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Implementing strategic changes in universities' knowledge exchange profiles: The role and nature of managerial interventions

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ABSTRACT

In a context of increasing managerialization of higher education and growing importance of the so-called 'third mission', universities increasingly seek to align their knowledge exchange (KE) profiles—i.e., the KE channels they use and the stakeholders with which they interact—to their institutional objectives. Using the lens of management control systems theory, we mapped changes in KE profiles to different management interventions. Building on 12 case studies of UK universities and combining content analysis and qualitative comparative analysis, we found that a) universities that had diversified their KE profiles had implemented belief and interactive control system interventions to encourage all staff members to exploit a wide range of KE opportunities; b) universities that had increased their KE specialization had implemented boundary and diagnostic control system interventions targeted at staff members performing specific KE activities; and c) universities that had reoriented their KE profiles had used a mix of interventions.

1. Introduction

The exchange of knowledge with external stakeholders has developed into a 'third mission' for universities, one central to their activities as their traditional involvement in teaching and research (Etzkowitz, 2004; Gunasekara, 2006). Understanding the nature, drivers, outcomes, and impact of knowledge exchange (KE), has taken on increasing importance for policymakers, practitioners, and researchers alike (Etzkowitz, 1998; OECD, 2007; Guerrero and Urbano, 2012).

Several studies have looked at universities' overall profiles of engagement in KE and at the factors that support such profiles (Hewitt-Dundas, 2012; Sánchez-Barrioluengo et al., 2019; de la Torre et al., 2018). These papers are positioned within a broader stream of literature—located at the intersection between higher education and innovation studies—which focusses on profiling university institutions in the context of the overall higher education system according to their engagement in research, teaching, and KE (see, e.g., Bonaccorsi and Daraio, 2008; Sánchez-Barrioluengo, 2014; Lepori, 2021). Here, it has been noted that universities have very different profiles of KE engagement, both in relation to the channels they use and to the stakeholders with which they engage (Hewitt-Dundas, 2012; Sánchez-Barrioluengo et al., 2019; de la Torre et al., 2018). KE profiles tend to be aligned to universities' organizational goals and objectives (Buckland 2009, Lepori et al., 2014), and to their resources—both tangible ones, including infrastructures, staff, research and active personnel, and intangible ones such as research orientation, subject specialization, entrepreneurial culture, and KE management competencies (Siegel et al., 2007; Hewitt-Dundas, 2012; Coates Ulrichsen, 2014).

Furthermore, universities have been found to modify their KE profiles over time in response to contextual conditions, particularly to changes in policy frameworks and in business and stakeholder demand for KE, and to increased competition with other universities. Changes in KE profiles have been linked to several university-level characteristics such as research intensity, size, and reputation (Hewitt-Dundas, 2012; Sánchez-Barrioluengo et al., 2019; Sengupta and Rossi, 2020).

In the context of the progressive managerialization of higher education (Teixeira and Koryakina, 2013) and of the greater strategic importance of KE as a mission, universities are likely to make strategic choices in relation to the KE activities in which they should engage, and to the stakeholders they should target to achieve their institutional objectives—including income growth, reputation, prestige, and visibility (Sánchez-Barrioluengo, 2014; Lockett et al., 2015; Siegel and Wright,

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2015; Sengupta and Ray, 2017, Miotto et al., 2020). Yet, limited conceptual and empirical research has been conducted on how universities change their KE activities strategically to achieve their institutional objectives (Buckland 2009; Siegel et al., 2003; Hewitt-Dundas, 2012) and on the kinds of managerial interventions through which such strategic changes are enacted.

The roles played by organizational and managerial factors in shaping universities' engagement with external stakeholders have been investigated in the context of a different stream of literature focussed on the development of the 'entrepreneurial university' (Clark, 1998; Etzkowitz et al., 2000). Such investigations emphasize the variety of internal and external factors affecting universities' entrepreneurial activities (Guerrero and Urbano, 2012; Centobelli et al., 2015). In particular, some looked at the role played by university management in shaping structures and processes, and in developing the strategic vision that governs organizational evolution (Navarro and Gallardo, 2003; Gibb and Hannon, 2006; and Vorley and Nelles, 2009). However, the focus of these studies is usually not limited to universities' KE engagement, and to the development of KE profiles in particular; rather, they focus on how universities' entrepreneurial engagement can be embedded across all of their missions (Vorley and Nelles, 2009; Guerrero and Urbano, 2012).

Our study addresses this twofold research gap by focussing on the kinds of management interventions associated with certain observed KE profile changes. To develop a conceptual framework suited to explain such associations, we drew on studies on the ways in which management interventions can be used to enact strategy (Langfield-Smith, 1997; Marginson, 2002; Kober et al., 2007), and, in particular, on levers of control (LOC) theory (Simons, 1994, 1995). Building on this theory and its subsequent developments, we argued that different types of management control systems are best suited to support different types of KE profile changes—namely, diversification and specialization. We then validated this framework by means of a mixed method quantitative–qualitative investigation.

Our empirical analysis involved two steps. First, we identified those universities that had exhibited relevant KE profile changes by analysing any dynamic changes in the relevant variables in a panel dataset encompassing most UK universities[2]. In this respect, another element of originality of our study is that we conceptualized and measured KE profiles and their changes in terms not only of the KE channels in which universities engage—as it is the case for most of the literature on university KE—but also of the stakeholders with which they interact; a much less investigated dimension of KE engagement (Rossi et al., 2017; de la Torre et al., 2018). Second, we focussed on 12 cases of universities that were representative of each change pattern, and investigated them through in-depth qualitative interviews and the analysis of publicly available KE strategy documents. The associations between management interventions and KE profile changes were scrutinised by means of thematic content and qualitative comparative (QCA) analyses.

Our findings confirm that different types of management interventions are relevant to different types of changes to be enacted in KE profiles. Those universities that diversify their KE profiles emphasize belief and interactive control system interventions that encourage staff to identify and exploit a wide range of KE opportunities in order to enable the emergence of new KE channels and stakeholders. Conversely, those that adopt more specialized KE profiles emphasize boundary and diagnostic control system interventions that enable already successful researchers to further improve their performance by building on the university's internal competitive strengths. We also empirically identified a third intermediate profile—which we called KE reorientation—that involves switching the focus of the university from certain KE channels and stakeholders to others. Through this analysis, we were able to generate a novel conceptual framework suited to explain the enactment of strategic change in relation to KE engagement.

