology universities

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Abstract

Purpose – The purpose of this paper is threefold. It is aimed at identifying: a broad set of entrepreneurial activities; different university entrepreneurial models; and the entrepreneurial best practices of advanced European S&T universities.

Design/methodology/approach – The paper has adopted a mixed-method design. By mainly relying on primary data, collected through questionnaires and interviews with those in charge of the technology transfer offices of 20 universities belonging to the CESAER association, the empirical analysis has combined both quantitative and qualitative approaches.

Findings – The results of the empirical analysis have allowed five entrepreneurial activities to be identified. Three main entrepreneurial university models, based on different configurations of entrepreneurial activities, on different organisational and ecosystem characteristics and on a set of entrepreneurial best practices: an “engage” model, which focusses on local economic development; a “formal” model, which focusses on the financial advantage of universities and their faculties; and a “comprehensive” model, which focusses on the local economic development and the financial advantage of universities and their faculties.

Research limitations/implications – The first limitation of the present paper concerns the limited number of sampled universities. Moreover, this paper is limited to the European area. Future research could enlarge this study by increasing the number of universities and by focusing on other geographical areas. Furthermore, the paper does not assess the effectiveness of the identified entrepreneurial models in supporting entrepreneurship and local economic development. Further research could extend the present analysis and fill these gaps.

Originality/value – The paper contributes to the extant literature under many respects. First, it relies on original primary data. Moreover, it extends previous literature by encompassing the conventional distinction between formal and informal entrepreneurial activities. It also contributes to the emerging literature on entrepreneurial university models and the strategic approaches by identifying the different models of entrepreneurial universities in the European setting of S&T universities focusing on the role played by organisational and regional factors in affecting the adoption of a specific model by universities.

Keywords Entrepreneurial university, Entrepreneurial university models, Entrepreneurial activities

Paper type Research paper

1. Introduction

Universities are increasingly using knowledge that stems from research and teaching activities to fulfil their so-called “Third Mission” of contributing to social, cultural and economic development (Etzkowitz et al., 2000). In this respect, the concept of entrepreneurial universities has recently been conceived (Etzkowitz et al., 2000) with reference to any entrepreneurial activity performed by universities “with the objective of improving regional or national economic performance as well as the university’s financial advantage and that of its faculty” (p. 313).
According to such a definition, universities perform a broad range of entrepreneurial activities, including patenting, licensing, research collaboration, consulting, networking, entrepreneurship education and support for the creation and growth of new ventures. Although several research studies have mapped the different entrepreneurial activities performed by universities (e.g. Philpott et al., 2011), their scope was mainly limited to the distinction between formal and informal activities (e.g. Abreu and Grinevich, 2013). Moreover, although several studies have acknowledged entrepreneurial universities as a global phenomenon, only a few of them have investigated the different strategic approaches that universities may undertake (e.g. Giuri et al., 2018; Baglieri et al., 2018). In fact, most of them have considered, either explicitly (Etzkowitz et al., 2000) or implicitly, that universities undertake the same entrepreneurial activities to the same extent, and thus refer to a single model of entrepreneurial universities, ignoring the fact that universities could adopt different strategic approaches to the entrepreneurial paradigm. In this respect, there is a lack of studies aimed at identifying the interplay between the organisational and territorial factors that may induce a university to embrace a specific model. A further gap pertains to a lack of research aimed at identifying the strategic “best practices” that could support universities on their entrepreneurial journey. In order to fill these gaps, this paper poses the following research questions:

**RQ1.** What are the different university entrepreneurial activities?

**RQ2.** Do universities follow a similar entrepreneurial model or do they adopt different models? How can the organisational settings of a university and the characteristics of the related ecosystem influence the adoption of a specific entrepreneurial model?

**RQ3.** What “best practices” are associated with a specific entrepreneurial university model?

We investigate these research questions by employing a mixed-method design consisting of a survey and multiple case studies based on interviews with the people in charge of technology transfer offices (TTOs) (including the Heads of Technology Transfer and Vice-Rectors for Technology Transfer) of 20 universities belonging to the CESAER association – the European association of doctorate – granting specialised and comprehensive science and technology universities. Such universities, which are also called specialist universities, include Engineering Schools, Polytechnic Schools, Institutes of Technology, universities of Applied Sciences and Medical Schools. These universities are less diffused in Europe than generalist universities (Daraio et al., 2011), yet they have a stronger orientation towards technology transfer and entrepreneurship and have much closer links with industry, given their application-oriented research and teaching activities. In order to retrieve data on the organisational and ecosystem characteristics of these universities, we complemented the primary data sources with secondary data from the European Tertiary Education Register (ETER) and the European Regional Innovation Scoreboard (RIS).

The contribution of this paper can be summarised as follows. First, we contribute to the university technology transfer and entrepreneurial university literature (see, e.g. Philpott et al., 2011) by analysing a broader set of university entrepreneurial activities than the previous studies that just considered the conventional distinction between formal and informal entrepreneurial activities. Second, we contribute to the emerging literature on the entrepreneurial university model and strategic approaches (see, e.g. Giuri et al., 2018; Baglieri et al., 2018) by identifying different university technology transfer models in the European setting of S&T universities. We also investigate the interplay between organisational and ecosystem factors that affects the adoption of a specific model by universities. Third, we highlight the entrepreneurial best practices of the most advanced S&T universities in Europe.

The paper is organised in five parts as follows. We review the literature on university technology transfer and entrepreneurial activities, the emerging literature on
entrepreneurial university models and the entrepreneurial best practices of universities in Section 2. The methodological design is presented in Section 3. Section 4 presents the results of our empirical analysis. We discuss the implications on theory, practice and policy in Section 5, where we also present the limitations of the study and ideas for future research.

2. Theoretical background

2.1 University technology transfer and entrepreneurial activities

University technology transfer has long been investigated in academic literature, given its relevance in fostering entrepreneurship and innovation, and thereby in contributing to national and regional economic development. University technology transfer, which is also referred to as the “Third Mission” of universities, includes an array of activities and processes that are adopted to transfer knowledge and technology from university to industry and society (Bozeman, 2000). Given the entrepreneurial nature of university technology transfer, these activities are also defined as entrepreneurial activities (Philpott et al., 2011). In fact, as universities embarked on their new “mission” of economic development, they progressively introduced a diversified range of entrepreneurial activities. They are now in fact involved in research and technology commercialisation (Markman et al., 2008), incubation programmes and start-up support (Siegel and Wright, 2015). They have also recently started to invest heavily in entrepreneurship education programmes (O’Connor, 2013) and provide funds for the technology development process (Bradley et al., 2013a), along with traditional research collaboration, networking, consulting and face-to-face communication with industry and society (Geuna and Muscio, 2009; Perkmann et al., 2013).

Scholars have identified different entrepreneurial activities. However, they do not always use the term “activity”, and usually refer to more nuanced concepts such as “channel” (Grimpe and Hussinger, 2008), “mechanism” (Bradley et al., 2013b; D’Este and Patel, 2007; Link et al., 2007) and “mode of governance” of university technology transfer (Alexander and Martin, 2013).

Accordingly, scholars have distinguished between “formal” and “informal” activities, channels or mechanisms, and contractual- and relational-based governance. On the one side of the spectrum, scholars include patenting, licensing and spin-offs in the formal entrepreneurial activities, which are also identified as research commercialisation (Perkmann et al., 2013); on the other side, training, networking, contract research, consulting and face-to-face communication in informal entrepreneurial activities have been identified as academic engagement (Perkmann et al., 2013). Research commercialisation and academic engagement differ in terms of objectives (Perkmann et al., 2013): the former takes place when an academic invention is exploited with the objective of obtaining financial rewards. The latter is instead broader and pursued for various objectives; these include access to additional financial resources, as well as to data and knowledge, in order to conduct further research, to buy equipment and to offer support for students, etc. The scope is not limited to publishing, and academics seek to provide know-how and advice to non-academic partners that may help to solve application-oriented problems (Perkmann et al., 2013). In this respect, academic engagement is not new, as it represents a natural extension of academic activities (Geuna and Muscio, 2009; Philpott et al., 2011). The complementary effects between formal and informal entrepreneurial activities are also acknowledged in literature. Previous works suggest that both mechanisms can occur simultaneously as, on the one hand, informal contacts can strengthen the quality of a formal relationship (Geuna and Muscio, 2009), which can prioritise interpersonal links of trust and learning through personal bonds, especially for SMEs (Garcia-Perez-de-Lema et al., 2017); on the other hand, formal arrangements are usually complemented by more day-by-day informal contacts between university scientists and the R&D personnel of an industry (Link et al., 2007; Cardamone et al., 2015; Grimpe and Fier, 2010).
Given the diversity of objectives of these activities, it is possible to question whether all of these activities should be considered “entrepreneurial”. In line with Philpott et al. (2011) and Etzkowitz et al. (2000), we consider the entrepreneurial activities of universities from a broad perspective, considering all the activities that may increase the regional and national economic performance as well as the financial income of the university and the faculties. Indeed, the fact that research commercialisation has been dealt with extensively in academic literature, so much so that many academics refer to it with the term “entrepreneurial universities” (Philpott et al., 2011), does not mean that the existence of other types of entrepreneurial activities, such as research collaboration, training, consulting, networking and face-to-face communication as well as other activities which provide support to entrepreneurship, i.e. start-up assistance, funding support and entrepreneurship education, should be neglected.

2.2 Entrepreneurial university models

Literature has provided a limited picture about the existence of different university entrepreneurial models, although there are some notable exceptions of an emerging literature (Giuri et al., 2018; Baglieri et al., 2018; Cesaroni and Piccaluga, 2016). Literature has acknowledged the importance of having a strategic orientation towards technology transfer and entrepreneurship in driving resource allocation decisions and setting priorities (Siegel et al., 2007; Giuri et al., 2018; Bozeman et al., 2015; Battaglia et al., 2017), as well as strategic positioning in the environment (Giuri et al., 2018), but it still lacks an analysis of the different strategic approaches that are reflected by different university entrepreneurial models.

This emerging literature has focussed on the relationships and complementarities between research and technology transfer by looking at formal entrepreneurial activities and strategic university objectives (Cesaroni and Piccaluga, 2016; Baglieri et al., 2018; Giuri et al., 2018). Cesaroni and Piccaluga (2016) acknowledged that a research commercialisation orientation is progressively being replaced by a model that is focussed on broader societal engagement. Baglieri et al. (2018) analysed openness and impact in a sample of 60 US universities and found four university technology transfer business models. Giuri et al. (2018) found that specialist universities, unlike generalist universities, are more oriented towards income generation strategies and faculty services (intellectual property rights) and dedicated less attention to local economic development. Taken together, these studies share the common view that entrepreneurial universities may be considered as a system of several entrepreneurial activities that the universities may perform differently. However, none of the existing studies has focussed on a broad and empirically based set of entrepreneurial activities or tried to identify the different models of entrepreneurial universities by adopting a combined ecosystem and organisational perspective. As far as this latter aspect is concerned, some scholars have taken into consideration how the development of the entrepreneurial competencies of universities depends on system-level specificities along with university-level internal support mechanisms and an individual scientist level factor (Grimaldi et al., 2011; Rasmussen et al., 2011). As far as system-level specificities are concerned, Grimaldi et al. (2011) argued that the strategy selection of universities is affected by the legal framework, institutional characteristics and the incentive system of their countries and regions. Moreover, they claim that a university’s entrepreneurial strategy should depend upon the degree of development of the local entrepreneurial context. Fini et al. (2011) argued that universities in a non-developed entrepreneurial context should facilitate contacts and build bridges among local actors rather that act in isolation, while Degroof and Roberts (2004) proposed that universities in an entrepreneurially developed contexts should adopt a fairly passive strategy. Taken together, these studies converge on the idea that a “one-size-fits all” approach for the development of entrepreneurial universities is ill-advised, and that it is necessary to consider the local and contextual
characteristics of where universities are located. This is particularly important for policy makers, as policies aimed at increasing the entrepreneurial propensity of universities should consider the local context, namely, the characteristics of the university and region, or the risk of being ineffective or even counter-productive could be high. In this respect, Grimaldi et al. (2011) suggested conducting further research in order to understand the “optimal” set of entrepreneurial activities for the regions in which universities are located. This paper aims at bridging this gap by considering how different entrepreneurial models, based on different configurations of entrepreneurial activities, are associated with regional and university characteristics.

2.3 The entrepreneurial “best practices” of universities
The term “best practices” originated in the business sector as a tool to “benchmark” against competitors, and it refers to emulating and transferring “state of the art” policies and practices from one setting to another in an attempt to increase the performance of an organisation (Brannan et al., 2008). Literature has largely remained silent on the entrepreneurial best practices of universities, with some notable exceptions (i.e. Fernández-Nogueira et al., 2018), and has instead focussed on empirical models of entrepreneurial universities and success factors (e.g. Clark, 1998; Guerrero and Urbano, 2012), without going into detail on the specific features of entrepreneurial universities. This gap is particularly critical, as understanding and replicating the best practices of an organisation could be helpful for university managers to enable them to engage practically in the development of entrepreneurial universities. This paper aims at bridging the aforementioned gap by looking at the entrepreneurial best practices in European S&T universities. In order to enhance the transferability or replicability criteria (Fernández-Nogueira et al., 2018) from these universities, we have associated these entrepreneurial best practices with a specific entrepreneurial model. In this way, universities that fit a particular entrepreneurial model may decide to adopt one or more best practices related to such a group of universities in order to enhance their development.

3. Research methodology
In an attempt to answer our research questions, we have benefitted from the work of the CESAER (www.cesaer.org) Task Force on Innovation, which was formed to study the role of universities in innovation ecosystems. The research design follows a mixed-method approach. We have adopted a sequential explanatory design composed of two sequential steps: a quantitative approach (based on a questionnaire) followed by a qualitative one (based on multiple case studies). We have also used information from the ETER and RIS data sets to check for differences in organisational and regional factors. This research design enables the quantitative findings, related to entrepreneurial activities and models, to be further validated, and the entrepreneurial best practices of the universities to be identified.

3.1 Data and sample
The data collection was based on a questionnaire that was discussed and tested during two of the CESAER task force meetings held in Vienna and Porto. The survey was part of a larger CESAER task force project that focussed on the role of universities in innovation ecosystems. The questionnaire was organised as follows. The first section identified the entrepreneurial activities performed by member universities; the second section investigated the engagement of institutions with the actors of regional ecosystems. The third section focussed on funding support and in particular on the main sources of innovation funding in an ecosystem. The fourth section collected information on the execution of more specific activities related to start-up support and the entrepreneurial orientation of a faculty. The final section investigated the objectives of the TTOs. The first
and last sections used a five-point Likert scale, while the other sections used binary variables to check the collaboration with the ecosystem’s actors and the execution of specific activities. The preliminary findings were discussed and validated during two internal workshops, held in Budapest and Turin, which involved all the universities that participated in the survey.

In order to corroborate the quantitative results and identify the best practices of entrepreneurial universities, the Task Force created a shared template for the interviews. Each interviewee was asked to present the university strategies and give details on their implementation (including the initiatives, collaborations and the sharing of resources and competences), the role within the ecosystem, funding streams and the university’s vision for the future. After conducting the interviews, which were performed by telephone and during the last workshop (held in Copenhagen), seven universities prepared a written case study on a voluntary basis, using the same shared template for the interviews. This approach, along with the notes of the interviews, favoured a comparison of the case studies. After receiving the written cases, the authors and the members of the task force performed several feedback and revision sessions with the authors of the case studies by telephone in order to check that all the questions were answered properly and to avoid the overlooking of specific aspects. Furthermore, we triangulated these data with official and internal documents from the same universities. This synergistic combination of different types of data strengthened and provided support to each other (Eisenhardt, 1989). For confidentiality reasons, we assigned a code (A, B, C, etc.) to each university. Some quotations of the interviewees involved in the case studies are included in the Results section.