By analysing how managerial interventions affect changes in universities' overall KE profiles, we addressed a hitherto under-researched dimension in the literature on universities' engagement in KE. We show that management control systems theory is a conceptual tool useful to understand the enactment of strategic change in relation to KE engagement. This opens up opportunities for further research into universities' KE engagement from a strategic perspective. We also contribute to the literature on entrepreneurial universities by digging deeper into one of the internal factors that support KE engagement—management control systems—that had hitherto been investigated to a lesser extent than the organizational and governance ones. As our findings shed light on the management interventions that universities may need to implement in order to adapt their KE strategies to changing external conditions—many of which are policy driven—they should be useful to policymakers and to university managers responsible for KE.

Several reasons made the UK an appropriate setting for the study of the management approaches underpinning strategic KE profile changes. One was the availability of detailed KE data made possible by the country having one of the world's most extensive systems aimed at collecting information about universities' KE activities (Rossi and Rosli, 2015). Furthermore, the UK has a large and very varied (mostly public) university system, with various institutions differing widely in terms of age, history, prestige, subject specialization, and orientation to research or teaching (Coates Ulrichsen, 2014; Rossi and Athreye, 2021). Combined with intense policy pressure for universities to engage in KE (Lockett et al., 2015), this has resulted in a wide variety of approaches to KE and a professionalized and strategic approach to KE management.

This paper is organized as follows. In section 2, we review the literature on universities' KE profiles and their changes over time. Also, building on arguments drawn from management control system theories, we discuss how different KE profile change patterns could be supported by different types of management interventions. In section 3, we describe our data and our methodology. In section 4, we present the results of our empirical analysis, and we discuss how they are aligned with our conceptual framework. In section 5, we conclude by discussing our study's implications for theory, policy, and management, followed by possible directions for further research.

2. Enacting changes in KE profiles: A conceptual framework

2.1. The diversification and specialization of KE profiles

Evidence from several countries—including Spain, Canada, and the UK—shows that universities engage in a variety of KE channels (D'Este and Patel, 2007; Wright et al., 2008), and that there are large variations in the mixes of channels they use (Sánchez-Barrioluengo, Uyarra, & Kitagawa, 2019; Hewitt-Dundas, 2012) and of the stakeholders they target (De La Torre et al., 2018). Research intensity and subject mix play an important role in driving this differentiation. Those universities that specialize in science, engineering, and medical subjects are more likely to exploit intellectual property and perform research contracts for industry (Hewitt-Dundas, 2012), while those that specialize in the arts, humanities, and social sciences tend to focus on consultancies, executive education, and regeneration programmes (Hewitt-Dundas, 2012; Olmos-Peñuela, Molas-Gallart, & Castro-Martínez, 2014). The former interact mainly with industry partners, while the latter engage mostly with public bodies, non-profit organizations, and other community groups (Benneworth and Jongbloed, 2010; Hewitt-Dundas, 2012). Research-intensive universities collaborate frequently with stakeholders outside their regions, while more teaching-oriented ones focus on providing skills and knowledge to their local communities (Jones and Craven, 2001; Schoen, Laredo, Bellon, & Sanchez, 2007; Wright et al., 2008; Meagher et al., 2008; Huggins, Johnston, & Stride, 2012).

Universities are increasingly confronted with market-type incentives

[2] These is a set of 150 universities that submits information to the national Higher Education Statistics Agency (HESA).

(Casani et al., 2014) that push them towards seeking market niches in which they can enjoy some competitive advantage (Antonelli, 2008; Berbegal-Mirabent et al., 2013). This leads them to develop individual KE profiles as they try to maximize the strategic fit between their institutional resources (subject mix, research, and teaching intensity and quality) and the opportunities that are present in their socioeconomic contexts (Siegel et al., 2003; Bekkers and Bodas Freitas, 2008; Rossi, 2010; Hewitt-Dundas, 2012; Berbegal-Mirabent et al., 2015; Kitagawa et al., 2016; Kehm and Stensaker 2009). A few studies have adopted a longitudinal approach, identifying different patterns in the evolution of KE profiles (Sánchez-Barrioluengo et al., 2019; Sengupta & Rossi, 2022). These have found that some universities use a narrower range of KE channels, or interact with a narrower range of stakeholders, while others move towards greater diversification, embracing a broader range of KE channels and/or stakeholders. By analysing UK universities over a period of nine years, Sánchez Barrioluengo et al. (2019) showed that relatively older, research-intensive universities increasingly specialize in research-oriented KE channels (such as contracts and collaborations), typically in partnership with large firms and non-commercial organisations, while younger, less research-intensive universities tend to expand their range of activities, thus reducing their specialisation.

By also focussing on the UK and using an eight-year panel dataset, Sengupta and Rossi (2022) found that universities experiencing increases in their shares of KE income tend to adopt more specialized KE profiles (i.e., they focus on narrower ranges of KE activities and stakeholders), while those undergoing increases in their shares of basic research income tend to adopt more diversified KE profiles. The evidence therefore suggests that universities undergo processes of KE profile diversification and specialization, and that, at least to some extent, such processes respond to changes in the universities' financial and intellectual resources.

However, this literature has hitherto not considered how changes in universities' KE profiles could be the outcome of strategic choices, and what kind of managerial interventions may be associated with the enactment of specific changes.

The literature on entrepreneurial universities has shed some light on the internal factors affecting the development of entrepreneurial processes and practices across such institutions, including the role played by university management. In their model—one of the more comprehensive ones of the development of the entrepreneurial university—Urbano and Guerrero (2012) pointed to the importance of a formal entrepreneurial organizational and governance structure, informal factors (e.g., attitudes towards entrepreneurship, entrepreneurial teaching methodologies, role models, and reward systems), resources (human, financial, and physical), and capabilities (status and prestige, networks and alliances, and localization). Pinheiro and Stensaker (2014) emphasized the role played by organizational structure, including the allocation of decision-making responsibilities. Vorley and Nelles (2009) argued that university leadership and management play a crucial role in embedding entrepreneurial activities in the context of all of the universities' missions. From the corporate entrepreneurship literature (Burns, 2005), they borrowed the concept of entrepreneurial architecture—defined as "*the institutional, communicative, coordinating and cultural elements of an organization oriented towards innovation*" (Vorley and Nelles, 2008, p. 289). Vorley and Nelles (2009) argued that, to successfully adapt to the third mission, a university needs an entrepreneurial architecture comprising five interrelated elements: structures, systems, strategies, leadership, and culture (Burns, 2005). The organizational structures supporting KE need to be "*embedded in coordinated systems, acting in concert with visionary leaders, as agents of a coherent entrepreneurial strategy, and within an environment that supports and sustains innovation*" (Vorley and Nelles, 2008, p. 289).

While this approach clearly emphasizes the role played by leadership and management in establishing institutional visions and strategies and in developing structures and systems, it does not delve into specific management interventions, nor it is focussed specifically on KE activities, but rather on how the third mission can be embedded in the context of the other two.

Hence, our study makes an original contribution to the debate by focussing on management interventions and on how these affect the enactment of different KE strategies. The question we address conceptually in the next section is the following: given that universities may decide to change their KE profiles in the direction of greater diversification or, alternatively, greater specialization, which management control systems interventions would we expect them to implement in order to enact these different changes?

2.2. Management control systems and the diversification and specialization of KE profiles

As an integral part of a typical university's strategy, KE evolves, together with the rest of the organization, as the external environment changes. Thus, universities initiate structural changes to their KE function by adopting alternative business models (Ambos et al., 2008; Sengupta and Ray, 2017), while, at the same time, putting in place support systems and incentives for administrative and academic staff to increase KE engagement (Agrawal, 2006; Ambos et al., 2008; Markman et al., 2009; Galán-Muros and Plewa, 2016; Gao and Haworth, 2016).

In order to conceptualize the management interventions that underpin different KE profile change patterns, we focussed on the use of management control systems within the organization. Such systems are the mechanisms through which organizations seek to cope with the problem of "*obtaining cooperation among a collection of individuals or units who share only partially congruent objectives*" (Ouchi, 1979, p. 833). As this problem has been widely studied in management theory, numerous frameworks have been proposed to characterize the various mechanisms that organizations have developed to this end—from Ouchi's early framework (1979), which provides a high level distinction between 'market', 'bureaucracy', and 'clan', to more recent efforts to delve into the mechanisms used by organizations to ensure that their internal systems consistently support the achievement of organizational objectives (Flamholtz et al., 1985, Langfield-Smith, 1997; Malmi and Brown, 2008; Ferreira & Otley, 2009; Merchant and Van der Stede, 2011). The literature has found that management control systems both inform and support the enactment of strategies (Henri, 2006; Marginson, 2002; Mundy, 2010; Otley, 1999; Simons, 2000). To provide coherent support for strategy, the different control systems need to be used as a package (Kimura and Mourdoukourtas, 2000) and management needs to have a comprehensive view of their nature and their integrated functioning (Gond et al., 2012).

Among the various management control system frameworks proposed over time, the influential 'levers of control' (LOC) one proposed by Simons (1994, 1995) is particularly appropriate to investigate the management interventions underpinning university strategies. Its appropriateness is due to several reasons. To start, it combines a high degree of generalizability with relative ease of operationalization (Gond et al., 2012). Then, as management control systems are grouped according to the organizational objectives they address— rather than to the organizational functions they support—this framework is suitable for application to a broad range of organizational settings (Martyn et al., 2016), including universities. In fact, Simons' framework has been widely used to study strategy formation and its general impact on management (Marginson, 2002), and has also been utilised in research contexts, such as to study how organizations achieve ambidexterity in their explorative and exploitative activities (Gschwantner & Hiebl, 2016; McCarthy and Gordon, 2011). In the context of higher education, it has been used in the analysis of performance management (Guenther and Schmidt, 2015; Pilonato and Monfardini, 2020), quality assurance systems (Daromes and Ng, 2015), research management (Agyemang and Broadbent, 2015), research motivations (Sutton and Brown, 2016), and the relationship between structural autonomy and performance (Heinicke and Guenther, 2019). To date, the LOC framework has not been

used as a theoretical lens to examine KE, although there is ample evidence to indicate that the management of KE is part of the key strategic initiatives enacted by most universities (Lockett et al., 2015; Sengupta and Ray, 2017; Siegel and Wright, 2015).

Simons (1994, 1995) identified four control systems, each targeted to different organizational blocks that prevent change, and for each of which appropriate managerial solutions can be devised. *Belief control systems* inspire employees to engage in activities central to the values, purposes, and directions of an organization. The interventions enacted in this domain are designed to communicate an organization's core value and mission, to garner the support of all employees for an organization's desired activities and outcomes. *Interactive control systems* scan for and communicate strategic information to employees, so as to adjust the direction of the organization. Interventions are aimed at opening up organizational dialogue to encourage learning, in order to enable new activities and outcomes. *Boundary control systems* aim to limit strategically undesirable activities and outcomes. Interventions specify and enforce the rules of the game, thus supporting the achievement of the desired activities and outcomes, and deterring from the pursuit of undesirable ones. *Diagnostic control systems* measure activities to ensure they are in accordance with organizational objectives. Interventions build and support clear targets, in order to focus organizational resources on their achievement. Considering the whole set of control systems together, rather than each individually, generates a more complete understanding of the set of levers management has at its disposal to trigger organizational change (McCarthy and Gordon, 2011).

We argue that LOC theory can help us to conceptualize the types of management control system interventions likely to be implemented by those universities that pursue the diversification or specialization of their KE profiles. We expect universities that pursue a diversification strategy to implement interventions that encourage staff at all levels to explore new opportunities and to act upon them. When everyone's effort is required in order to diversify the range of KE opportunities to be pursued, it might be important to implement belief control system interventions designed to align the objectives of all staff with the organization's overall strategy. Interactive control system interventions may also support KE diversification, as they aim to open up organizational dialogue to encourage learning—for example, by providing incentives for staff to identify opportunities to engage in new KE channels and with new stakeholders, and for the organization to learn from the experience of others. Belief and interactive control system interventions, together, have been found to enhance exploratory activities (McCarthy and Gordon, 2011) and to empower organizational actors (Simons, 2000). Widener (2007) found that interactive control is used to scan the external environment, which helps in the pursuit of diversification opportunities. Hence, we expect universities pursuing a diversification strategy to particularly emphasize belief and interactive control system interventions.

KE specialization requires universities to focus on specific KE channels and stakeholders, rather than searching in different directions. When a university wishes to achieve a clearly specified objective, enforcing the rules of the game is particularly important. Hence, boundary control system interventions (such as support systems designed to promote engagement in specific KE activities and with specific stakeholders) and diagnostic control system interventions (such as identifying clear targets and measuring their achievement), could be particularly important to foster KE specialization. Boundary and diagnostic control system interventions, together, have been found to enhance exploitation activities (McCarthy and Gordon, 2011) and to constrain and ensure compliance with rules (Simons, 2000). Hence, we expect universities pursuing a specialization strategy to particularly emphasize boundary and diagnostic control system interventions.