The respondents of the questionnaire and the interviewees were mainly Technology Transfer Vice-Rectors and/or the Heads of university TTOs, while Technology Transfer Vice-Rectors prepared the written case studies.

Overall, out of the 50 questionnaires that were sent, we received 20 answers (response rate of 40 per cent; for more details see Appendix). These sampled universities covered a population of approximately 502,000 students in the S&T fields. The sample universities belonged to 14 different European countries: Belgium (2), the Czech Republic (1), Denmark (2), Germany (4), Ireland (1), Italy (1), the Netherlands (1), Norway (1), Lithuania (1), Poland (1), Portugal (2), Spain (1), Sweden (1) and the UK (1). The descriptive statistics of the sampled S&T universities are reported in Table I, which shows that the sampled universities were medium-large sized, with respect to the population of European S&T universities. However, despite the smaller mean and median value of the PhD students, the considered universities had higher numbers of students and academic staff, with median values of 22,720 (vs 18,728 of the population) and 2,171 (vs 1,283 of the population), respectively. The populations of the S&T universities were computed by filtering, from the ETER database, those universities that had students enroled in the following three fields of study: natural sciences, mathematics

<table>
<thead>
<tr>
<th>Students enroled at ISCED 5-7 level</th>
<th>PhD students (ISCED 8 level)</th>
<th>Academic staff (FTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 20</td>
<td>Sample 20</td>
<td>Sample 20</td>
</tr>
<tr>
<td>Mean 25,133.9</td>
<td>Mean 1,912.6</td>
<td>Mean 2,645.0</td>
</tr>
<tr>
<td>Median 22,720</td>
<td>Median 1,796</td>
<td>Median 2,171</td>
</tr>
<tr>
<td>SD 9,573.9</td>
<td>SD 1,046.0</td>
<td>SD 1,731.4</td>
</tr>
<tr>
<td>Min. 10,444</td>
<td>Min. 228</td>
<td>Min. 881</td>
</tr>
<tr>
<td>Max. 46,076</td>
<td>Max. 4,440</td>
<td>Max. 7,084</td>
</tr>
<tr>
<td>Observations 20</td>
<td>Observations 20</td>
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<tr>
<th>European S&amp;T universities</th>
<th>European S&amp;T universities</th>
<th>European S&amp;T universities</th>
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</thead>
<tbody>
<tr>
<td>Mean 21,865.0</td>
<td>Mean 2,171.3</td>
<td>Mean 2,171.3</td>
</tr>
<tr>
<td>Median 18,728</td>
<td>Median 2,189</td>
<td>Median 2,171</td>
</tr>
<tr>
<td>SD 15,848.2</td>
<td>SD 814.8</td>
<td>SD 1,731.4</td>
</tr>
<tr>
<td>Min. 2,739</td>
<td>Min. 41</td>
<td>Min. 881</td>
</tr>
<tr>
<td>Max. 158,076</td>
<td>Max. 4,461</td>
<td>Max. 7,084</td>
</tr>
</tbody>
</table>

Table I. Sample and population statistics

Source: ETER (2014)
and statistics; information and communication technologies; engineering, manufacturing and construction. This population of universities consisted of 367 universities.

The data show how the sampled universities were well positioned in research and technology transfer, with respect to the average European universities. In fact, they performed above average with respect to the “Output in the top 10 citation percentiles” (Figure 1) and “Academic-Corporate collaboration” (Figure 2) indicators, compared to similar institutions from the European Economic Area. These indicators measure the number of publications that are highly cited, that is, those belonging to the top 10 per cent of percentiles throughout the world and the percentage of publications with both academic and corporate affiliations with respect to the total number of publications. Overall, these universities show a limited ability to combine the quality of research and research collaboration with companies.

![Figure 1. Outputs for the top 10 citation percentile (%)](image1)

Source: Scival

![Figure 2. Academic-industry collaboration (%)](image2)

Source: Scival
3.2 Data analysis

The data analysis consisted of three stages. In the first stage, we used an exploratory factor analysis to group the different university entrepreneurial activities into macro-dimensions. We employed an exploratory approach to detect the structure from among the variables and so as not to force any constraints on the relationship between the variables, given the relatively new phenomena of entrepreneurial universities. In a similar way to Giuri et al. (2018), we worked out the items into factors by computing the weighted average, where the weights were the scoring coefficients of the factors extracted from the factor analysis. In this way, the most closely related items had a greater weight in the definition of the factors. At this stage, we also performed a reliability analysis to check that items of the same construct stay together and the ability of the analysis to measure the same construct (Forza, 2002). We used the internal-consistency method and in particular the Cronbach coefficient $\alpha$ test for this purpose. In the second stage, in order to position each university on the spectrum of activities and to elaborate a taxonomy of the different models that universities adopt to foster innovation in their ecosystems, we employed a two-step cluster analysis: hierarchical clustering and k-means. We applied the former, using Ward’s method, to determine the number of clusters. We then used that number in the latter method to iterate the cluster assignment process and ensure that each university belonged to the right cluster. We performed a descriptive analysis to define each cluster using: organisational indicators retrieved from the ETER database (i.e. the number of academic staff out of the total number of staff; enrolled students over the total number of academic staff; core budget); technology transfer indicators (i.e. spin-offs, patent applications and commercialised patents) retrieved from the survey; ecosystem indicators retrieved from Eurostat and the RIS for 2017 (i.e. employment in the public and private sectors; R&D expenditure of the public and private sectors; co-publications of public and private and product/process innovations; lifelong education and population with tertiary education).

The third stage involved confirming the quantitative results of the previous stages through a qualitative approach: the entrepreneurial activities and models, as well as the identification of the best practices for each cluster, were corroborated through the seven case studies.

4. Results

4.1 Factor analysis

Before performing the factor analysis, we conducted a correlation analysis of the survey items, which revealed a high correlation (Table AII). We noted, after the first iteration of the factor analysis (Table AII), that two survey items (i.e. TTO activities[1] and entrepreneurship education for students) presented high cross-loadings with the other factors. This implied that these two items represented factors per se, and we therefore removed them from the factor analysis, but then introduced them into the conceptual framework. The second iteration of the factor analysis revealed three factors which explained 73 per cent of the variation of the remaining ten survey items (Tables AIII–AIV). The value of the KMO Measure of Sampling Adequacy was adequate and reached 0.673 (0.673 > 0.5; the larger the KMO is, the more suitable the sampling is for factor analysis). Bartlett’s Test of Sphericity, which tests whether the redundancy between items can be summarised with fewer factors, was statistically significant ($p < 0.01$). We checked the reliability of the analysis for the three obtained factors using Cronbach’s $\alpha$ and obtained acceptable values for the three extracted factors, reaching values of 0.760; 0.749; and 0.669, respectively (Tables II and AV). Finally, we computed the values of each factor as a weighted average of the scoring coefficients (Table AVI).

4.2 A conceptual framework to classify university entrepreneurial activities

Overall, the factor analysis revealed the presence of five factors which, on the basis of contributions found in literature on university technology transfer and entrepreneurial
universities, we identified as follows: research commercialisation, entrepreneurship education for students; support for technology development, venture creation and growth; academic engagement; the creation of an entrepreneurial climate (Table II). The identified factors are described in detail in the following sections and interpreted on the basis of the related literature.

4.2.1 Research commercialisation. Research commercialisation (Fini et al., 2018), which is also referred to as “academic entrepreneurship” (Siegel and Wright, 2015), refers to either the founding of a firm by faculty members with the objective of commercially exploiting a patented or non-patented invention (Perkmann et al., 2013), or to the licensing of a patented or otherwise protected invention in return for royalties (Jensen and Thursby, 2001). Commercialisation is regarded as the first measurable and tangible impact of entrepreneurial universities (Markman et al., 2008; Philpott et al., 2011). These activities are institutionalised (Geuna and Muscio, 2009) into a specific knowledge intermediary organisational unit, the TTO, which is created to help researchers commercialise their research results along the entire process. In addition, the university TTOs establish research and cooperation agreements with external actors, facilitate consulting activities and sponsor entrepreneurship education initiatives (Fini et al., 2018).

4.2.2 Entrepreneurship education for students. Entrepreneurship education has become an important activity for university managers, professors and researchers (Kuratko, 2005) because of the positive benefits associated with having students with an entrepreneurial
attitude, skills and intention that could foster entrepreneurship and innovation, and therefore stimulate economic growth (Rauch and Hulsink, 2015). Several studies (e.g. Bae et al., 2014; Fayolle and Gailly, 2015; Nabi et al., 2017) have shown that entrepreneurship education can have an impact on the entrepreneurial intention of academics and students. As a result, the number of entrepreneurship courses is increasing (Kuratko, 2005), as is the creation of entrepreneurship centres where these courses are offered (Siegel and Wright, 2015). Entrepreneurship education is also directed at creating an entrepreneurial mind-set, which could benefit from the creation of new businesses and from established public and private organisations that could provide students with the necessary employability skills (Etzkowitz et al., 2000).

4.2.3 Support for technology development, venture creation and growth. Research commercialisation can be considered an old and consolidated form of academic entrepreneurship, which focusses solely on gaining direct financial returns while supporting a faculty throughout the process (Siegel and Wright, 2015; Corbett et al., 2014; Grimaldi et al., 2011). A new perspective of academic entrepreneurship, which reflects wider social and economic benefits for a university ecosystem, is appearing, with the support of technology development, venture creation and growth, and it is addressed to alumni, students and young researchers. The overall aim is to favour science-based entrepreneurship and innovation (Fini et al., 2018; Corbett et al., 2014). University support includes a diversified range of activities: incubators/accelerators, either as programmes or institutions; entrepreneurship courses; the provision of spaces where students, faculty members and external firms can connect and organise business plan competitions for students; commercialisation of funds for alumni and students (Siegel and Wright, 2015) in order to increase the level of technology development with a variety of programmes, e.g. proof of concept, university seed funds, innovation grants, etc. (Bradley et al., 2013b; Hayter and Link, 2015). These activities have two objectives. First, to protect newly created enterprises from the liability of newness (Singh et al., 1986) and from the difficulties associated with establishing the necessary resources and social relationships with the external environment (Amezcua et al., 2013). Second, to foster the creation of entrepreneurial teams that are able to form start-ups. Amezcua et al. (2013) referred to these activities as organisational sponsorship, and defined it as any attempt to mediate the “relationship between new organisations and their environments by creating a resource-munificent context that is intended to increase survival rates among organisations” (p. 1628).

4.2.4 Academic engagement. Research commercialisation reflects a generative role of universities that is based on knowledge capitalisation and other capital formation projects (Gunasekara, 2006; Uyarra, 2010). In the last 30 years, universities have complemented this approach with a developmental role of innovation ecosystems, based on the concept of “engaged institutions” (Gunasekara, 2006; Uyarra, 2010). In this conceptualisation, universities, through their resources, skills and knowledge – which determine a capacity to attract talent, innovative companies, university and other actors – play a significant role in regional and international networking and institutional capacity building (Gunasekara, 2006). As such, universities act as innovation ecosystem integrators by bringing together different actors (e.g. firms, governments, RTOs, banks and investment funds) and by indirectly governing the relationships between these actors. Universities become “regional animators” (Gunasekara, 2006; Uyarra, 2010) as they build regional and international networks while coordinating the activities of several actors in a synergic way and providing leadership and vision (Colombelli et al., 2019; Rissola et al., 2017).

At the individual level, those universities that are engaged in these activities convey the engagement of academics (or academic engagement) which occurs through knowledge-related collaborations (Perkmann et al., 2013) with international and regional actors. When
collaborating with firms, the *quid pro quo* that leads universities and firms to collaborate may be exclusively financial (researchers work in exchange of a financial reward), or may consist of non-financial rewards, such as access to data and knowledge to perform further research. Researchers do not limit their scope to scientific publications, but also create concrete benefits for their research counterparts, for instance by sharing know-how that may be helpful to solve application-oriented problems (Perkmann et al., 2013).

4.2.5 Creation of an entrepreneurial climate. Borrowing from the organisational climate construct, defined in the context of innovation implementation (Klein and Sorra, 1996), we defined entrepreneurial climate as the extent to which entrepreneurship is rewarded, promoted and supported, and we included all the activities that foster such an entrepreneurial climate, including entrepreneurship training of the faculty members, training of the staff (academics and non-academics) in the commercialisation of new technologies and assisting researchers in finding investors. The creation of an entrepreneurial climate is particularly important for universities to achieve the third mission. Philpott et al. (2011) argued that: “For universities embarking on the journey towards the entrepreneurial university ideal, they must first undertake education and training of their academic community”. The authors acknowledged that without such entrepreneurial training, a university risks having a “schizophrenic entrepreneurial divide within their institution”. The creation of an entrepreneurial climate, through a clear university mission and organisational leadership in technology transfer and entrepreneurship, is complimentary with research commercialisation, in terms of licences and royalty income (Friedman and Silberman, 2003). Moreover, fiscal incentives have been found to increase the research commercialisation outcomes of universities (Friedman and Silberman, 2003).

4.3 Entrepreneurial university models
The adopted two-step clustering procedure revealed three clusters (Table III). We performed an ANOVA test to check whether the means of the three clusters were different, and we found statistically relevant differences between them. In order to characterise the clusters,

<table>
<thead>
<tr>
<th></th>
<th>Cluster 1 n = 6</th>
<th>Cluster 2 n = 10</th>
<th>Cluster 3 n = 4</th>
<th>ANOVA (F-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research commercialisation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.33</td>
<td>4.00</td>
<td>3.75</td>
<td><em>F = 6.80</em></td>
</tr>
<tr>
<td>SD</td>
<td>0.52</td>
<td>0</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td><strong>Entrepreneurship education for students</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.50</td>
<td>3.70</td>
<td>3.75</td>
<td><strong>F = 12.10</strong></td>
</tr>
<tr>
<td>SD</td>
<td>0.55</td>
<td>0.48</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td><strong>Support for technology development, venture creation and growth</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.15</td>
<td>3.00</td>
<td>3.95</td>
<td><em>F = 5.02</em></td>
</tr>
<tr>
<td>SD</td>
<td>1.04</td>
<td>0.94</td>
<td>0.10</td>
<td></td>
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<tr>
<td><strong>Academic engagement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.54</td>
<td>2.91</td>
<td>4.00</td>
<td><strong>F = 13.32</strong></td>
</tr>
<tr>
<td>SD</td>
<td>0.23</td>
<td>0.58</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Entrepreneurial climate</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>F = 8.57</strong></td>
</tr>
<tr>
<td>Mean</td>
<td>1.80</td>
<td>3.32</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.55</td>
<td>0.43</td>
<td>1.37</td>
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**Notes:** Significance level *p < 0.05; **p < 0.01

Table III. Results of the two-step cluster analysis
we provided information on organisational technology transfer and ecosystem indicators (Tables IV–VII) as well as on entrepreneurial best practices.