Table 1 summarizes our conceptual framework linking different types of management interventions—each typical of a certain control system—to the patterns of change in KE profiles that are most likely to be supported by these interventions.

Table 1
Management interventions supporting changes in KE profiles.

Control system	Possible interventions	Relevant pattern of change in KE profile
Beliefs systems – communicate core value and mission – to get people to contribute	Definition of strategies, communication of mission	KE diversification
Interactive control systems – open organizational dialogue to encourage learning - to get people to see and grasp opportunities	Definition of incentives, promotion of organizational learning	KE diversification
Boundary systems – specify and enforce rules of the game – to get people to do the right thing	Provision of targeted support activities	KE specialization
Diagnostic control systems - – build and support clear targets – to get people to achieve	Setting of performance targets, benchmarking	KE specialization

3. Data and methodology

We adopted a multiple case study research design (Yin, 2009), and took a mixed method approach to data analysis. In the first stage, described in section 3.1 (and Appendix 1), relying on information from an eight-year panel dataset (covering the academic years 2008–09 to 2015–16) of 150 universities based in the UK, we identified an appropriate sample (Eisenhardt and Graebner, 2007; Gibbert et al., 2008) of universities that had undergone different patterns of changes in their KE profiles. In the second stage of the data collection, described in section 3.2, we selected, from the sample thus constructed, a set of 34 universities that had displayed one of the three change patterns identified in their KE profiles—diversification, specialization, or reorientation. We searched the websites of these 34 universities in order to identify the person or team responsible for KE, and we contacted them to request an interview. We received positive responses from KE managers at 12 of these universities, whom we thus interviewed in order to understand the management approaches underpinning KE at their respective institutions. Subsequently, through a combination of thematic content analysis and qualitative comparative analysis, we scrutinised the evidence collected from the interviews, together with additional secondary evidence about these universities' KE strategies. The methods used for the data analysis are described in section 3.3.

3.1. Sample selection based on changes in KE profiles

To identify our list of 34 UK universities that had exhibited remarkably dynamic KE profiles, we utilized a 'purposeful sampling' method. All these universities had displayed significantly large changes in the composition of their KE profiles in terms of their internal diversification and of their differentiation from the others in their group. The process by which we carried out our purposeful sampling is described in detail in Appendix 1.

For these 34 universities, we analysed the patterns of diversification and differentiation of income from different KE channels and from different stakeholders. The data revealed that, in our sample, universities' changes in KE profiles had followed *three* possible patterns: (i) KE profile diversification (14 universities), indicating those universities that, despite initially having been relatively more specialized in using certain KE channels and/or in engaging with certain stakeholders, had over time diversified their range in regard to one or both, leading to a more balanced KE portfolio; (ii) KE profile specialization (14 universities), indicating those universities that, having started out with a more diversified portfolio, had over time become increasingly specialized in certain KE channels and/or in engaging with certain KE stakeholders; (iii) an additional pattern, KE profile reorientation (six universities),

which indicated those universities that had changed the mix of KE channels in which they engaged, or the mix of KE stakeholders with whom they worked, without substantially changing their overall degree of specialization or diversification. Based on the literature on KE we had not anticipated this latter type of KE profile change; however, as it was found to be empirically significant, we included the universities that had undergone KE profile reorientation in our empirical analysis.

Table 2 summarizes the distribution of our 34 sample universities by size (we defined them as large, medium, small based on the corresponding thirds of the income distribution) and by KE change pattern.

3.2. Data collection: Case studies drawn from the three patterns of KE profile change

We contacted the KE teams of the 34 universities that formed the sample for our analysis. Of these, 12 agreed to be interviewed by us. These 12 universities were distributed across the three size groups (five large, five mid-sized, and two small) and across the three change patterns (three KE profile diversifiers, six KE profile specializers, and three KE profile reorienters). Table 3 shows the distribution of the 12 universities (represented by anonymized identifiers), by type of KE profile change pattern, specifying whether such change refers to KE channels or KE stakeholders.

Our interviews were based on a semi-structured questionnaire (shown in Appendix 2) designed to collect detailed information about the university's KE, teaching, and research activities, the nature and history of these activities, and the strategies and management practices underpinning KE. This questionnaire was then used to interview one to two key staff members in each of our 12 sample universities; we interviewed relatively senior managers involved with the KE processes, who could provide us with a detailed picture of the complexity of the interactions taking place among various players within the university. The interviews, which were carried out (either individually or in pairs) by two investigators and a research assistant, were recorded and then transcribed professionally.

For each university, we also collected secondary evidence capturing its management's perspective of its KE strategies. Including different perspectives, rather than relying on the interpretation of a single actor, increases the validity and reliability of qualitative data (Lincoln and Guba, 2000; Bisbe et al., 2007). In particular, we used the institutional strategies that the universities had submitted to England's higher education funding body for the 2011–12 and 2016–17 periods. These strategic documents, which universities in receipt of HEIF (Higher Education Innovation Funding) were obliged to submit, were available for both periods for nine of our 12 cases. We retrieved documents outlining the KE strategies of the remaining three universities—which had not received HEIF due to being either based in Scotland or too small—from their websites. For each university, Table 4 reports the job roles of the interviewees and the types of strategic documents consulted.

3.3. Data analysis methods

The 12 interview transcripts and the 21 strategic documents retrieved were then coded using Nvivo and analysed through a detailed thematic analysis. The documents were coded by a research assistant who had been briefed on the project objectives. To enhance the interpretative rigour of the findings (Eisenhardt and Graebner, 2007), the outcomes of this initial coding were then discussed and agreed collectively by the entire research team over the course of several in-person meetings. Subsequently, the research team collaboratively generated first and second order themes using an inductive approach, and aligned such themes with the four key areas of management interventions identified by LOC theory. This enabled us to examine whether there had been any differences in management interventions between universities exhibiting the three KE profile change patterns. The output of these activities is shown in Table 5.

To identify any relevant differences between the three groups of universities, we examined which first and second order themes were relatively more prevalent in each group (see sections 4.1 and 4.2). For this purpose, we computed revealed comparative advantage (RCA) indexes (Balassa 1965; see Laursen, 2015, for an overview of some of the literature using the index) measuring the ratio between the frequency with which a certain theme was mentioned in the documents relating to that group, and the frequency with which it was mentioned in the documents relating to all 12 universities (the frequency was measured as the proportion of coded references belonging to a specific theme) [3]. If the RCA index was found to be greater than 1, the group of universities exhibiting a change pattern had discussed a theme with greater frequency than the overall sample. This analysis enabled us to identify differences in the relative frequencies of the use of certain management control systems across the groups that had followed different KE profile change patterns. We enrich the presentation of these relationships through illustrative quotations from our interviews.

Subsequently, we performed qualitative comparative analysis (QCA) to identify which intervention configurations were associated with each of the three patterns (section 4.3). QCA uses fuzzy set theory and Boolean logic to identify relationships among different combinations (called configurations) of antecedent conditions and outcomes (Fiss, 2011), specifying which configurations are necessary and sufficient for the presence of an outcome (Plewa et al., 2016; Vis, 2012). In so doing, QCA allows for causal complexity (each outcome is assumed to result from the combined effects of antecedent conditions) rather than linear causal associations, and equifinality (the same outcome may be reached through multiple paths). Another advantage of QCA over traditional regression is that it can be used reliably with a smaller number of observations than is allowed in inferential statistics (Fiss 2007; 2011). We used QCA to analyse how our outcome variable of interest—a specific university KE profile change pattern—could be explained by alternative configurations of antecedent conditions. We performed separate QCA analyses for three alternative outcome variables: *Specialization*, a binary variable set to 1 if the university had embarked on a KE specialization profile; *Diversification*, a binary variable set to 1 if the university had engaged in diversification; and *Reorientation*, a binary variable set to 1 if the university had changed the mix of KE activities in which it engaged. As antecedents, we created four variables corresponding to the control system interventions listed in Table 5. Each variable was constructed as the share of overall references in a document that had been coded as belonging to a specific type of intervention. To calibrate the data for QCA analysis, we transformed the four antecedents into crisp sets using the variable mean as the threshold value for membership; for all variables, this was very close to the median. In so doing, we followed established QCA practice (Jordan et al., 2011). This analysis was performed using the *Fuzzy* package for Stata (Longest and Vaisey, 2008).

4. Findings

4.1. Typology of KE profile changes

We first considered how the universities had described their KE profile change patterns, and the general contexts in which they had been implemented. In particular, we focussed on: (i) the types of KE channels in which a university had engaged—whether research collaborations, consultancies, research contracts, IP-based channels (such as patent licensing, spinning out companies), Knowledge Transfer Partnerships (KTPs, collaborative projects between academics and businesses funded

[3] The RCA index is defined as follows: $S_{ji} = (x_{ji} / X_j) / (x_j / X)$, where: x_{ji} is the number of coded references of type i in the documents relative to group j, X_j is the overall number of coded references in the documents relative to group j, x_j is the number of coded references of type i in all documents, X is the number of all coded references in all documents.

Table 2
Distribution of 34 universities with significant changes in their KE profiles.

	KE diversification (14)			KE specialization (14)			KE reorientation (6)		
	Change in KE:			Change in KE:			Change in KE:		
Income category	Channels	Stakeholders	Both	Channels	Stakeholders	Both	Channels	Stakeholders	Both
Large	4	1	1	1	3	1	1	0	0
Middle	3	3	0	3	0	0	0	2	1
Small	1	1	0	4	2	0	1	1	0
Total	8	5	1	8	5	1	2	3	1

Table 3
Distribution of 12 cases.

		Pattern of change:		
		KE profile diversification	**KE profile specialization**	**KE profile reorientation**
Nature of change	**KE channels**	D-1	S-1	R-1
		D-2	S-2	
			S-3	
	KE stakeholders	D-3	S-4	R-1
			S-5	R-2
			S-6	R-3

Table 4
Interviewee details and additional documents consulted.

University	Position of interviewee	Additional documents
D-1	Deputy Director of Business Development	HEIF strategy 2011/12 and 2016/17
D-2	Head of School – Enterprise and Commercial	HEIF strategy 2011/12 and 2016/17
D-3	Director of Business Solutions	HEIF strategy 2011/12 and 2016/17
S-1	Director of Knowledge Exchange, Enterprise and Innovation	HEIF strategy 2011/12 and 2016/17
S-2	Enterprise and Employer Engagement Manager	Research, Scholarship and Enterprise Strategy 2015–2020
S-3	Director of Research and Enterprise Office	HEIF strategy 2011/12 and 2016/17
S-4	Knowledge Exchange Manager–College of Arts, Humanities and Social Sciences	Strategy for Research and Knowledge Exchange 2016–2021
S-5	Knowledge Transfer Executive	HEIF strategy 2011/12 and 2016/17
S-6	Head of Innovation, Research and Innovation Services	HEIF strategy 2011/12 and 2016/17
R-1	Innovation Director	HEIF strategy 2011/12 and 2016/17
R-2	Corporate Development Manager	HEIF strategy 2011/12 and 2016/17
R-3	Head of Research Services Research administrator	Research and enterprise strategy webpage

Table 5
Conceptual categories and emerging first and second order themes.

Types of control systems interventions	Second order themes: types of interventions	First order themes
Belief systems interventions	Strategies	Central KE strategy
		Departmental KE strategy
	Awareness	Strategic importance of KE
		Creating awareness of KE
Interactive systems interventions	Generic incentives	Career incentives for academics
		Other incentives for academics
		Incentives for initiatives
	Organizational learning	Best practices in KE
Boundary systems interventions	Targeted support for individuals	Support for KE: general support
		Support for KE: mentoring
	Targeted support for teams	Support for KE: meetings
		Support for KE: Seminars/workshops
		Strategies to encourage collaborations
		Strategies to encourage interdisciplinarity
		Events to encourage collaborations
Diagnostic systems interventions	Targets	Incentives for managers
	Measurements	Benchmarking

by the UK's public innovation agency InnovateUK), or a mix of channels; (ii) whether the universities had experienced an expansion or a reduction in KE opportunities, and whether they had discussed the time needed to make changes or the drivers of the KE change; and (iii) the external events that had affected the universities' environment (changes in innovation policy, changes in the evaluation of universities' research activities through the Research Excellence Framework (REF),[4] the newly implemented evaluation of universities' teaching activities (TEF),[5] or more general changes).

Table 6 reports the first- and second-order themes relating to the universities' KE activities and how these had changed, and the universities' perceptions of their external contexts. We show the RCA index for each first-order theme and change pattern. Themes with RCA values greater than 1 exhibit above-average frequency in that specific group.