4.3.1 Cluster 1: the engaged entrepreneurial model. The first cluster contains six universities. The universities in this cluster perform all the entrepreneurial activities to a lesser extent than those in the other clusters. Among these activities, they give more importance to research commercialisation (3.33), academic engagement (2.54) and entrepreneurship education for students (2.50). However, despite a similar number of patent applications (44.8), this cluster is less effective in commercialising patents (5.5) and in spin-off creation (6.7). The organisational indicators reveal that the universities in this

<table>
<thead>
<tr>
<th>Table IV. Organisational indicators for universities (Mean values)</th>
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<tr>
<td></td>
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<tr>
<td>Cluster 1</td>
</tr>
<tr>
<td>Cluster 2</td>
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<tr>
<td>Cluster 3</td>
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</table>

Source: ETER (2014)

<table>
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<tr>
<th>Table V. Technology transfer indicators (Mean values)</th>
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<tr>
<td></td>
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<tr>
<td>Cluster 1</td>
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<tr>
<td>Cluster 2</td>
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<td>Cluster 3</td>
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Source: Self-reported data (2015)

<table>
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<tr>
<th>Table VI. Ecosystem indicators (Mean values)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Cluster 1</td>
</tr>
<tr>
<td>Cluster 2</td>
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<tr>
<td>Cluster 3</td>
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</table>

Source: Regional Innovation Scoreboard (2017)

<table>
<thead>
<tr>
<th>Table VII. Population, GDP per capita and share of employment at the NUTS2 level (Mean values)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Cluster 1</td>
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<tr>
<td>Cluster 2</td>
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<tr>
<td>Cluster 3</td>
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</table>

Source: Eurostat (2016)
cluster have the highest number of students per academic (15.42) and a lower budget (€157.9m). The analysis of some ecosystem indicators revealed the non-central role that such universities play in their ecosystems, as demonstrated by the considerable share of employment in industry and construction and the small number of people with tertiary education (0.461). The relatively high value of non-R&D innovation expenditures (0.384) revealed that firms in such ecosystems focus on incremental product or process innovations. In this respect, such universities seem to help industry leaders in their ecosystems in solving specific technical problems and transferring mainly tacit knowledge. In this respect, the respondent of University A stated: “We adopt a mainly ‘market-pull’ approach to help large companies to solve specific technical problems by exploiting existing competencies and eventually developing basic technology for new products and processes”. A case in point in this cluster is University B, which applies three major approaches to transform “generated knowledge into useful solutions for companies”: the protection and commercialisation of research results in collaboration with companies (e.g. patent co-ownership), the development of joint research projects with medium-large sized firms, and the creation of spin-offs within the university’s ecosystem. The importance of transferring knowledge and of being valuable for companies is embodied in a sentence of one of the interviewees: “This very significant role of university as a major research unit in the country is seen by the university as an opportunity, but also as an obligation: to actively contribute to the creation of value based on the knowledge produce […] A university creates knowledge, but companies need solutions to improve products, processes and business models. […] a key success factor of any university is the ability to transform (which is more than transfer) knowledge into valuable solutions for companies”. The decision to include the university incubator in the science park, which hosts R&D centres of medium-large sized companies, reflects the intention of connecting new ventures with the local ecosystem. In addition, University B markets the spin-offs with the university brand and supports entrepreneurship clubs to promote networking and marketing, technological and financial opportunities. The university is committed to the generation of new ventures and provides two complementary mentoring programmes: the first one is a technology-driven mentoring programme open to faculty members, and the second is a market-driven programme, open to entrepreneurs, that also provides networking opportunities. Engagement though lifelong education is of great importance for these universities. University A, for example, collaborates with local industrial associations to offer master courses for managers, employees and graduate students:

In short, the universities in this cluster perform entrepreneurial activities to a relatively low extent, but focus on academic engagement aimed at supporting firms’ innovation processes. In consideration of these factors, we called this cluster: “engaged entrepreneurial model with focus on local economic development”.

4.3.2 Cluster 2: the formal entrepreneurial model. The second cluster is the largest and it contains ten universities. These institutions on average perform all the aforementioned entrepreneurial activities. With respect to Cluster 3, this group is more committed to commercialising research results (4.00) and to creating an entrepreneurial climate (3.32). This cluster is the one with the lowest students/academic ratio (9.29) and the highest core budget (€324.4m). As far as research commercialisation is concerned, this group of institutions is the best performing one, with an average of 47 patent applications, 14.7 commercialised patents and 20.8 spin-offs. The great value of R&D expenditure of the public sector (0.695), lifelong learning (0.570), population with tertiary education (0.631) and the highest share of employment in the public sector (39.7 per cent) testify the prominent role of these universities in their ecosystems. The universities in this cluster build an entrepreneurial climate that stimulates bottom-up student initiatives which are
complemented with top-down management. An example is the initiative of University C, through which entrepreneurial “champions” (students, professors, researchers, etc.) undertake initiatives that support a university-wide innovative and entrepreneurial climate. In order to leverage on and manage such initiatives, the university has established a TTO core team that is actively engaged with these entrepreneurial individuals, thereby creating a university-wide entrepreneurial community. Top-down management is performed to ensure a synergic effect of the different entrepreneurial bottom-up initiatives and alignment with the university’s strategic plan and to assign responsibility to different departments (Levie, 2014). Sponsorship from university leaders (Levie, 2014) creates consensus among academics. Thus, University C places great emphasis on students to build an entrepreneurial climate: “As far as entrepreneurship is concerned, many good ideas exist within the community (of students, researchers and professors). Hence, a supporting role of the university offers a good approach to leverage on its entrepreneurial potential”. The importance of building on the students’ entrepreneurial attitude further strengthens the importance of universities in regional ecosystems: “a large and motivated entrepreneurial student population is ideally placed to have a significant impact on the entrepreneurial culture of Europe’s future workforce. In this process, the university becomes even more embedded in the local eco-system”.

In this cluster, the effectiveness of research commercialisation resides in incentives for researchers (including non-monetary ones) and for TTO employees as well as in TTO budgetary and HR autonomy. At University C, more than 80 per cent of the revenues generated from research commercialisation flows back to the inventors and is invested in research-related expenses (e.g. lab equipment, lab technicians, etc.). Non-monetary incentives are also present: the university indicates the exploitation of research results as the outcome of excellent research projects. Thus, according to the academics, revenues are generated on the basis of their research results. Another best practice in research commercialisation comes from University D, which initiated an open-source strategy (Siegel and Wright, 2015; Kenney and Patton, 2009) through which the university offers a trial period to use the technology before signing a commercial licence. This was pointed out, in a study by Kenney and Patton (2009), as an alternative to the traditional licensing process:

In short, the universities in this cluster perform entrepreneurial activities to a relatively high extent and focus on research commercialisation and an entrepreneurial climate, with the latter having the potential to increase the effectiveness of the former. In consideration of these factors, we identified this cluster as “formal entrepreneurial model based on the systemic exploitation of research results”.

4.3.3 Cluster 3: the comprehensive entrepreneurial model. The third cluster comprises four universities. These universities perform all the aforementioned entrepreneurial activities: academic engagement (4.00), supporting activities (3.95), research commercialisation (3.75) and entrepreneurship education for students (3.75). The entrepreneurial climate is more limited (2.56), but with a large variability within the cluster (standard deviation of 1.37). With respect to the organisational and technology transfer indicators, this cluster falls between Clusters 1 and 3, while the ecosystem indicators are similar to those of the second cluster.

Research commercialisation is performed by means of the identification and capturing of innovation opportunities at an early stage: “At University E, we literally dig this information through short in situ interviews with potential innovators, that is, not only research staff but also M.Sc. students”. In doing so, the university TTO explores and maps the university innovation ecosystem and is very effective in signalling research collaboration opportunities with external actors. The university TTO then supports researchers in explaining their research through infographics, props, animations,
prototypes and interactive objects. Finally, the selected ideas are exposed at a research exhibition, which is an annual event with external companies.

The universities in this cluster have a holistic approach to entrepreneurial supporting activities. For instance, University E supports entrepreneurial individuals along the different stages of entrepreneurial journeys with different supporting tools. Through the incubator, the university offers different programmes that combine entrepreneurship education, support for early stage start-ups to identify their market/product combinations in a pre-acceleration programme and support for late stage start-ups to help them accelerate. The universities in this cluster adopt a student-based support system as in the case of University F: “The core of our key initiative is coaching. Students with some entrepreneurial experience, for example from running their own start-up, are coaching novice student entrepreneurs”. Here, entrepreneurship education was initiated by a local state-owned utility company which considered entrepreneurship education as beneficial to facilitate business growth in the region together with a more experience-based learning of students, in order to inspire the organisations’ entrepreneurial spirit and help market themselves as attractive employers. In addition to research commercialisation, supporting activities and entrepreneurship education, these institutions also engage with the ecosystems to create open innovation processes, where external parties collaborate with researchers and benefit from their skills, knowledge and unique research facilities. These universities, in close collaboration with firms and public bodies, focus on fundamental and pre-competitive research areas with a high innovation potential. A case in point is University G, whose innovation and research strategies are closely linked, in particular in those areas, which show the highest innovation. To achieve this, long-term innovation partnerships are undertaken, and translational organisations, upon which new partnership can be build, are attracted. The university creates and orchestrates the innovation ecosystem by providing leadership and vision for the future: “As the only organisations that bring together new talent, new technologies, openness to new business practices and international networks linked to the most competitive ideas available, universities should play an anchor role in developing their regional knowledge economies”. Cooperation with regional knowledge institutions, companies and governmental bodies – by means of regional innovation clusters, for example – plays a significant role. Engagement and collaboration in this cluster is also performed with SMEs, which require special support, in consideration of their limited resources. The local government innovation council, where University G resides, provides innovation vouchers to those SMEs that undertake a collaborative research project with University G. Moreover, universities in this cluster open their research facilities to SMEs in order to conduct research and product experimentation. Thus, the universities in this cluster adopt a balanced configuration of entrepreneurial activities, as an interviewee of University E stated: “our main innovation goals are to continue to encourage entrepreneurship and stimulate the translation of our research findings into innovative, commercial activities, to increase the number of large-scale, long-term and sustainable programmes for public-private partnerships (PPPs) and to promote and facilitate Open Innovation”. On the basis of the quantitative and qualitative data of these universities, it is possible to assert the following: the universities in this cluster perform the entrepreneurial activities to a relatively high extent and focus on academic engagement, supporting activities and research commercialisation. Given these factors, we identified this cluster as “comprehensive entrepreneurial model with focus on local economic development and the university’s financial advantage”

5. Discussion, implications and conclusion
5.1 Discussion
This paper has investigated the entrepreneurial activities, models and best practices adopted by 20 leading European science and technology universities. We used a
quantitative survey to carry out this investigation and conducted seven case studies with the collaboration of the CESAER innovation task force, and this allowed us to gather unique insights from the heads of technology transfer and the rectors of leading S&T universities in Europe. In addition, we complemented the analysis using data from the ETER and RIS data sets. This study was motivated by the lack of a framework covering the different entrepreneurial activities of universities, the limited number of investigations on the existence of different entrepreneurial university models and the limited knowledge about the best practices of entrepreneurial universities.

We identified five entrepreneurial activities, which we interpreted in light of the relevant literature: research commercialisation; entrepreneurship education for students; support for technology development, new venture creation and growth; academic engagement; the creation of an entrepreneurial climate. In addition, we found three main entrepreneurial university models on the basis of different configurations of entrepreneurial activities, organisational and ecosystem characteristics and a set of entrepreneurial best practices: an "engage" model focussed on local economic development; a "formal" model focussed on the systemic exploitation of research results; a "comprehensive" model focussed on local economic development and a university’s financial advantage. The key findings of this paper are summarised in Table VIII, which also shows the relative importance of each activity to each cluster. Table IX provides schematically the key results, introducing an outline of the research methodology process.

The "engage" model performs entrepreneurial activities to a relatively low extent, but focusses on academic engagement and, albeit not effectively, on research commercialisation. The relatively low performance level in all the other entrepreneurial activities seems to

| Table VIII. |
| Outline of university entrepreneurial models |

| Table VIII. |
| Outline of university entrepreneurial models |

<table>
<thead>
<tr>
<th>Cluster 1 - Engaged entrepreneurial model with focus on local industry development</th>
<th>Cluster 2 - Formal entrepreneurial model based on the systemic exploitation of research results</th>
<th>Cluster 3 - Comprehensive entrepreneurial model with focus on local economic development and the university’s financial advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research commercialisation</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Entrepreneurship education</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Supporting activities</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Academic engagement</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Entrepreneurial climate</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organisational indicators</th>
<th>Highest student/professor ratio Lowest budget</th>
<th>Lowest student/professor ratio Highest budget</th>
<th>Average value for all the indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology transfer indicators</td>
<td>Higher number of filed patents, lower number of commercialised patents and created spin-offs</td>
<td>Leader in filed and commercialised patents</td>
<td>Average position for all the indicators</td>
</tr>
<tr>
<td>Regional indicators</td>
<td>Lower value for all the indicators</td>
<td>Higher value for all the indicators (such as Cluster 3)</td>
<td>Higher value for all the indicators (such as Cluster 2)</td>
</tr>
<tr>
<td>Population, GDP per capita and share of employment at the NUTS 2 level</td>
<td>Low GDP per capita (1/3 of the other clusters)</td>
<td>Prevalence of industry and construction sectors</td>
<td>Prevalence of public administration, defence, education and human health sectors</td>
</tr>
</tbody>
</table>

| Best practices | Life-long education to develop skills and competencies for industry with extensive use of specialising master courses Location of the university incubator in the local science parks to facilitate contact with companies in the local ecosystem for new ventures Complementary technology-driven and market-driven mentoring programmes Spin-offs can use the university brand | Building an entrepreneurial climate by complementing bottom-up entrepreneurial initiatives with top-down management to ensure a synergic effect (i.e. a core team in TTO and sponsorship from the top) Monetary and non-monetary incentives for researchers and TTO employees | Early stage identification and capturing innovation opportunities Holistic approach to all the stages of the entrepreneurial journey Entrepreneurial support and education provided by students to students Direct involvement of university rector in regional strategic development trajectories Attraction of translational organisations and long-term innovation partnerships Support for innovation in SMEs |
depend on the structure of the local economy as well as on limited organisational resources. Universities engage with industry through lifelong education and research collaboration to develop skills and competencies; they locate the university incubators in local science parks in order to connect new ventures with local ecosystems and provide complementary technology and market mentoring programmes to promising entrepreneurs. This cluster focuses on supporting local economic development.

The “formal” model performs entrepreneurial activities to a relatively high extent, but focuses on research commercialisation, entrepreneurial climate and entrepreneurship education. They stimulate an entrepreneurial climate by complementing bottom-up entrepreneurial initiatives with top-down management, and they ensure effective research commercialisation by providing monetary and non-monetary incentives to researchers that engage in formal entrepreneurial activities (i.e. patenting, licensing and spin-offs). This cluster focusses on providing financial advantages to universities and their faculties.

The “comprehensive” entrepreneurial model performs entrepreneurial activities to a relatively high extent with the exception of the creation of an entrepreneurial climate. With similar ecosystem and organisational characteristics to the previous model, this cluster reflects a more balanced and comprehensive entrepreneurial model which considers all the previously mentioned kinds of entrepreneurial activities. They do so by identifying innovation opportunities at an early stage; employing support for all the entrepreneurial stages; empowering students to support and educate their peers; attracting translational organisations; building innovation partnerships; and supporting innovation in SMEs. This cluster focusses on providing local economic development and, at the same time, financial advantages to universities and their faculties.

5.2 Implications
5.2.1 Implications for theory. The findings of this paper contribute to university technology transfer and entrepreneurial university literature with respect to four main research topics.
First, we contribute to the literature that acknowledges different entrepreneurial activities. Our main contribution concerns the extension of the conventional distinction between formal and informal entrepreneurial activities (e.g., Perkmann et al., 2013; Philpott et al., 2011; Bradley et al., 2013b; D’Este and Patel, 2007; Link et al., 2007) to include other types of entrepreneurial activities: entrepreneurship education for students, support for technology development, new venture creation and growth; creation of an entrepreneurial climate. Although these entrepreneurial activities have already been discussed in literature, a framework that brings them together has not yet been proposed. These findings reveal how S&T universities are able to create a wide set of internal competencies, incentives and organisational processes that go beyond the simple introduction of TTOs and the distinction between formal and informal entrepreneurial activities. In this respect, our findings are in contrast with the literature that points out that informal entrepreneurial activities are performed more by generalist universities, while specialist universities focus only on formal entrepreneurial activities (Giuri et al., 2018).

Second, we contribute to the emerging literature on university entrepreneurial models (Baglieri et al., 2018; Giuri et al., 2018; Sánchez-Barriolengo and Benneworth, 2018; Cesaroni and Piccaluga, 2016) by highlighting three different strategic approaches with different entrepreneurial activity configurations. In line with previous literature, we argue that entrepreneurial universities may not only focus on formal entrepreneurial activities with the objective of gaining financial returns, but may also focus on other types of entrepreneurial activities with the objective of providing social and economic returns to the ecosystem (Cesaroni and Piccaluga, 2016). In addition, this study investigates the role of context (Autio et al., 2014), providing interesting insights about the relationship between a university’s organisational characteristics and the characteristics of its ecosystem through the adoption of a specific model. In this vein, we contribute to the literature that acknowledges how different factors can influence university strategies (Grimaldi et al., 2011). In particular, organisational resources appear to be relevant in greatly influencing the ability of a university to implement the needed set of entrepreneurial activities in the medium term. Moreover, we have found evidence that, in ecosystems with a strong industry focus, universities perform all the entrepreneurial activities poorly and tend to support local companies with soft or informal entrepreneurial activities (i.e., academic engagement). In this vein, we acknowledge the importance of system-level factors (i.e., the institutional characteristics of regions) in shaping the university strategy (Grimaldi et al., 2011) and we contribute to recent literature (Colombelli et al., 2018) that has analysed the relationship between university and industry in the shaping of regional technological specialisation. In this respect, universities in ecosystems with an important presence of industry follow and support the technological exploration of industry. We suggest the need for further research aimed at explaining which social, technological/industry, organisational and policy/institutional characteristics lead universities to embrace a specific entrepreneurial model.

Third, we contribute to an as yet under-developed form of literature related to the entrepreneurial best practices of universities (Fernández-Nogueira et al., 2018). In order to strengthen the replicability criteria in different universities, we have associated each entrepreneurial best practice to a particular entrepreneurial university model.

Finally, this paper contributes to the literature that considers students as important actors for entrepreneurial universities (Hayter et al., 2017; Boh et al., 2016). By employing case studies, we have found that students play an important role in building an entrepreneurial climate within a university, and in providing entrepreneurial support and education to their peers. In this vein, we suggest further research that could shed light on the mechanisms through which students support the identified entrepreneurial activities, and therefore play a key role in the entrepreneurial journey of universities.
5.2.2 Implications for practice. This study also has some implications for practice. University managers, in particular, could compare the execution of their universities’ entrepreneurial activities with those identified in this study. The decision to invest in a particular entrepreneurial activity should involve considering the specific entrepreneurial model the university has in place as well as the characteristics of the surrounding ecosystem and the available resources. For instance, focusing on research commercialisation could be risky in an ecosystem, which is not “ready”. This could be the case for the engaged entrepreneurial model, which was not able to transform patent applications into commercialisation. Industry, in fact, may place more value on informal entrepreneurial activities, such as research collaboration, consulting and training. Moreover, to engage practically with the development of entrepreneurial universities, these institutions may adopt one or more than one of the identified entrepreneurial best practices that best fit their entrepreneurial university model.

5.2.3 Implications for policy. This paper acknowledges that one-size-fits-all is not the case in this field, but rather that entrepreneurial universities, and therefore their impact on ecosystems, may take on different forms, depending, among other things, on the organisational resources, the presence of an advanced local innovation ecosystem and a strong presence of industry. This has important implications for the current discussion, at a European level, on the innovation impact assessment of universities, which should acknowledge the diversity of entrepreneurial approaches of universities, their resources and their surrounding ecosystems. Moreover, this paper provides important implications for policies aimed at increasing the entrepreneurial competencies of universities. In particular, universities in connection with the region and other public bodies should guarantee an appropriate amount of their budget, which should lead to an adequate student/academic ratio, leaving more time for research and technology transfer. In a similar vein, entrepreneurship and technology transfer strategies that do not consider the characteristics of a region (e.g. the level of employment and innovativeness of industry, lifelong learning and population with tertiary education) appear to be ineffective and even counter-productive.

5.3 Limitations and further research

This work is not free of limitations. First, we acknowledge that the sample size was limited. However, this issue was overcome by employing qualitative case studies. These, in turn, suffer from some limitations related to the generalisability of the results. We reduce this limitation by considering the unique setting of advanced European S&T universities. In addition, we acknowledge that the writing of case studies on a voluntary basis may lead the authors of the case studies to focus on specific aspects and avoid other ones. We mitigated this limitation by using a common and shared template for the case studies and by performing several feedback and revision sessions with the authors of the case studies to check that all the questions were answered properly, and specific aspects were not neglected. Second, this paper is limited to the European setting. Future research could enlarge this study by focusing on other settings and comparing them with the European one. Third, we did not analyse whether the adoption of a specific model depends on the timing of the adoption (Cesaroni and Piccaluga, 2016). It could be the case that the transition to a more balanced model may require time and the deliberate allocation of resources (Cesaroni and Piccaluga, 2016). Finally, we did not assess the effectiveness of the three university entrepreneurial models in supporting entrepreneurship and local economic development. Our analysis suggests that the comprehensive entrepreneurial model may even be more effective with lower research commercialisation outcomes, considering the existence of other types of entrepreneurial activities.
1. Which were subsequently recoded as research commercialisation, in view of the literature.

References


Appendix
List of sampled European universities:

1. The University of Porto (Portugal)
2. Ghent University (Belgium)
3. University College Dublin (Ireland)
4. Universitat Politècnica de Catalunya (Spain)
5. Instituto Superior Técnico (Portugal)
6. The University of Strathclyde (the UK)
7. The Norwegian University of Science and Technology (Norway)
8. The Technical University of Denmark (Denmark)
9. The Technical University of Darmstadt (Germany)
10. The Technical University of Berlin (Germany)
11. Poznan University of Technology (Poland)
12. Politecnico di Torino (Italy)
13. KU Leuven (Belgium)
14. KTH Royal Institute of Technology (Sweden)
15. Kaunas University of Technology (Lithuania)
16. Delft University of Technology (the Netherlands)
17. Brunswick University of Technology (Germany)
18. Brno University of Technology (the Czech Republic)
19. Aalborg University (Denmark)
20. Aachen University (Germany)
Table A1. Pairwise correlation of survey question items

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
<th>(13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TTO activities (IPR, Licensing)</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. International networking with universities</td>
<td>0.157</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. International networking with companies</td>
<td>0.095</td>
<td>0.523*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Training staff in the commercialisation of technologies</td>
<td>0.220</td>
<td>-0.169</td>
<td>0.009</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Entrepreneurship education for students</td>
<td>0.413</td>
<td>0.224</td>
<td>0.517*</td>
<td>0.091</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Entrepreneurship education for faculty members</td>
<td>-0.020</td>
<td>-0.097</td>
<td>0.084</td>
<td>0.489*</td>
<td>0.379</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Lifelong education for graduate students/scientists/industry members</td>
<td>0.180</td>
<td>0.411</td>
<td>0.664**</td>
<td>-0.020</td>
<td>0.412</td>
<td>-0.099</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Mentoring programmes for entrepreneurs</td>
<td>-0.219</td>
<td>0.288</td>
<td>0.300</td>
<td>-0.098</td>
<td>0.447*</td>
<td>0.372</td>
<td>0.142</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Business plan competitions</td>
<td>-0.245</td>
<td>0.377</td>
<td>0.192</td>
<td>-0.357</td>
<td>0.200</td>
<td>0.058</td>
<td>0.375</td>
<td>0.594**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Incubator programmes</td>
<td>-0.037</td>
<td>0.151</td>
<td>-0.068</td>
<td>-0.284</td>
<td>0.354</td>
<td>0.138</td>
<td>0.122</td>
<td>0.453*</td>
<td>0.629**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Funding support for technology development, start-ups and spin-offs</td>
<td>0.401</td>
<td>0.230</td>
<td>0.422</td>
<td>0.121</td>
<td>0.469*</td>
<td>0.294</td>
<td>0.447</td>
<td>0.351</td>
<td>0.310</td>
<td>0.419</td>
<td>0.335</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>12. Assistance in finding investors</td>
<td>0.443</td>
<td>0.279</td>
<td>0.526*</td>
<td>0.338</td>
<td>0.720**</td>
<td>0.378</td>
<td>0.402</td>
<td>0.355</td>
<td>0.192</td>
<td>0.256</td>
<td>0.440</td>
<td>0.710**</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Notes: Significance level *p < 0.05; **p < 0.01
### Table AII. First iteration of factor analysis: matrix of rotated components

<table>
<thead>
<tr>
<th>Component</th>
<th>Components 1</th>
<th>Components 2</th>
<th>Components 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>International networking with companies</td>
<td>0.890</td>
<td>0.148</td>
<td>0.196</td>
</tr>
<tr>
<td>Lifelong education for graduate students/scientists/industry members</td>
<td>0.850</td>
<td>0.156</td>
<td>−0.105</td>
</tr>
<tr>
<td>International networking with universities</td>
<td>0.734</td>
<td>0.199</td>
<td>−0.120</td>
</tr>
<tr>
<td>Incubator programmes</td>
<td>0.951</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business plan competitions</td>
<td>0.314</td>
<td>0.752</td>
<td></td>
</tr>
<tr>
<td>Mentoring programmes for entrepreneurs</td>
<td>0.237</td>
<td>0.592</td>
<td>0.421</td>
</tr>
<tr>
<td>Funding support for technology development, start-ups and spin-offs</td>
<td>0.325</td>
<td>0.572</td>
<td>0.272</td>
</tr>
<tr>
<td>Entrepreneurship education for faculty members</td>
<td>0.200</td>
<td></td>
<td>0.890</td>
</tr>
<tr>
<td>Training staff in the commercialisation of technologies</td>
<td>−0.384</td>
<td>0.735</td>
<td>0.131</td>
</tr>
<tr>
<td>Assistance in finding investors</td>
<td>0.388</td>
<td>0.285</td>
<td>0.539</td>
</tr>
<tr>
<td>TTO activities (IPR, Licensing)</td>
<td>−0.116</td>
<td>−0.125</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurship education for students</td>
<td>0.418</td>
<td>0.322</td>
<td>0.429</td>
</tr>
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</table>

**Notes:** Loadings < 0.10 have been removed. Method, principal component analysis; rotation, varimax with Kaiser normalisation.

### Table AIII. Second iteration of factor analysis: matrix of rotated components

<table>
<thead>
<tr>
<th>Component</th>
<th>Components 1</th>
<th>Components 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubator programmes</td>
<td>0.879</td>
<td></td>
</tr>
<tr>
<td>Business plan competitions</td>
<td>0.843</td>
<td>0.245</td>
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<tr>
<td>Mentoring programmes for entrepreneurs</td>
<td>0.711</td>
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</tr>
<tr>
<td>Funding support for technology development, start-ups and spin-offs</td>
<td>0.627</td>
<td>0.278</td>
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<tr>
<td>International networking with companies</td>
<td>0.887</td>
<td></td>
</tr>
<tr>
<td>Lifelong education for graduate students/scientists/industry members</td>
<td>0.821</td>
<td></td>
</tr>
<tr>
<td>International networking with universities</td>
<td>0.795</td>
<td></td>
</tr>
<tr>
<td>Training staff in the commercialisation of technologies</td>
<td>−0.285</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurship education for faculty members</td>
<td>0.214</td>
<td></td>
</tr>
<tr>
<td>Assistance in finding investors</td>
<td>0.386</td>
<td>0.369</td>
</tr>
</tbody>
</table>

**Notes:** Loadings < 0.10 have been removed. Method, principal component analysis; rotation, varimax with Kaiser normalisation.

### Table AIV. Total variance explained

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial eigenvalues</th>
<th>Extraction sum of the squared loadings</th>
<th>Rotation sum of the squared loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of variance</td>
<td>cumulative</td>
</tr>
<tr>
<td>1</td>
<td>3.651</td>
<td>36.508</td>
<td>36.508</td>
</tr>
<tr>
<td>3</td>
<td>1.723</td>
<td>17.231</td>
<td>73.062</td>
</tr>
<tr>
<td>4</td>
<td>0.819</td>
<td>8.193</td>
<td>81.255</td>
</tr>
<tr>
<td>5</td>
<td>0.457</td>
<td>4.573</td>
<td>85.828</td>
</tr>
<tr>
<td>6</td>
<td>0.423</td>
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<td>90.054</td>
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<td>3.107</td>
<td>96.878</td>
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<td>9</td>
<td>0.182</td>
<td>1.816</td>
<td>98.693</td>
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<td>10</td>
<td>0.131</td>
<td>1.307</td>
<td>100.000</td>
</tr>
</tbody>
</table>

**Table AIV.**

Total variance explained.
Corresponding author
Alessandra Colombelli can be contacted at: alessandra.colombelli@polito.it

Table AV.
Reliability analysis

<table>
<thead>
<tr>
<th>Factor</th>
<th>Items</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Support for technology development, new venture creation and growth</td>
<td>Incubator programmes</td>
<td>0.760</td>
</tr>
<tr>
<td></td>
<td>Business plan competitions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mentoring programmes for entrepreneurs</td>
<td></td>
</tr>
<tr>
<td>2. Academic engagement</td>
<td>Funding support for technology development, start-ups and spin-offs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International networking with companies</td>
<td>0.749</td>
</tr>
<tr>
<td></td>
<td>Lifelong education for graduate students/scientists/industry members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International networking with universities</td>
<td></td>
</tr>
<tr>
<td>3. Creation of an entrepreneurial climate</td>
<td>Training staff in the commercialisation of technologies</td>
<td>0.669</td>
</tr>
<tr>
<td></td>
<td>Entrepreneurship education for faculty members</td>
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<tr>
<td></td>
<td>Assistance in finding investors</td>
<td></td>
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</table>

Table AVI.
Factor scoring coefficients

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<th></th>
<th>1</th>
<th>Factor</th>
<th>2</th>
<th>3</th>
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</thead>
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<tr>
<td>Incubators programmes</td>
<td>0.390</td>
<td>−0.141</td>
<td>−0.082</td>
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<tr>
<td>Business plan competitions</td>
<td>0.347</td>
<td>0.013</td>
<td>−0.155</td>
<td></td>
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<tr>
<td>Mentoring programmes for entrepreneurs</td>
<td>0.258</td>
<td>−0.006</td>
<td>0.091</td>
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<tr>
<td>Funding support for technology development, start-ups and spin-offs</td>
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<td>−0.024</td>
<td>0.161</td>
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<td>International networking with companies</td>
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<td>0.412</td>
<td>0.076</td>
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</tr>
<tr>
<td>Lifelong education for graduate students/scientists/industry members</td>
<td>−0.043</td>
<td>0.365</td>
<td>−0.025</td>
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<tr>
<td>International networking with universities</td>
<td>−0.026</td>
<td>0.346</td>
<td>−0.144</td>
<td></td>
</tr>
<tr>
<td>Training staff in the commercialisation of technologies</td>
<td>−0.186</td>
<td>0.013</td>
<td>0.438</td>
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</tr>
<tr>
<td>Entrepreneurship education for faculty members</td>
<td>0.062</td>
<td>−0.135</td>
<td>0.379</td>
<td></td>
</tr>
<tr>
<td>Assistance in finding investors</td>
<td>0.009</td>
<td>0.114</td>
<td>0.266</td>
<td></td>
</tr>
</tbody>
</table>

Note: Method, regression based on varimax rotated factors

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Analyzing technology transfer offices’ influence for entrepreneurial universities in Portugal

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Abstract
Purpose – The purpose of this paper is to examine how important technology transfer offices (TTOs) – which in Portuguese are called “industrial property support offices” or GAPIs – are in terms of fostering patent applications and technology transfer in countries characterized by low performance records in these activities.
Design/methodology/approach – Among the existing 23 Portuguese GAPIs, only eight agreed to provide answers to a semi-structured questionnaire survey. Content analysis was performed on the data collected using NVivo software.
Findings – The results show that GAPIs play an important role in the innovation life-cycle, speeding up the transfer of knowledge and technology to society. The regulation of intellectual property (IP) ownership and royalty sharing with inventors was identified as a major result, strengthening entrepreneurial universities’ role. In addition, after the GAPIs were created, networks were formed that facilitate the sharing of knowledge and experience and promote the development of further collaborative partnerships.
Practical implications – This study’s results offer new insights into how GAPIs contribute to socio-economic growth by fostering more entrepreneurial universities and increasing the transfer of technology to society. In addition, these offices promote the creation of networks between GAPIs, enabling them to leverage universities’ potential for participation in socio-economic development.
Originality/value – No previous research has focused on GAPIs/TTOs’ point of view regarding policies that enhance IP and technology/knowledge transfer.
Keywords Entrepreneurial university, Intellectual property (IP), Knowledge and technology transfer, Technology transfer offices (TTOs)
Paper type Research paper

1. Introduction
Over the last 20 years, universities have been searching for new forms of funding and thus shaping research to meet business needs (Etzkowitz, 1996; Van Vught, 1999; Leydesdorff, 2013; Kaklauskas et al., 2018). Universities and other centers of knowledge transfer have
concentrated on industry interface offices to promote institutional relationships and projects. These offices offer development and management services and play a fundamental role in bridging the gap between suppliers and users of knowledge (Alexander and Martin, 2013; Perkmann et al., 2013).