The three groups of universities were found not to differ particularly with respect to the range of KE channels discussed in the interviews and in their strategic documents, as all RCA indices were very close to 1. The

[4] The UK higher education sector has witnessed shifts in how the REF is conducted, with increasing focus on 'research impact' alongside traditional measures of research output and quality, such as publications and grants.

[5] The TEF, or the Teaching Excellence and Student Outcomes Framework has been introduced in England in order to measure and rank different universities on the likelihood of their students of finding graduate employment and engaging in further studies.

Table 6
KE engagement and external context.

Second-order themes	First-order themes	Specialization	Reorientation	Diversification
KE channels	Collaboration	**1.08**	0.95	0.93
	Consultancy	**1.02**	0.99	0.97
	Contracts	0.93	**1.01**	**1.09**
	IP	0.98	0.89	**1.10**
	KTPs	0.99	0.98	**1.02**
	Mix	0.98	**1.09**	0.97
	Average	1.00	1.00	1.00
Changes in KE	Drivers	**1.02**	0.97	0.99
	Expansion	0.99	**1.05**	0.98
	Reduction	0.96	0.65	**1.32**
	Time	0.93	**1.13**	**1.01**
	Average	1.00	1.00	1.00
External events	Changes in innovation policy	0.96	**1.08**	**1.05**
	REF	**1.16**	0.87	0.69
	Tuition fees	**1.03**	0.57	**1.19**
	TEF	**1.17**	0.96	0.61
	General trends	0.93	**1.10**	**1.09**
	Average	1.00	1.00	1.00

only remarkable, though unsurprising, difference involved KE reorienters having discussed mixing KE channels to a slightly greater extent. In terms of external contexts, the differences between the three groups were found to be more marked. The KE specializers were particularly concerned about the impact of policy evaluation frameworks (TEF and REF). For example, interviewee S-5 stated that:

> "*There seems to be a shift in funding, generally, from dual research to more applied research, so things like the industrial strategy coming out, Innovate UK growing […] So, we're seeing a shift towards applied R&D. And that's quite a profound impact, I think, for the university, especially one like ours, where we're traditionally focused on this research.*"

Some respondents suggested that they did not have the resources to do everything that was demanded of them. Hence, these universities appeared to increase their KE specialization as a way to increase efficiency by building on what they were already doing well in the face of competing demands from policymakers and limited resources to deal with them.

KE diversifiers particularly mentioned the impact of tuition fees[6] and how their dependency on market demand made them vulnerable to sudden drops in income. They also appeared to be particularly worried by student number reductions. For example, interviewee D-2 stated that:

> "[In the] *post-92 sector is a growing prioritization of external income generation activity and that, I think, is about diversification of the portfolio, so that, you know, if, for example, the Chinese students stop coming, the financial hit that universities will take will be minimized.*"

Hence, KE diversification appears to be a way in which universities had diversified their portfolios in order to insulate themselves against any negative impacts of external events, particularly shocks on the number of students enrolled and the consequent drops in tuition fee income, which could significantly impact their financial positions.

KE reorienters had refocussed their KE activities or stakeholders, possibly following the emergence of unexpected new opportunities, or the drying up of previous sources of KE funding. Compared with the other groups, they were more concerned about general changes in innovation policy and general trends, than about the REF, TEF, and tuition fees. They were also more likely to mention an expansion in KE activities. Their actions appeared to be driven by the search for new opportunities in response to generic market threats. For example, interviewee [R-1] stated that:

> *"SMEs are a difficult kind of sector really, and, you know, a lot of people work in SMEs across Europe, but they're the ones… ironically, they're struggling to get access to some of the nice things that go on in universities. So, a university, the things that are happening there with 1,200 academics and about 30 different departments and facilities and all the rest of it and knowledge assets. Then to not tap into that just doesn't make sense."*

4.2. Management control system interventions underpinning each KE profile change pattern: Content analysis

We compared the three different KE profile change patterns according to the types of management control system interventions discussed in the interviews and in the strategic documents. The interventions were coded following the conceptual framework presented in Table 5. In Table 7, we display the RCA values for each type of management control system intervention and for each type of KE profile change; in this case, the denominator is the share of references for all universities in all the themes listed in the table. To further illustrate the specificities of the KE profile change patterns, Table 8 presents the RCA values aggregated into the main types of control system interventions.

In line with our expectations, management control system interventions relating to belief and interactive control systems, albeit being also mentioned often by KE reorienters, had been mentioned the most frequently by KE diversifiers. Management interventions relating to boundary and diagnostic control systems had been mentioned relatively more frequently by KE specializers.

In relation to belief control system interventions, KE diversifiers had particularly reported centralized KE strategies; these are important in order to increase the diversification of KE activities by involving the entire institution in expanding in previously unexplored areas. For example, interviewee D-1 stated that:

> "*The way* [the university] *seems to be going is that a lot of knowledge exchange activities are being centralized* […] *there is obviously engagement with academics based in, sort of, faculties and schools, but the overall management of knowledge exchange activities sits centrally and sort of rests with non-academic staff."*

KE diversifiers also emphasized the strategic importance of KE and of making academics aware of it in order to encourage all members of an institution to explore any available opportunities to engage in it. For example, interviewee D-1 stated that:

[6] The introduction of fees for home students in UK universities had been a paradigm shift in the country's higher education landscape. Barring Scottish universities, the rest are allowed to charge much higher fees from home students, while public funding for higher education has been radically reduced.

Table 7
RCA indices relating to different types of interventions.

Types of control systems interventions	Second order themes: types of interventions	First order themes	Specialization	Reorientation	Diversification
Belief systems	Strategies	Central KE strategy	0.92	0.99	**1.14**
		Departmental KE strategy	0.88	**1.12**	**1.10**
	Awareness	Strategic importance of KE	**1.03**	0.84	**1.08**
		Creating awareness of KE	0.92	0.99	**1.13**
Interactive systems	Generic incentives	Career incentives for academics	0.87	**1.20**	**1.05**
		Other incentives for academics	0.92	**1.14**	**1.02**
		Incentives for initiatives	0.82	**1.25**	**1.10**
	Organizational learning	Best practices in KE	0.84	**1.09**	**1.20**
Boundary systems	Targeted support for individuals	Support for KE: general support	**1.06**	0.92	0.96
		Support for KE: mentoring	**1.12**	0.80	0.95
	Targeted support for teams	Support for KE: meetings	**1.20**	0.80	0.83
		Support for KE: Seminars/workshops	**1.30**	**1.01**	0.51
		Strategies to encourage collaborations	**1.07**	0.99	0.89
		Strategies to encourage interdisciplinarity	**1.25**	0.68	0.86
		Events to encourage collaborations	**1.01**	**1.34**	0.70
Diagnostic systems	Targets	Incentives for managers	**1.22**	**1.24**	0.45
	Measurements	Benchmarking	**1.08**	0.97	0.89
Average			1.00	1.00	1.00

Table 8
RCA indices for four main types of interventions.