Political interest has been growing – especially in Europe – in both the efficient transfer of knowledge produced in universities and the scientific research produced in public institutions for commercial purposes. Patents are often seen as a possible source of commercial technology. University patents, together with licensing, can provide the right incentives to develop products and can be a source of extra funds for universities and technology centers (Bacchiocchi and Montobbio, 2009). In most European countries, universities are thus increasingly involved in the management of internally produced inventions (Etzkowitz and Klofsten, 2005; Simeone et al., 2017). Patent registration is advocated as a strategy to improve the immediacy and effectiveness of knowledge transfer from academia to industries, thereby promoting universities’ ability to contribute to innovation and socio-economic development (Blind and Thumm, 2004; Geuna and Rossi, 2011).

Following this, Stankeviciënė et al. (2017) argue that more studies are needed to assess technology transfer offices’ (TTOs’) importance to technology transfer between universities and companies. In addition, Siegel and Wright (2015) and De Beer et al. (2017) report that little evidence exists of TTOs’ effectiveness regarding technology transfer. This is especially true of regions and/or countries with a weak tradition of co-operation between universities and companies (see also Wright et al., 2008), as appears to be the case for Portugal (Teixeira and Coimbra, 2014; Arqué-Castells et al., 2016; Cartaxo and Godinho, 2017).

Portuguese universities’ investment in the registration and licensing of technology as a source of revenue emerged in the 2000s, with the creation of GAPIs – Portuguese acronym for “industrial property support offices” – by Instituto Nacional da Propriedade Industrial (INPI). Until that period, Portugal’s experience in registering intellectual property rights (IPR) and/or technology transfer was almost null, thus becoming a recent phenomenon compared to other European countries such as Spain, France or Germany.

Grounded on the Portuguese case, this study sought to examine how important GAPIs are in terms of fostering patent applications and technology transfer in countries characterized by low intellectual property (IP) protection, addressing the following research question:

**RQ1.** What is the importance of GAPIs in patent registration and knowledge/technology transfer in a country with low IP protection?

The remainder of this paper is organized as follows. The next section presents a review of the literature on entrepreneurial universities and the importance of TTOs to knowledge and technology transfer. Section 3 provides the methodological background, while Section 4 discusses the results obtained. The last section presents the study’s contributions and a roadmap for future research.

### 2. Literature review

#### 2.1 Entrepreneurial universities

Universities are no longer confined to purely academic research and teaching as they have become increasingly involved with external partners through entrepreneurial activities (Clark, 1998; Glückler, 2007; Vorley and Nelles, 2008; Guan and Liu, 2016; Guerrero et al., 2016; Leih and Teece, 2016; Zhang et al., 2016; Peng et al., 2017; Lopes et al., 2018). The new component of entrepreneurship in universities’ mission offers many opportunities for these institutions to establish associations with industrial sectors. More specifically, this involves creating university spin-offs, conducting licensing, generating research contracts, providing consulting services and facilitating the mobility of graduate students and researchers throughout these sectors (Elia et al., 2017; Vaz de Almeida et al., 2018).
National and regional governments have sought to encourage the transfer of university technology to industries to sustain and develop national and regional economic systems, thereby leveraging the “third component of their [universities’] mission” (Etzkowitz et al., 2000; Laredo, 2007; Carayannis and Campbell, 2012; Kochenkova et al., 2016). Policymakers are thus increasingly interested in stimulating entrepreneurial behaviors among academic researchers based on the belief that academic research is an important engine of economic growth. The perception also exists that academic institutions should now include business-related activities in addition to teaching and researching.

These behaviors can be encouraged by applying numerous government stimuli, such as tax policies, employment policies, subsidies, business education and IP policies (Lambert, 2003; Cassia et al., 2014; Czarnitzki et al., 2015). The resulting increase in university knowledge and technology transfer activities has facilitated the establishment of new partnerships (Zomer and Benneworth, 2011; Maas and Jones, 2017; Secundo et al., 2017). The growing amount of technology transfer between countries over recent decades has been largely supported by public policy measures that promote technology transfer activities by universities or public research organizations (Philpott et al., 2011; Feldman et al., 2012; Kemeny et al., 2016).

2.2 TTOs’ importance to knowledge and technology transfer

Europe’s much weaker results in comparison to the USA in terms of the number of patents, spin-offs and licensing led the European Commission, in 2000, to rethink its strategies for transferring knowledge generated by universities (Slaughter and Leslie, 1997; Siegel et al., 2007). As far as knowledge is concerned, a consensus exists among scholars and policymakers that knowledge is one of the main drivers of long-term economic growth. Knowledge is also an increasingly critical dimension of competitive advantages (Balland and Rigby, 2016).

The most important components of the entrepreneurial university model are the creation and implementation of new knowledge and transferable behaviors. All these aspects include topics related to research and development (R&D) funding, inventions and patents. Patents alone are insufficient evidence of universities’ business-related behaviors, but patents are the first step toward allowing newly created knowledge to meet real business needs. Patent holders rely on this exclusive ownership for licensing, with TTOs being primarily responsible for the technology transfer resulting from patent registration.

The increased number of patents registered by science producers, especially public institutions generating innovations, is a fundamental feature of this process not only for governments but also for industrial sectors. On the one hand, public research organizations are the leading producers of scientific and technological knowledge in the current innovation and knowledge-driven economies (Secundo et al., 2018). Thus, the way these organizations implement and exploit the results of their research activities directly influences the extent and mechanisms of knowledge diffusion and transfer. On the other hand, firms’ innovative efforts are closely linked to external sources of knowledge (e.g. universities and other research institutions). As a result, any shift in knowledge diffusion mechanisms directly influences firms’ competitiveness and productivity and, consequently, national economic development (Cesaroni and Piccaluga, 2005; Geuna and Nesta, 2006; Perkmann et al., 2013).

Strategies focused on monopolizing profits through legal mechanisms and key resource control may work in some industrial settings but may hinder innovation in others, leaving promising technologies unexplored. More open approaches to industrial property management can be combined with proposals that emphasize cognitive and socio-political legitimacy, thereby leading to a more effective diffusion of ideas (Hall et al., 2014). The links between academia and industries represent an important form of knowledge transfer to the industrial sectors. According to Berbegal-Mirabent et al. (2015), universities and TTOs need, therefore, to create supporting activities and implement
normative frameworks that facilitate knowledge flows to industries and societies. In this area, Portugal has yet a long way to go. If IP protection culture is recent, technology transfer actions are even more recent (Arqué-Castells et al., 2016; Cartaxo and Godinho, 2017).

3. Methodology
The present study sought to develop a fuller understanding of the importance of TTOs (or GAPIs) in terms of fostering patent applications and technology transfer in Portugal. Figure 1 presents the conceptual model applied in this research.

Given that the current study aimed to investigate interorganizational relationships, a qualitative research approach was selected as this is useful in exploratory research and allows network actors to think freely about the topic under study (Yin, 2015). The intersubjective relationships between interviewers and interviewees are a central feature of qualitative interviews, since these connections facilitate the negotiation of visions of reality based on the dynamics between participants. In general, all methods should seek to find answers – whether positive or negative – to at least four requirements of empirical research: construct validity, external validity, internal validity and confidence in results (Yin, 2015).

Interviews are one of the most common methods used in small-scale research. In semi-structured interviews, the interviewer establishes a general structure, deciding in advance the terrain to be covered and the main issues to be addressed. A more detailed structure is elaborated during the interview, and the interviewee has a reasonable degree of freedom regarding what to talk about, how much to say and how to express it (Minichiello et al., 2008). Semi-structured interviews are thus an extremely flexible technique appropriate for studies with a limited scope (Drever, 1995).

The qualitative approach further fully acknowledges the challenge of doing original research and pursuing three important goals: transparency, method and adherence to evidence (Yin, 2015). More specifically, a case study is a type of research that examines people, programs or institutions in their real situation via interviews, observations, documents, questionnaires and artefacts (Yin, 2015). In the present research, the case study was Portugal’s GAPIs.

3.1 Case study selection
With a gross domestic product (GDP) of EURO 17,329.5 and public budget allocations of 0.9 percent of GDP for R&D, Portugal still has a low number of patent registrations. In terms of knowledge/technology transfer between universities and companies, the Portuguese panorama is also not the best. To address this issue, the Lisbon Strategy defined the economic agenda of the European Union (EU) members, aiming to bridge the gap between Europe, Japan and the US, and making Europe the most dynamic knowledge-based economy and competitive in the world by 2010, notably through patent protection.
In terms of IPR registrations, Portugal occupied, in the late 1990s, the last positions in the European ranking. To remedy this failure and comply with the EU impositions in terms of increased patent registration, the Portuguese Government, through INPI, decided to create a network of GAPIs to support the transfer of IP rights and transfer of knowledge/technology. Currently, this network of GAPIs is comprised of 23 offices located throughout the country. GAPIs are autonomous operating units based in university-enterprise interface institutions, business associations and technology centers. These offices seek to increase patent registration and IPRs-based commercialization, as well as boosting business strategies with a strong focus on innovation and internationalization.

With this network’s creation, the Portuguese Government intended, first, to address the problem of the country’s weak propensity to innovate and use IP and, second, to increase investment in R&D. The third goal was to disseminate information on IP by centralizing it in the INPI. Fourth, the government sought to strengthen the interaction between IP and innovation systems. The last goal was to move Portugal up from the bottom of list of significant international IP organizations.

Among the 23 existing GAPIs in Portugal, only eight were interested or available to participate in this study. It is worth noting, however, that the following sample criteria were ensured:

- GAPIs located in the north, center and south of Portugal;
- GAPIs located in inland and coastal areas of Portugal;
- GAPIs located in territories of high and low population densities; and
- GAPIs belonging to universities, business associations and technology centers.

### 3.2 Data collection and analysis

To achieve the present study’s proposed objectives, the data collection process comprised semi-structured interviews with GAPI functionaries (see Appendix). In addition, a close examination was carried out of reports published by the INPI (2017), WIPO (2017) and Pordata (2017) regarding IP. These multiple data sources facilitated triangulation (Creswell and Clark, 2007), the validation of interview constructs and the confirmation of the results’ reliability (Yin, 2015). Out of the 23 GAPIs contacted, eight agreed to an interview. Although relatively small, it is worth noting that our sample included representatives of all types of organizations belonging to the GAPIs’ network. These included the following institutions:

1. Association of Metallurgical and Mechanics Industries of Portugal (AIMMAP);
2. Technological Center of Ceramics and Glass (CTCV);
3. Technological Center of the Textile and Clothing Industries of Portugal (CITEVE);
4. University Institute of Lisbon (ISCTE);
5. University-Company Association for Development (TecMinho);
6. University of Évora (UEvora);
7. University of Algarve (UALG); and
8. University of Trás-os-Montes e Alto Douro (UTAD).

To collect the desired data, individuals in senior positions were interviewed. Table I presents the interviewees’ profile.

The interviews took place in April 2017, and each lasted approximately 40 min. The data obtained were analyzed using the NVivo 11.0 software, which facilitated the creation of node
structures, as well as the processing of different types of queries ranging from the identification of unique terms to the elaboration of matrix queries to detect patterns (Richards, 1999; Lew et al., 2016). The information obtained in the interviews was subjected to systematic coding and categorizing, so the results were thus produced in the form of codes and categories. The coding system created was used to identify the information obtained in the texts and answer the previously formulated research question. The codes could appear either alone or in groups (i.e. categories). When texts with similar or identical information appeared, the same codes were used, and, when the information to be coded was new, new codes were created. The secondary data collected were processed using descriptive statistics. A descriptive analysis was conducted to identify the number of national, European or Patent Cooperation Treaty (PCT) patents.

4. Results and discussion
Based on the interviews, GAPIs have been of great importance to increasing patent registration in Portugal, and this increase is reflected in the transfer of technology and knowledge. Figure 2 shows the factors that the interviewees reported have influenced national results in terms of both patents and the transfer of technology and knowledge.

![Figure 2. Map of nodes and relationships generated by NVivo to address the research questions](image)

**Table I.** Interviewees' profiles

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Age</th>
<th>Gender</th>
<th>Academic qualifications</th>
<th>Training area</th>
<th>Position in GAPI</th>
</tr>
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<tbody>
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<td>47</td>
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<td>Project manager</td>
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<tr>
<td>CITEVE</td>
<td>2</td>
<td>39</td>
<td>Female</td>
<td>Master's</td>
<td></td>
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<td></td>
<td></td>
<td>Economics and</td>
<td></td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>innovation</td>
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<td>CTCV</td>
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<td></td>
<td></td>
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<td>Ceramics and</td>
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<td></td>
<td></td>
<td>glass</td>
<td></td>
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<tr>
<td>TecMinho</td>
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<td>Female</td>
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<td>Electrotechnology</td>
<td></td>
</tr>
</tbody>
</table>

The information obtained in the interviews was subjected to systematic coding and categorizing, so the results were thus produced in the form of codes and categories.
4.1 Patent application

According to the interviewees, GAPIs are important to patent registration mainly because of their knowledge about IP, the support provided by these offices to researchers and companies and the subsequent significant increase in interest in IPRs. The latter includes requests for patents and the IP regulations that have emerged.

4.1.1 Increase in number of patents. Advances in knowledge have been responsible for much economic development, and innovations are acknowledged to be a catalyst for economic growth and regional competitiveness (Guerrero and Sero, 1997; Ács et al., 2002; Tödtling and Trippl, 2005; Bottasso et al., 2014; Trippl et al., 2015). These advances strengthen organizations’ ability to attract human capital and increase their entrepreneurial spirit (Wright et al., 2014; Ács et al., 2015; Vogel, 2015). In this context, patents have become one of the main measures of innovation as they represent state-of-the-art ideas and make tracking knowledge flows easier (Nelson, 2009). The growing interest in patents’ contribution to innovation has been stimulated by a significant overall increase of patent applications in recent years (Roper and Hewitt-Dundas, 2015).

Regarding the number of patents, the TecMinho GAPI interviewee, for example, said “in terms of intellectual property, our entry into the GAPI [network] brought a substantial increase in patent applications by TecMinho and by the University of Minho. […] We currently have more than 150 patent applications”. Overall, patent filing data for the national, European and PCT routes (see Figure 3) show an increase in the number of patent applications from the start of the GAPI program in 2000 until 2015.

Patents are a strong indicator of innovation, and they play an important role in economic growth, which is reflected in countries’ GDP. According to the Global Innovation Index (2017), the greater the number of innovations registered in a given country, the better that nation’s results are in overall innovation rankings. The 2010 IPR Index (see INPI, 2017), in turn, reports that countries with weaker IPRs have lower per capita income, while countries with higher IPRs attract more foreign investment. Developing countries with stronger IPRs also present higher GDP growth per capita. Regarding

![Patent Application Variation](image)

**Source:** INPI (2017)
variations in IP patent applications and Portugal’s GDP, the evolution over the last 15 years is shown in Figure 4.

As Figure 4 reveals, trademarks are the most protected IPR in Portugal, followed by design, while patents present by far the smallest number. During the period shown, economic growth in Portugal has been extremely low but stable.

4.1.2 Intellectual property knowledge and support provided to researchers and companies. Siegel et al. (2007) note that the lack of experienced knowledge transfer staff has been a common problem among European countries, and Portugal is no exception. At the time the GAPI network was created, this country had no tradition of IPRs protection and few people were familiar with issues related to IP law. According to the interviewees, the subsequent increase in the number of patents is related to the knowledge acquired by each office’s specialists, which enabled them to begin providing support to both researchers and companies. Therefore, the IP knowledge acquired by the specialists allocated to each GAPI was extremely important. This facilitated not only the development of internal mechanisms to support IP registrations but also the promotion of awareness of IP-related issues. The GAPI representative at AIMMAP asserted, “with this knowledge, we promoted and raised awareness of how companies in the sector can use intellectual property to enhance their innovation activities”. Figure 5 shows the patent concessions over the years by the type of applicant.

As can be seen in Figure 5, no patents were granted to universities until the 1990s. Notably, in Portugal and in accordance with the legislation on IP in force, patents are not granted any sooner than 21 months after their filing with the INPI. This helps explain the increase in the number of concessions from 2002 onward – two years after the GAPIs’ first phase started.

4.1.3 Intellectual property regulation. In recent decades, most European universities have become increasingly involved in the management of inventions produced internally. Patent protection of these inventions is seen as a strategy to improve the universities’ image and the effectiveness of knowledge transfer from academia to industries. This, in turn, promotes universities’ ability to contribute to innovation and socio-economic development (Geuna and Rossi, 2011). In Portugal, Nos 1 and 2 of Article 59 of the Intellectual Property Code (i.e. Law No. 143 of July 25, 2008) state: “If the invention is created during the fulfillment of an employment contract in which the inventive step is specified, the right to the patent belongs to the respective company. [...] If the inventive step is not specifically remunerated, the inventor is entitled to remuneration in accordance with the invention’s importance”.

Figure 4.
IPRs and economic growth

Source: WIPO (2017)
The percentage of remuneration associated with universities’ royalties was not clearly stipulated when the GAPIs were first opened. Given the low number of universities in IP applications, one of the GAPI network’s main achievements was undoubtedly the creation of IP regulations that eventually standardized the protection of universities’ R&D activities. The regulations now cover any exploitation of the results obtained, thereby fostering technology transfer and interaction between academia and businesses. For example, the TecMinho GAPI interviewee said, “there was no [intellectual property] regulation formalized prior to the GAPIs’ incorporation [into organizations]”. The subsequent increase in the number of patent applications thus served as a lever for the transfer of technology and knowledge in Portugal – a process that was further examined based on the interview results.

4.2 Transfer of technology and knowledge

Knowledge, which is generated mainly in universities, should be transferred to industries to create value, thereby enhancing regional and national economic development. Bercovitz and Feldman’s (2008) work highlights the role of universities in creating new knowledge and their ability to make this knowledge economically useful by transferring it to industries in exchange for royalty payments. According to Lockett et al. (2005), licensing is the most common knowledge transfer taking the form of patent protected technology. Licensing has been the dominant route for the commercialization of IP generated by the public sector, although the formation of university-run companies (i.e. spin-offs) is a potentially important but not yet fully explored option.

Innovation is an extremely important factor in companies’ success. However, businesses’ innovation-based performance depends to some extent on the ability to create networks including the scientific community. Companies that benefit from scientific knowledge become more competitive by exploiting innovations that distinguish these firms from competitors. Currently, TTOs and industry–university interface offices are mainly responsible for establishing university–industry partnerships. R&D contracts or licensing agreements exemplify the indirect mechanisms through which companies and universities collaborate on a profit-sharing basis (Berbegal-Mirabent et al., 2015). This is one of the functions of the offices belonging to the GAPI network. According to the interviewees, technology and knowledge transfer is evident in the increased use of technology transfer
contracts, number of spin-offs created, promotion of university–industry relations and significant decentralization of knowledge.

4.2.1 Increase in technology transfer contracts. The importance of universities to innovation policies in a knowledge society extends to the legal protection of university research results and their transposition into economic value (Meusburger and Antonites, 2016). Universities play an active role in the promotion and dissemination of internally generated innovation (Cesaroni and Piccaluga, 2005). They have increasingly focused on the processes of creating and spreading innovation and knowledge, thus confirming their role as the promoters of regional and national economic systems – a characteristic that companies have noticed and supported (Corsi and Prencipe, 2016).

Regarding the growing number of patents mainly from universities (see Figures 2–4), licensing has become significantly more common in Portugal since 2000, when this activity was almost residual for most institutions in the GAPI network. The interviewees consider the increase in technology transfer contracts to be a major factor in technology and knowledge transfer. The UTAD GAPI interviewee said, “at this point, we have five licensing agreements. Before the GAPIs, there were none. In fact, we only had one patent that was never licensed”.

The UALG GAPI functionary also reported, “in 2016, we had eight licensing agreements. Before the GAPIs, there were none”. In addition, the TecMinho GAPI interviewee noted, “previously, we did not count the contracts. Now, we have an yearly average of 15”.

4.2.2 Spin-off creation. University spin-offs can be considered another primary source of technology transfer. These companies are established on the basis of university knowledge, so, in this way, universities demonstrate their important role in the knowledge economy and regional economies (Lockett et al., 2003; Rasmussen et al., 2014; Pitsakis et al., 2015). In the US, for example, university technology transfer has been increasingly supported by policymakers, who see it as an important factor in the creation of spin-offs, growth of existing firms and new job creation (Siegel et al., 2003). In Portugal, the increased number of university patents and the GAPIs’ awareness-raising initiatives have led researchers and/or inventors to realize the financial importance of the patents filed. In addition, the GAPIs’ support of spin-off creation has generated a growing number of spin-offs formed by inventors.

The interviewees’ responses regarding the creation of spin-offs in their institutions included the UEvora GAPI functionary’s statement: “we provide support for the creation of university spin-offs, since UEvora created a specific regulation to stimulate the creation of spin-offs in 2015”. The UALG GAPI interviewee said, “we support entrepreneurship, incubation, training programs, idea competitions, and support in the form of funding for project applications involving UALG”. In turn, the TecMinho GAPI functionary reported that “business projects that commercially exploit R&D results include a business idea lab (IdeaLab), business lab (LabEmpresas), entrepreneurship support office (Start@TecMinho), and business ideas contest (SpinUM)”.

4.2.3 Promoting university–industry relations. According to Nelson (1993), public R&D institutions had little effect on business innovation in the 1980s, and the co-operation between universities and industries was confined to some companies with great innovative power. The Bayh-Dole Patent and Trademark Amendments Act of 1980 changed the rules for ownership of US IP (Mowery, 2011), as well as decreasing government incentives, which led research organizations to seek funding from industrial sectors (Etzkowitz, 1983). In general, the movement has been toward a new innovation environment in which universities and other knowledge-producing organizations play an extremely important role in the global economy (Perkmann and Walsh, 2007).

Academic co-operation with the business world involves an increasing number of researchers in various disciplines, creating income for universities through marketing that extends to patent licensing and spin-out activities (Perkmann et al., 2013). Governments – especially in European
countries—have been strengthening the role of universities in their national innovation systems by encouraging more interaction between universities and industries (Etzkowitz and Leydesdorff, 2000; Beesley, 2003; Bican et al., 2017).

Those in charge of technology center GAPIs are familiar with business realities and the lack of contact between companies and universities, which is a further example of the GAPI network’s added value. The CITEVE GAPI interviewee said: “In the specific case of technological centers, their proximity to the business world along with the decentralization inherent in this network has helped facilitate companies’ access to this type of knowledge, which is essential to carrying out their activities in an increasingly global market”. The CTCV GAPI functionary suggested, “links should exist between technology centers, universities, and science and technology parks, although each group has different objectives that shape their respective approaches”.

4.2.4 Decentralization of knowledge. The economic effects of higher education institutions’ decentralization policies on the level of productivity and innovation have been measured, for example, by the increase in the number of patents granted to university inventors (Andersson et al., 2009). Knowledge is no longer encapsulated within universities, with research kept in the laboratories where it is conducted, and the results are now being transferred to the outside world. The introduction of entrepreneurship into academic settings has affected the educational and research mission components of all higher education institutions, so that they have become more open to society (Etzkowitz et al., 2000). Thus, the transfer of university-generated knowledge, which contains codified and uncoded information, has become an important source of industrial innovation. The geographical restrictions on universities’ knowledge flows make proximity to these institutions a great advantage, resulting in the creation of learning regions (Hong, 2008).

The GAPI network covers both institutions and regions as these offices have been created in all of Portugal, thereby bringing knowledge producers closer to the business world. Knowledge is no longer enclosed within innovation centers, such as universities or technology centers, and these are developing more contacts with industries. The decentralization of knowledge and closer ties with businesses has promoted university–company relations, as mentioned by the head of AIMMAP GAPI: “We have promoted ‘closer’ relationships between the academic community and national business environment and helped to increase the value of the knowledge produced in universities, technological centers, and companies. Heterogeneity, as well as GAPIs’ sector and geographic coverage, has been fundamental to the successful transfer of knowledge that has occurred”.

At a time when universities are increasingly aware of the value of their IP, its protection can be an asset and used as a resource for business activities (McConnachie, 1997; Landry et al., 2013). IP protection through patents, designs or trademarks generates unique and distinctive assets that cannot be legally imitated for a certain period of time. IPRs provide knowledge producers with the temporary opportunity to exploit the benefits of being at the forefront alone and with an incentive to invest in R&D (Blind and Thumm, 2004; Zhang et al., 2016). Thus, experts widely recognize that the knowledge production sector and especially its public component have contributed to innovative business activities and economic development in general (Cesaroni and Piccaluga, 2005).

However, patents are not the only important form of connection to industrial sectors. The links between academia and industries represent another significant form of knowledge transfer to the business world. Many companies consider this transfer to be appreciably more valuable than university patent licensing (Cohen et al., 2002). Universities’ income from academic involvement in businesses is thus generally much higher than that obtained by licensing (Perkmann et al., 2011).
The present study’s results were obtained from interviews and statistics from the various databases consulted, thereby addressing the research questions formulated. The findings include a significant increase in patent applications for the national, European and PCT paths. This is corroborated by Geuna and Nesta (2006) and Geuna and Rossi (2011), who indicated a low level of patent registrations by European countries until the beginning of the 2000s and a significant increase thereafter.

5. Conclusion

The present study sought to understand GAPIs’ importance in terms of increasing patent applications and knowledge/technology transfer in Portugal. According to the interviews and secondary data, GAPIs have revolutionized the state of IP in Portugal by increasing the volume of patent registrations and knowledge and technology transfer. The promotion and awareness of IPRs and knowledge-sharing processes have been the main drivers of patent registrations as demonstrated by the increase in contracts for technology and knowledge transfer. This IP awareness, associated with knowledge decentralization, has led to the openness of universities to companies and society. The entrepreneurial university, as a new approach of thinking, or rethinking of research and work for the exterior, has emerged with these offices. In fact, a major driver of innovation and knowledge and technology transfer has also been the new partnerships between universities and companies that have developed. While promoting the registration of patents, GAPIs also fostered a search for innovation partnerships between educational institutions and companies. The existence of IP in the form of university-owned patents has led these institutions to seek out for companies that want to acquire and take the patents to market, which has also stimulated the search for new companies that want to work with universities and vice versa. A very important result of this IP awareness policy results from the internal IP regulation, which is missing in almost all Portuguese universities. Besides the regulatory aspect, regarding IP ownership, the regulation of royalties was, as stated by some of the interviews, one of the most important aspects. Not all the universities have the same royalty distribution. However, in all of them, inventors have a percentage of it. This royalty sharing helped the transition of publication to a patent application. This also led to a change of mentality on the part of researchers, becoming entrepreneurial scientists concerned with the economic aspects of the results of their inventions.

These results expand the existing literature by showing that TTOs working in a network, especially in countries with low percentage of patent application and technology transfer, can leverage universities’ skills and role in society, allowing co-operation between academia, technology centers and business associations to be fostered. That said, this study provides empirical evidence that GAPIs/TTOs can contribute to patent registration and knowledge transfer/technology in countries with poor performance records in this area. Regarding practical/managerial implications, it is hoped that our results will allow for the emergence of new policies that contribute to universities’ entrepreneurial spirit, reducing their dependence of public funding. An example of such policies could be the distribution, for these offices, of a percentage of the royalties received, which would allow for their sustainability and financial autonomy. These policies could help countries with a low tradition in this area, such as Portugal, to be closer to countries such as the US, where there is high competition in terms of patent registration and technology/knowledge transfer.

During the process of conducting this study, some limitations were identified that need to be considered in both the interpretation of the results and future research. The first limitation is the issues associated with subjectivity. Although precautions were taken, qualitative studies like this one always include some subjectivity in the analysis of results and the interview coding system. Another limitation is that interviews with the GAPIs functionaries were conducted only once, and analyses of other relevant entities, such as
researchers or companies, would have been desirable. The last limitation is related to this study’s focus on the importance of the TTOs in only one country.

These limitations can be a starting point for future investigations. The present study should be extended to include other countries to compare TTOs’ roles in different socio-economic contexts. Another suggestion would be to study entrepreneurial universities’ impacts on regional development and their contributions to the development of innovation. Finally, further research is needed on the reasons why most patents are not transferred to companies.

References


(The Appendix follows overleaf.)
Appendix. Interview guide for GAPI officer

Institution:

Officer:

- Name:

- Age:

- Academic Qualifications and Training Area:

- Position:

- Contact:

1. When did you join the GAPI Network? How did the possibility of joining this network arise? It was initiative of your institution or by invitation of INPI?

2. Do your Institution still use the GAPI designation?

3. How many officers did your GAPI have in the beginning? And how many do you have today?

4. In terms of Intellectual Property, how did your entry in the GAPI Network manifest itself in terms of registration of patents, trademarks or design?

5. How many patents had they registered when joining the GAPI Network? And these days? Can you specify the areas? Which scientific area with the most patents?

6. In terms of technology transfer, how many technology transfer contracts do you have? And before the GAPI Network, how many?
7. Who else use your services? Companies or researchers? Can you specify the percentage between each other?

8. In addition to supporting Intellectual Property and technology transfer, do they also provide support for the formation of start-ups or spin-offs? If so, can you specify what kind of support?

9. Have you contacted members of the GAPI Network for consortium projects? And for other matters related to your activity?

10. To what extent do you consider that the GAPI Network is still active?

11. Can you briefly describe the importance of the GAPI Network for knowledge transfer at the national level?

THANK YOU FOR YOUR COLLABORATION AND TRUST

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Abstract

Purpose – Universities play a central role in scientific development and progress in societies, so, the need for supporting new businesses in universities becomes very important that science and technology park-based incubators can meet it. The purpose of this paper is to prioritize the factors influencing strategic management of university business incubators (UBIs).

Design/methodology/approach – Present research prioritizes the factors influencing strategic management of incubators using analytic network process (ANP). The authors gathered data from UBIs affiliated with science and technology park of Guilan, located in city of Rasht (Iran) using the ANP questionnaire during year 2017.