Types of control systems interventions	Specialization	Reorientation	Diversification
Belief systems interventions	0.97	0.93	**1.11**
Interaction systems interventions	0.88	**1.15**	**1.07**
Boundary systems interventions	**1.09**	0.98	0.87
Diagnostic systems interventions	**1.09**	0.99	0.86
Average	1.00	1.00	1.00

> *"Within each school, we have Associate Deans who are responsible for commercial activities, and we liaise very, very closely with those guys and I regularly have bi-monthly meetings with them* […] *those relationships are absolutely key and that's what makes things work really well for us."*

The opposite was found to occur in the case of KE specializers, who focussed on KE activities stemming out of specific research departments areas. For example, interviewee S-2 stated that: *"We don't have a knowledge exchange strategy as such; it is primarily situated in one faculty and is more oriented towards public sector work or, as I said, social enterprise."*

Interestingly, KE reorienters emphasized the importance of departmental KE strategies. This may have been because they were switching from certain areas of engagement to others, and hence needed certain departments to be particularly involved in and strategic about KE. This was supported by the fact that the strategic documents of all KE reorienters emphasized their prioritisation of target sectors, which may have required more intensive engagement on the part of specific departments.

As expected, interactive control systems interventions were particularly mentioned by KE diversifiers, but equally by KE reorienters. Both emphasized the introduction of incentives—career-related and other types—for academics to engage in and undertake KE initiatives. They also supported organizational learning by encouraging awareness of KE best practices. For example, interviewee R-2 stated that:

> *"I have regular forums with businesses and I do a quarterly update on what themes are coming out from* [them]. *I run a logistics forum at the moment, and one of the things coming out of that is health and wellbeing; so, we're feeding that back into our health faculty because there are various things around wellbeing that they're looking to develop that could link back into it."*

As expected, boundary control system interventions were mentioned particularly often by KE specializers, who, with a consistent focus on encouraging more activities in those areas in which they already did well, emphasized the provision of targeted support to help specific individuals and teams to succeed in KE. Such support could take the form of mentoring and operational support, and the organization of meetings and seminars or workshops to inform academics of KE opportunities. For example, interviewee S-2 stated that:

> *"In terms of resources, I would say they were twofold. One is through the consultancy support framework that we use, which enables any income generated through consultancy or third stream activities more generally to be then used by the department that generated it. So, we have a framework that I would say then supports people or encourages that activity. Then the second one is through the provision of the enterprise and employment coordinator."*

KE specializers and reorienters also mentioned events and strategies aimed at encouraging collaboration and interdisciplinarity. Perhaps, as funders increasingly prioritize interdisciplinary research approaches, these initiatives are aimed at further increasing the opportunities for the most successful academics to engage in research and KE. This was explicitly acknowledged by S-1: "*Funders require rapid responses to specific funding calls, have introduced mechanisms to manage demand, and have shifted the emphasis from small-scale funding for individuals towards fewer awards for large interdisciplinary research teams*"; therefore "*maintaining interdisciplinary collaborations is a priority*".

Finally, again as expected, diagnostic control systems were mentioned particularly frequently by KE specializers, who discussed the importance of setting incentives for managers, usually in the form of performance targets (this was also emphasized by KE reorienters) and of benchmarking a university's performance against that of other institutions. For example, interviewee S-6 stated that:

> *"We encourage our KE professionals to take on leadership positions or actively participate in national bodies to garner best practice.* […] *We also are willing to help other HEIs that seek advice/insights/comparisons* […]. *We also look abroad for best practice, particularly the US."*

4.3. Configurations of interventions underpinning each KE profile change pattern: Qualitative comparative analysis

We performed QCA analyses on the set of 33 observations corresponding to the documents we had coded. This analysis enabled us to

identify particular configurations of management control system interventions associated with the achievement of specific KE profile change patterns.

Table 9 presents the results of three QCA analyses, one for each change pattern (KE diversification, specialization, reorientation). For each, we ran the fuzzy algorithm in Stata, identified highly consistent configurations, and implemented the Quine–McCluskey algorithm to produce a reduced final solution set. The analysis of necessary conditions and the truth tables are reported in Appendix 3. When calculating consistencies, we clustered standard errors by university to adjust for intragroup correlation. We found three parsimonious configurations of antecedents leading to *Specialization*, one leading to *Reorientation*, and one leading to *Diversification*. Each configuration was evaluated based on two parameters, coverage and consistency. Coverage indicates the empirical relevance of a configuration. The higher the coverage, the more common the configuration, which consequently accounts for more of the outcome (Schneider and Wagemann 2012). Raw coverage can be interpreted as analogous to R-square values, with higher values indicating greater empirical relevance (Ragin, 2009), while unique coverage refers to "*the proportion that uniquely covers the outcome*" (Poveda and Martínez, 2013, p. 1318). Consistency measures the extent to which cases sharing similar conditions exhibit the same outcomes. This measure ranges from 0 (a combination of conditions that do not produce the outcome on a regular basis) to 1 (a combination always associated with that particular outcome). Finally, the solution consistency and solution coverage values provide the overall fit of the configurations to the data.

As shown in Table 9, the unique coverage values in our results were all greater than 0, as required (Ragin, 2009), while all the consistency scores exceeded the minimum value of 0.8, thus indicating goodness of fit (Ragin, 2009). The solution consistency and the solution coverage values matched the recommended ranges (Woodside, 2013).

The three configurations leading to *Specialization* included either mention of diagnostic (1a) or boundary control system interventions (1b, 1c), as expected. However, configuration 1a also included mention of belief and interactive control system interventions, while 1c also included mention of belief control system interventions.

Table 9
QCA results.