Findings – Factors influencing strategic management of incubators comprised of four main criteria and 14 sub-criteria. The criteria and sub-criteria were ranked based on their importance. Results show that “talented managers” has the highest importance for strategic management of UBIs.

Originality/value – This study offers a novel analysis and contribution to the knowledge of ranking UBIs with a multi-criteria decision-making technique. Results of this research show the relative importance of criteria and sub-criteria, which contributes to further improvement of incubator management. University managers and incubator directors can utilize the findings for better resource allocation and aligning the strategies of incubators with macro strategies of the country.

Keywords Strategic management, Analytic network process (ANP), University business incubators

1. Introduction
Today new technology-based firms contribute significantly to the economic development through jobs creation, profit making, development of new markets and facilitation of technological development (Sung et al., 2003). Start-up firms often face resource constraints, lack of relevant technical and marketing capabilities and their access to financial resources are limited (Hackett and Dilts, 2004). A business incubator (BI) is defined as shared value-added tangibles, such as office-space facility, university labs, infrastructure and financial grants (Al-Mubarak and Busler, 2017), and intangible resources such as knowledge (Gassmann and Becker, 2006) that facilitate development of new business (Caiazza, 2014) with supporting for strategic, value-added intervention system of monitoring, business assistance (Al-Mubarak and Busler, 2017) and technology venture’s development (Gassmann and Becker, 2006). The National Business Incubation Association (NBIA) defines BIs as economic development tools that provide entrepreneurs with various services that include assistance with marketing, business and management, financial services, access at a low-priced rent services, facilitate development of networks and many other services (Rubin et al., 2015).
BIs are entrepreneurship promoters (Carvalho and Vasconcelos Ribeiro Galina, 2015); they help entrepreneurs to develop their ideas, commercialize it and launch new firms (Caiazza, 2014; Lee and Osteryoung, 2004) by providing several services including financial support, physical support, administrative support, technical support (Al-Mubaraki and Busler, 2017; Caiazza, 2014), legal assistance, helping in marketing (Al-Mubaraki and Busler, 2017) and helping in development of networks with other firms (Al-Mubaraki and Busler, 2017) regionally and internationally (Caiazza, 2014). Numerous countries promote BIs programs to support local economic performance, to create employment (Al-Mubaraki and Busler, 2017; Carvalho and Vasconcelos Ribeiro Galina, 2015; Lee and Osteryoung, 2004) and to nurture high-technology industries (Lee and Osteryoung, 2004). BIs support research and development (R&D), technology transfers and regional development, provide social programs for community, provide entrepreneurship education (Carvalho and Vasconcelos Ribeiro Galina, 2015), help new start-ups to survive (Al-Mubaraki and Busler, 2017; Voisey et al., 2006), create entrepreneurial and innovative environment and create smart services and products (Al-Mubaraki and Busler, 2017).

BIs will create an effective relationship between technologies, capital and technical knowledge, and build a solid ground for firms’ growth, as well as increasing the capabilities of entrepreneurs and technological productivity (Khakbaz and Eivaz Pour, 2013; Lee and Osteryoung, 2004). BIs and their management help in creating knowledge-based institutions and firms by providing a range of supporting services (Khakbaz and Eivaz Pour, 2013). Therefore, prospective candidates for incubation should develop their market, management and financial plans to increase their chance of being selected as tenants (Ayatse et al., 2017).

Recently, the number of BIs has significantly increased. According to NBIA, the number of BIs in North America has doubled during the period 1998–2006 and there is a trend in promoting and establishing incubators in developing countries in order to assist in developing innovative and technology oriented businesses (Akçomak, 2009). In UK, Government supported entrepreneurial development by adopting policies and developing organizations at government level to achieve such purposes (Mine et al., 2005). These changes have led the researchers to investigate how BIs will capture strategic position (Vanderstraeten and Matthysssens, 2012).

The main goal of BIs is to develop start-up firms which results in innovation and development of their region (Mas-Verdú et al., 2015). Large number of universities consider BIs as organizations that may collaborate with universities to achieve less expensive resources, because universities are able to distribute resources and provide entrepreneurs with initial capital to launch their businesses (Lockett et al., 2003).

In this context, university business incubators (UBIs) are established to accelerate development of national economy via assisting start-ups, particularly new technology-based firms, in their growth and development stages (Studdard, 2006). Moreover, UBIs support research, technology transfer, scientific knowledge and entrepreneurship. They enrich experience and knowledge of entrepreneurs by providing them with education and training programs (Lee and Osteryoung, 2004) and by establishing their business networks with other entrepreneurs, managers, clients, suppliers, etc (Redondo and Camarero, 2018). Successful UBIs will achieve their goals in supporting and assisting start-ups and hence contributing in economic growth, however, not all UBIs are successful (Somsuk and Laosirihongthong, 2014). There are many factors that help BIs to succeed (Lee and Osteryoung, 2004). Prioritizing these factors will help managers and decision makers for better exploitation of resources and efforts toward the significant factors instead of devoting resources toward all factors simultaneously (Somsuk and Laosirihongthong, 2014). In addition, measuring these factors helps incubators management to effectively manage the UBIs and hence to succeed in achieving its goals. Success factors can be related to
operational policies and goal strategy (Lee and Osteryoung, 2004), human resources, financial resources (Lee and Osteryoung, 2004; Somsuk and Laosirihongthong, 2014) and technological resources (Somsuk and Laosirihongthong, 2014).

In real life, strength of preferences is usually expressed in linguistic terms and it is very difficult to measure these preferences using exact numerical values. Thus, multi-criteria decision-making (MCDM) methods are proposed to represent linguistic values by numbers (Kiani Mavi, 2014). MCDM techniques have several applications such as entrepreneurship (Kiani Mavi, Kiani Mavi and Goh, 2017; Kiani Mavi and Afshar, 2017; Nikfarjam et al., 2013), business intelligence (Kiani Mavi and Standing, 2018a) supply chain management (Tavana et al., 2016; Kiani Mavi et al., 2016; Fazli et al., 2015; Kiani Mavi, 2015) and transportation and logistics (Kiani Mavi et al., 2018, 2013; Kiani Mavi, Goh and Zarbakhshnia, 2017). There are many MCDM methods including analytic hierarchy process (AHP) and analytic network process (ANP) (Kahraman, 2008). AHP simplifies decision making by weighing attributes and specifies which attribute is more important than others by making series of pairwise comparisons among competing attributes (Khanfar et al., 2018; Kiani Mavi and Kiani Mavi, 2014). Although AHP solves problems with a uni-directional hierarchical relationship, however, it cannot solve problems with complex interrelations among decision levels and attributes because of the interaction between higher level and lower level elements in the hierarchy. To overcome this issue, ANP is used for such complex problems (Kahraman, 2008; Kiani Mavi and Standing, 2018b; Toosi and Samani, 2012). ANP is a MCDM technique that helps decision makers to make complex decisions in a systematic and structured way (Aragónes-Beltrán et al., 2014). ANP has many applications in different fields; it is implemented in project management, information technology projects selection, forest management, manufacturing, knowledge management, entertainment business, transportation, solving real-world multi-criteria high-tech selection problem, medical field, etc (Toosi and Samani, 2012).

This paper presents a decision-making approach based on ANP that may help UBIs management to understand which factors significantly impact on strategic management of UBIs. Therefore, it tries to answer the following research questions:

**RQ1.** What are the main factors influencing the strategic management of UBIs?

**RQ2.** What is the priority (ranking) of these factors using ANP technique?

The remainder of this paper is organized as follows: Section 2 reviews the literature on UBIs. Section 3 presents the research methodology. Section 4 illustrates the case study and discusses the findings. Finally, Section 5 concludes the paper.

### 2. Literature review

#### 2.1 Business incubators

The first science and technology BI was developed in the USA in 1960s (Lose and Tengeh, 2015) and then started to evolve continually (Caiazza, 2014). BIs became a phenomenon (Gassmann and Becker, 2006; Lose and Tengeh, 2015) due to their role in supporting regional development (Caiazza, 2014) and supporting new businesses and entrepreneurs (Caiazza, 2014; Voisey et al., 2006) as well as economic growth (AL-Mubaraki and Busler, 2014; Voisey et al., 2006). BIs are essential tools for entrepreneurship, business development (Lose and Tengeh, 2015), technology development and innovation policy especially in the USA and Europe (Caiazza, 2014).

It is estimated that 7,000 incubators could exist worldwide in 2014 (Evleens et al., 2017). There were more than 1,400 incubators in USA as of 2006 (Shepard, 2013) and reached to approximately 1,800 as of 2014 (AL-Mubaraki and Busler, 2014), and it reached 900 incubators in Europe as of 2014 (AL-Mubaraki and Busler, 2014).
BIs can contribute to increasing the national income by exporting new technologies to other countries (Taghvaeeyazdi et al., 2017), creating wealth (Mine et al., 2005) and improving sustainability of small business companies due to their importance for the local economy, especially for those small companies that have high failure rate and are easily affected by economic and political status of the country (Fakhari et al., 2013). All governments need to formulate effective policies related to supporting innovation and entrepreneurship and fostering incubators to improve national economic performance (Bergek and Norrman, 2008).

The principal drivers for establishing technology BIs are to provide support services in order to facilitate the formation and growth of early stage technology-based firms and to promote regional economic development (Xiao and North, 2017).

Incubators have changed their way from focusing on providing the infrastructure to providing one-on-one business advice and network facilitation by providing intangible services such as knowledge and legitimacy to support start-ups (Eveleens et al., 2017). Incubators have become an integral part of entrepreneurial ecosystem by supporting the growth of new ventures based on a broad range of measures (Hausberg and Korreck, 2018).

Wann et al. (2017) proposed eight key performance indicators for university incubators that three of them relate to initiation and operation of incubators and five factors relate to functions and services of UBIs. Evaluating the impact of technology and innovative policies on development and establishing new firms is being noted as a hot political and economic issue (Schwartz and Hornych, 2008). BIs try to compensate start-ups resource constraints and maintain their economic growth and long-term trading capability (Schwartz and Hornych, 2008).

2.2 Management of BIs

Incubator management team “constructs and frames the network and makes it available to the incubating firms,” and incubators should keep growing the network of relationships with actors and talents that can contribute to the development of incubators. Consequently, incubators have relationships with multiple actors and talents that will have differing perspectives, and thus exert an influence on incubators’ mission and operational procedures (Shih and Aaboen, 2018).

This research studies strategic management in BIs from resource-based view (RBV). Table I represents the dimensions of RBV. RBV considers internal resources of an organization as the main factor of competitive advantage and has an inside-outside viewpoint with respect to the development of competitive advantage; it assumes an organization as a set of unique resources which some of them will contribute to a sustainable competitive advantage (Erabi et al., 2009). Resources are defined as “financial resources” which refer to financial supports and debts, which may be used by start-ups. “Organizational resources” refer to capabilities of organization for formal planning or informal planning, cooperation and coordination (Barney, 1991). “Human resources” refer to characteristics and qualities of the founding team, BI and staff which their unique talents and skills are essential for achieving the goals of BIs. “Technological resources” refer to specific products of firms and physical technology (Borch et al., 1999).

Somsuk and Laosirihongthong (2014) studied the factors influencing strategic management of UBIs. They found that human resources and financial resources have the first and second priority, respectively, and technological resources placed at a least priority. With respect to sub-criteria, talented managers and access to financial resources obtained first and second ranks, respectively. Ja’fari Eskandari et al. (2014) showed that “society and processes” is the most-important criterion for knowledge-based firms. When business is considered in combination with other variables, then the business volume is a sufficient condition for start-up survival. BIs are not able to influence the start-up survival alone and the combination of BI and other factors are necessary for survival of the start-up firm (Mas-Verdú et al., 2015). Strategies with focus on supply of knowledge assets and creation of
Communicational assets are more effective than those merely focus on supply of physical infrastructure for incubates (Fernandes et al., 2017).

Technical support contributes to formation of skills and technical knowledge by ventures through interactions with management of BIs based on communication network (Scillitoe and Chakrabarti, 2010). Lasrado et al. (2016) investigated the benefits of university incubators for

<table>
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<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Definition</th>
<th>References</th>
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<tbody>
<tr>
<td>C1: human resources</td>
<td>C11: talented managers</td>
<td>Talented managers who understand and manage business incubators and develop effective plans</td>
<td>Hisrich and Smilor (1988), Somsuk and Laosirihongthong (2014)</td>
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<td></td>
<td>C12: expert organizations</td>
<td>Organizations which are skillful in using exact engineering principles, effective project management and multi-disciplinary team leadership</td>
<td>Lee and Osteryoung (2004), Schwartz and Hornych (2008)</td>
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<tr>
<td></td>
<td>C13: coaching</td>
<td>Training and workshops including seminars and free or fee-based programs</td>
<td>Peters et al. (2004)</td>
</tr>
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<td></td>
<td>C14: on-site business skills</td>
<td>On-site expertise of management, marketing, business planning and accounting</td>
<td>Hackett and Dilts (2004), Wiggins and Gibson (2003), Merrifield (1987)</td>
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<tr>
<td>C2: financial resources</td>
<td>C21: access to capital and financial resources</td>
<td>Evaluation, access to loans and grants, loan packages, access to venture capitals</td>
<td>Hackett and Dilts (2004), Wiggins and Gibson (2003), Merrifield (1987)</td>
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<tr>
<td></td>
<td>C22: financial supports and consulting</td>
<td>Providing information to clients, data analysis, providing financing recommendations along with conclusions on financing and monetary assistance</td>
<td>Lee and Osteryoung (2004), Schwartz and Hornych (2008)</td>
</tr>
<tr>
<td></td>
<td>C23: in-kind financial support</td>
<td>Secretarial and administrative support through facilities provided to start-ups</td>
<td>Hackett and Dilts (2004), Merrifield (1987)</td>
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<td>C3: technological resources</td>
<td>C31: technology/ ideas</td>
<td>Using science particularly for industrial or commercial goals. Thoughts or suggestions, particularly with respect to what can be done in a specific business situation</td>
<td>Hisrich and Smilor (1988), Somsuk and Laosirihongthong (2014)</td>
</tr>
<tr>
<td></td>
<td>C32: know-how</td>
<td>Every proprietary or confidential technique or information likely contributing to production or process of goods</td>
<td>Hisrich and Smilor (1988), Somsuk and Laosirihongthong (2014)</td>
</tr>
<tr>
<td></td>
<td>C33: infrastructure</td>
<td>Physical infrastructure including rental spaces, equipment, facilities, etc.</td>
<td>Lee and Osteryoung (2004), Peters et al. (2004)</td>
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<td></td>
<td>C43: mutual trust and respect</td>
<td>Ability to accept differences in culture, values, interests, goals and priorities and focus on problems</td>
<td>Bollingtoft and Ulhøi (2005), Sherer (2003)</td>
</tr>
<tr>
<td></td>
<td>C44: technology and R&amp;D</td>
<td>Transfer of knowledge scientific information, technology, technology-based ideas and research results</td>
<td>Lee and Osteryoung (2004)</td>
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</table>

**Table I.** Criteria and sub-criteria influencing strategic management of university business incubators from a RBV perspective

Source: Somsuk and Laosirihongthong (2014)
business enterprises and found that their performance is different from that of businesses that are not associated with university incubators. Wulung et al. (2014) investigated interactive businesses with a focus on business management and showed that business managers are able to influence business selection process as decision makers. Wonglimpiyarat (2016) conducted a research on university business strategy and innovation and found that business plan is one of the main mechanisms of innovation and supporting policies as a mediator between university and industries to facilitate the interactions. Albort-Morant and Oghazi (2016) revealed that BI services benefit experienced and educated young people. Hernández and Carrà (2016) conducted a conceptual approach to investigate BIs interdependencies and showed that coordination strategies are used by BIs to promote interdependencies and to improve relationships toward securing required resources which in turns results in providing high quality services to the clients.

2.3 BIs in Iran

Iran is a country in Southwest Asia with over 81m inhabitants comprising a land area of 1,648,195 km² (636,372 sq. mi.), and its economy mainly relies on three fields; industry: petroleum, petrochemicals, textiles, cement and other construction materials; agriculture: wheat, rice, other grains, sugar beets; dairy products; caviar; and exports: petroleum, carpets, fruits and nuts, iron and steel, chemicals (http://nationfacts.net). Although Iran has experienced progressive scientific growth during last 15 years, going forward to the knowledge-based economy has a low speed. UBIs have not gained their position in Iran's economy because of heavy reliance on crude oil export to fund 53 percent of government expenses (Entezarian, 2015). Over 3,700 knowledge-based companies are operating in Iran which have contributed about $500m to the export income and generated 200,000 jobs (www.bnn.ir). Transition to a knowledge-based economy in Iran requires UBIs to improve the productivity of established companies and enhance their competitive advantages through incremental change to efficient financial rules (Ghasemi et al., 2018).

In Iran, BIs started in 1990s (www.monitoreconomy.ir, 2018). Although Iran did not use incubators prior to the 1990s, since then it has achieved significant results and re-positioned itself as a higher growth oriented economy (www.isna.ir, 2018). Iran established its first science and technology park in 1997 (Solemani, 2012) and this remained the only incubator until 2001. Iran Government established other eight science and technology parks in 2001 and further 17 incubators in 2002. By 2006, this increased to 43 incubators suggesting positive government intend. By 2016, the number of incubators reached to 178 covering all provinces of Iran. Moreover, the number of company-based incubators grew from 676 incubators in 2006 to 3,223 incubators in 2015 (www.monitoreconomy.ir, 2018). As a result, the income of utilizing those incubators reached to $280m (www.isna.ir, 2018). However, this number can further improve by utilizing young and educated people in the country who have the best potential to become entrepreneurs. In Iran, BIs contribute to national economic development and encourage industry innovation. Indeed, incubators can adopt and support new ideas (Mine et al., 2005) that can turn into new technology-based firms (Lee and Osteryoung, 2004) which can enhance the local industry and market (Al-Mubaraki and Busler, 2017) as well as contribute in lowering the percentage of unemployment (Mine et al., 2005).

This research aims to identify and prioritize the factors influencing strategic management of BIs located in city of Rasht (Iran) using ANP. This study can help UBIs management to understand the importance of different factors on strategic management of UBIs.

3. Research methodology

This research aims to prioritize the factors influencing strategic management of UBIs using ANP. We gathered data from UBIs affiliated with science and technology park of Guilan, located in city of Rasht (Iran) in 2017. The Science and Technology Park of Guilan started its operations in city.
of Rasht in September 2002; its purpose was to convert scholars’, graduates’ and innovators’ technological ideas into business outcomes. The Guilan technology-based incubators started their operations in 2003 to prepare an appropriate ground for practitioners’ activities, jobs creation and exploitation of existing opportunities related to information and communications technology, and since 2005, continued their activities with a focus on recruiting people with technological ideas in other technical fields including electronics, management and planning, tourism, agriculture and rural development, agricultural complementary industries and medicinal herbs.

The questionnaire consists of pairwise comparisons of the factors with possible nine options from “1: Equally Important” to “9: Extremely Important” and vice versa (Aragonés-Beltrán et al., 2014; Toosi and Samani, 2012). If the inconsistency ratio of a pairwise comparison matrix is below 0.1, then its resulting priority weights are valid and reliable (Azar and Rajab Zadeh, 2010). Respondents are expert in the field and have full knowledge in BIs. Since MCDM methods rely on experts’ judgment, thus they do not need many respondents to complete the questionnaire. Scholars have used small number of experts to implement ANP method for example 3 experts (Quezada et al., 2018), 5 experts (Gómez-Navarro et al., 2009), 6 experts (Sadeghi and Larimian, 2018), 11 experts (Ming-Lang et al., 2009), 13 experts (Chou, 2018) and 15 experts (Tseng et al., 2018). In total, 15 experts were identified by snowball sampling and participated in this study. All participants held master’s degree and above, ten years and more working experience at incubators, and full familiarity with BIs.

Various industries are using AHP to address multi-criteria decision-making problems (Saaty, 1980). Many decision-making problems, however, cannot be organized as a hierarchy and should be considered as a network because they involve interdependences and interactions between elements at different levels. Hierarchies have a linear structure but networks extend in all directions and consist of loops between and within clusters (Saaty, 2001). One method to conduct calculations in ANP is that the weights obtained from pairwise comparisons are set in a matrix called supermatrix. In order to understand the concept of supermatrix, assume that the problem has K clusters $C_1, C_2, \ldots, C_K$ and there are $n_i$ elements $e_{i,1}, e_{i,2}, \ldots, e_{i,n_i}$ ($i = 1, 2, \ldots, K$) in the ith cluster. If two clusters $i$ and $j$ are chosen and all elements of cluster $i$ are compared in a pairwise manner with respect to the first element of cluster $j$, then, the resulting eigenvector will be $w_{j,i}^{1}$ which shows the priority weights of $e_{i,1}, e_{i,2}, \ldots, e_{i,n_i}$ in regards to $e_{j,1}$ (the sum of weights will be one). If the pairwise comparison is not significant, the eigenvector is zero (Saaty, 2008):

$$w_{j,i}^{1} = \begin{bmatrix} w_{j,i,1}^{1} \\ w_{j,i,2}^{1} \\ \vdots \\ w_{j,i,n_i}^{1} \end{bmatrix}.$$  \hspace{1cm} (1)

When all elements of cluster $i$ are compared against all elements of cluster $j$ in a pairwise manner, matrix $W_i$ is obtained as (2) which will be a block in the initial supermatrix. In this matrix, the $n_j$th column vector is the local priority vector shows the influence degree or weight of all elements in cluster $i$ on the element $e_{j,n_i}$ from cluster $j$. Therefore, each column of $W_i$ sums to 1:

$$W_i = \begin{bmatrix} w_{i,1,1}^{1} & w_{i,1,2}^{1} & \cdots & w_{i,1,n_j}^{1} \\ w_{i,2,1}^{1} & w_{i,2,2}^{1} & \cdots & w_{i,2,n_j}^{1} \\ \vdots & \vdots & \ddots & \vdots \\ w_{i,n_i,1}^{1} & w_{i,n_i,2}^{1} & \cdots & w_{i,n_i,n_j}^{1} \end{bmatrix}.$$

$$W_j = \begin{bmatrix} w_{j,1,1}^{1} & w_{j,1,2}^{1} & \cdots & w_{j,1,n_i}^{1} \\ w_{j,2,1}^{1} & w_{j,2,2}^{1} & \cdots & w_{j,2,n_i}^{1} \\ \vdots & \vdots & \ddots & \vdots \\ w_{j,n_j,1}^{1} & w_{j,n_j,2}^{1} & \cdots & w_{j,n_j,n_i}^{1} \end{bmatrix}.$$  \hspace{1cm} (2)
If the above matrix is obtained for all clusters, those results altogether represent the initial supermatrix as (3). Supermatrix is a matrix resulted from the relations between network components and is obtained from eigenvectors of these relations:

\[
\begin{bmatrix}
  e_{1,1} & e_{1,2} & \ldots & e_{1,n_1} \\
  e_{2,1} & e_{2,2} & \ldots & e_{2,n_2} \\
  \vdots & \vdots & \ddots & \vdots \\
  e_{K,1} & e_{K,2} & \ldots & e_{K,n_K}
\end{bmatrix}
\]

\[
\begin{bmatrix}
  W_{11} & W_{12} & \ldots & W_{1K} \\
  W_{21} & W_{22} & \ldots & W_{2K} \\
  \vdots & \vdots & \ddots & \vdots \\
  W_{K1} & W_{K2} & \ldots & W_{KK}
\end{bmatrix}
\]  

* (3)

Unweighted supermatrix can include the priority weights of main criteria and priority weight vectors of alternatives in terms of sub-criteria. After formation of initial supermatrix, i.e., unweighted supermatrix, its columns are normalized to achieve the weighted or normalized supermatrix. To do so, all elements at each column of initial supermatrix are divided by the sum of the priority weights of that column, respectively. Saaty (2008) used probability matrices and Markov chains and proved that final weight of elements is obtained as follows:

\[
W = \lim_{n \to \infty} w^{2n+1},
\]

where \( n \) is a natural number. After solving the above relation, final or limit supermatrix is obtained in which all numbers in a row are the same and show the weight of the criterion related to that row (Saaty, 2006).

To construct the network of criteria and sub-criteria, decision tree of this research is depicted in Figure 1.

4. Case study

To do network analysis in ANP, at first, main criteria are compared in a pairwise manner. For this end, geometric average of each element is calculated to construct the aggregated pairwise decision matrix from which weight vector is obtained. Following AHP weighting procedure (Singh and Nachtnebel, 2016), the weight vector for the main criteria is \((0.654, 0.096, 0.204, 0.046)^T\) with inconsistency ratio of 0.061. In the second step of ANP technique, sub-criteria related to each criterion are compared in a pairwise manner. There are four criteria and each one has its own sub-criteria. Each pairwise comparison is done separately for each cluster. All weight vectors are included in the initial unweighted supermatrix based on the objective and internal relations between criteria. Each block of the unweighted supermatrix represents the relationship between two clusters in a system. Unweighted supermatrix is converted to weighted (normalized) one using normalization concept. In weighted supermatrix, the sum of elements at each column equals 1. Table II shows the unweighted supermatrix and Table III presents the weighted supermatrix.
The next step is to calculate the limit supermatrix. It is resulted from raising the weighted supermatrix to powers. This process is repeated until all elements of each row in the supermatrix converge to the same value. Table IV shows the limit supermatrix which has been achieved at power 17.

According to Table V, experts considered “human resources” as the most-important factor for strategic management of BIs. “Technological resources” and “financial resources” obtained second and third ranks, respectively. “Organizational resources” obtained the lowest rank. Among sub-criteria, “talented managers” obtained the first rank from among 14 sub-criteria implying high importance of this sub-criterion among others. Sub-criteria of “access to capital and financial resources” and “technology and ideas” obtained the second and third ranks, respectively. Complete ranking of sub-criteria is shown in Table V. High importance of “financial resources” resulted in high priority of the two sub-criteria of “access to capital and financial resources” and “financial support and consulting” for UBI management. In contrast, low importance of “organizational resources” resulted in low priority of the two sub-criteria of “program milestones with clear policies and procedures” and “technology transfer and R&D.”

4.1 Discussion
UBIs provide variety of services that assist entrepreneurs and development of new firms (Lee and Osteryoung, 2004), and provide activities that contribute in job creation (Stokan et al., 2015) and economic development. Those activities include transferring technology and scientific knowledge, fostering entrepreneurship and marketing research (Redondo and Camarero, 2018).
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|----------|----|-------|----|--------|---------|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|
| C2 | 0.096 | 0.254 | 0 | 0.214286 | 0.129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C3 | 0.204 | 0.1895 | 0.129 | 0 | 0.0525 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C4 | 0.046 | 0.0665 | 0.0625 | 0.071429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

<p>| Sub-criteria | C11 | 0 | 0.329329 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|--------------|-----|----|----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| C12 | 0 | 0.044545 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C13 | 0 | 0.076076 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C14 | 0 | 0.05005 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C21 | 0 | 0 | 0.297 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C22 | 0 | 0 | 0.1245 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| C23 | 0 | 0 | 0.0785 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| C31 | 0 | 0 | 0 | 0.3655 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| C32 | 0 | 0 | 0 | 0.084 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| C33 | 0 | 0 | 0 | 0 | 0.0405 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| C41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| C42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| C43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
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Table IV. Limited supermatrix

Strategic management of university business
Main factors influencing the strategic management of UBIs. There are many factors that influence the management of BIs. Adopting RBV, this research focused on four criteria of “human resources,” “financial resources,” “technological resources” and “organizational resources” with 14 sub-criteria as are listed in Table I.

**Priority and ranking of factors using ANP technique.** Results highlight that “human resources” is the most-important criterion; indeed, the main objective of establishing BIs is to adopt entrepreneurs with their innovative ideas in which there would be no incubator without existence of these entrepreneurs (Franco et al., 2018). Moreover, the ranking of sub-criteria is consistent with this result where the first ranked sub-criterion is “talented managers”; the managers who are managing these incubators effectively and developing effective plans (Somsuk and Laosirihongthong, 2014; Hisrich and Smilor, 1988). The more the managers’ experience in business field, the more assistance to business that generates value-added activities in incubators, therefore, more assistance to managers who lack entrepreneurial characteristics which impair access of incubators to other business networks (Redondo and Camarero, 2017). Some managers have experienced the war and sanction periods, and have led their organizations under those unfavorable situations. In addition, outstanding academics are guiding students in management fields, thus there is no deficiency in management resources in Iranian context. With respect to this fact, it is clear why the sub-criterion “talented managers” obtained the first rank in this study.

Results show that the second ranked criterion is “technological resources,” and third sub-criterion is “technology and ideas,” which supports the importance of new technological ideas in influencing management of UBIs. Original technological ideas significantly contribute to enhancing markets and industries as well as reducing unemployment (Taghvaeeyazdi et al., 2017). Similarly, “financial resources” criterion has third place, so, “access to capital and financial resources” and “financial support and consulting” sub-criteria are ranked second and fourth, respectively. This result suggests that accessing financial resources such as loans and grants is very important factor on managing UBIs as well as providing financial consultations due to its strategic role in supporting new firms and incubators. Iran owns great mineral and underground resources and can be counted as a wealthy country regarding financial resources. In addition, Iran has young population with higher education in various fields and high technical capabilities, thus it has no
deficiency in the field of human resources. With respect to USA and EU led sanctions (e.g. banking sanctions) against Iran, commercial and monetary transactions with other countries have become more difficult. Moreover, Iranian organizations have been put in a non-competitive position because of the lack of technological resources due to obstacles on importing new technologies to the country as a result of these sanctions. Therefore, the criterion of “technological resources” obtained second rank in this study. As mentioned above, sanctions caused difficulties for Iran to acquire new technologies and this issue causes the inability to import and employ latest technologies from developed countries. Even due to sanctions, R&D collaboration between Iranian organizations and their counterparts in Europe and US is not in a desirable situation, thus it is not surprising that this situation caused many problems for Iranian organizations, that is why “technology transfer and R&D” obtained the lowest rank in this study.

5. Conclusion

Universities are the major centers for generating science and innovation that can be exploited and commercialized in the market. Therefore, universities have a close relationship with BIs. In this research, we used ANP to analyze and rank factors influencing strategic management of UBIs. The results show that “human resources” is the most-important factor followed by technological, financial and organizational resources. Talented managers and employees are the backbone of all organizations and particularly incubators. Businesses compete to acquire the highly competent people to run the business, and for growth and competitive advantage. A talented manager supports the incubator for entrepreneurial development and further innovation by establishing strong links among members of Triple Helix system (government, academia and industry). The results of this study might partially fill the gap in the development policy of UBIs in developing countries by clarifying more important factors and devoting higher attention to them. Prioritizing criteria and sub-criteria will help managers to understand and be familiar with the degree of influence of these factors, which in turn will facilitate decision making about related strategies, improve their position in the workplace and external environment and improve their performance in BIs. UBI managers know that they are able to improve the role of universities in scientific progress of their countries and its direction toward self-sufficiency. Since human judgments always involve uncertainty, future studies can employ fuzzy sets theory to analyze the interrelations among criteria with fuzzy decision-making trial and evaluation laboratory (fuzzy DEMATEL) and fuzzy ANP to rank the criteria and sub-criteria.

References


Further reading


**Appendix. Weblinks**

www.monitoreconomy.ir

www.isna.ir

www.bmn.ir/fa-IR/News/News/76650

http://nationfacts.net/iran-facts

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