	Specialization			Reorientation	Diversification
Solution number	1a	1b	1c	2a	3a
Belief	Y	–	Y	N	Y
Interactive	Y	N	N	N	Y
Boundary	N	Y	Y	N	N
Diagnostic	Y	N	–	N	N
Consistency	1.000	1.000	1.000	1.000	1.000
Raw coverage	0.062	0.125	0.125	0.125	0.111
Unique coverage	0.062	0.062	0.062	0.125	0.111
Solution consistency	1.000			1.000	1.000
Solution coverage	0.250			0.125	0.111

Frequency threshold = 1. Consistency threshold = 0.8. "Y" indicates the presence of a condition, "N" denotes its absence, and a blank cell represents an ambiguous condition.

Note to Table 9: the value of the variable *Belief* for document *i* is the number of Nvivo references coded as "Central KE strategy", "Departmental KE strategy", "Strategic importance of KE" or "Creating awareness of KE" in document *i* divided by the overall number of Nvivo references in document *i*. Similarly, the variable *Interactive* is the share of references in a document that have been coded as "Career incentives for academics", "Other incentives for academics", "Incentives for initiatives" or "Best practices in KE"; the variable *Boundary* is the share of references in a document that have been coded as "Support for KE": "General support", "Mentoring", " Meetings", "Seminars/workshops", "Strategies to encourage collaborations", "Strategies to encourage interdisciplinarity" or "Events to encourage collaborations"; finally the variable *Diagnostic* is the share of references in a document that have been coded as " Incentives for managers" or "Benchmarking".

The configuration leading to *Diversification* included a combination of belief and interactive control system interventions, as expected. Instead, the configuration leading to *Reorientation* did not include any type of system intervention. This may be linked to this change pattern being associated with a large variety of management intervention combinations, which makes the absence of interventions the only recurring configuration.

Hence, looking at how individual universities combine different types of interventions to achieve certain strategic outcomes, we found several configurations that only partially reflected the associations hypothesized in our conceptual framework. Here, we must remember that specific packages of management control system interventions in organizations may be the outcome of different decisions taken at different organizational levels and at different points in time, rather than being entirely planned (Malmi and Brown, 2008). For example, generic incentives for academics may have been put in place before any decision to focus on a few KE channels, and may have remained in place despite not being strictly necessary for the pursuit of that strategy. It is thus unsurprising to find universities pursuing the same strategy discussing a variety of combinations of management control systems interventions.

What is interesting for our purposes is that *all* of the combinations associated with KE specialization included frequent mentions of at least one boundary or diagnostic control systems interventions, whereas this did not occur for any of those associated with KE reorientation and diversification. On the other hand, the only combination to only include frequent mentions of belief and interactive system interventions was associated with KE diversification.

5. Conclusions

The study contributes to a better understanding of the factors underpinning different universities' KE profiles, adding a dimension that had hitherto been under-researched: the role of managerial interventions in support of KE. This had been neglected by previous studies focussed on associating universities' KE profiles, and their changes, with institutional characteristics such as age, size, and research orientation (Siegel et al., 2007; Hewitt-Dundas, 2012; Coates Ulrichsen, 2014; Sánchez-Barrioluengo et al., 2019; de la Torre et al., 2018). This study shows that management control systems theory provides a conceptual tool useful to understand the enactment of strategic change in relation to KE engagement. This opens up opportunities for further research into universities' KE engagement from a strategic perspective. In the context of the KE profiles literature, this study introduces diversification and specialization as useful constructs to explore and invites further research into these aspects.

This study also contributes to the literature on entrepreneurial university by confirming the important role of internal factors in affecting universities' engagement in KE (Guerrero and Urbano, 2012; Centobelli et al., 2015). We also dug deeper into one of the internal factors which support KE engagement—management control systems—which had hitherto been investigated to a lesser extent than organizational and governance factors.

Conceptually, our findings are aligned with the argument that universities attempting to diversify their KE profiles would want to exploit their full panoply of competencies in order to enable the emergence of new KE channels and stakeholders, and thus encourage staff to identify and exploit a wide range of KE opportunities; while universities attempting to increase their KE profiles' specialization would want to focus on their internal competitive strengths, thus enabling researchers to do more of what they are already doing well. In particular, we found support for linking: i) the enactment of a KE diversification strategy to the implementation of belief and interactive control system interventions, and ii) the enactment of a KE specialization strategy to the implementation of diagnostic and boundary control system interventions.

In providing evidence about the kind of interventions associated with

universities' KE profile changes, this study has implications for university managers implementing similar changes in their organizations. Those aiming for KE diversification could implement belief control system interventions in the form of a centralized approach to KE strategizing and of the creation of awareness around the strategic importance of KE in order to recruit all parts of the institution in supporting this pattern of change, as well as interactive control system interventions in the form of incentivizing academics at all levels to engage in KE in order to facilitate the exploration of new areas of engagement. Those aiming for KE specialization could implement targeted boundary control systems interventions to support and mentor academics already engaged in specific KE channels or with specific stakeholders in order to encourage them to improve their performance; and diagnostic control systems interventions by setting performance targets aligned with those activities and benchmarking their performance. Finally, managers aiming to reorient their universities' KE profiles would need to shift their institutions' focuses from certain KE channels and stakeholders to others. As such, they could focus any exploratory activities aimed at seeking new opportunities (through belief and interactive control systems designed to enhance the exploration of new forms of KE engagement) in specific directions rather than widely (through boundary and diagnostic control systems interventions designed to enhance the further exploitation of current KE activities).

As our findings shed light on the kind of support that universities might need in order to adapt their KE strategies to changing external conditions—many of which are policy driven—they also have implications for policymakers. As evidenced by our analysis of the contextual factors underpinning the various types of KE profile changes (section 4.1), universities that are struggling with competing demands on their resources might adopt a KE specialization strategy. This would require them to provide targeted support to individuals and teams that are already successful at KE. Such universities therefore might need help in implementing adequate support systems and adequate performance measurement systems.

Universities worried about their financial viability may want to implement a KE diversification strategy to hedge against the risk of losing specific sources of income. To do so, they may need help in implementing the appropriate incentives for academics and the appropriate strategies to support the diversification effort.

Finally, universities confronted with new opportunities in previously unexplored KE areas and, possibly, with the drying up of opportunities in KE areas in which they were already engaged may want to implement a KE reorientation strategy. Refocussing a university's KE engagement is a complex undertaking that may require support in implementing a variety of initiatives to facilitate it, including both interventions promoting the exploration of new activities and others targeting support for them.

One of the several limitations of this study is the small number of cases investigated. This was due to the need to focus precisely on those universities that had exhibited relevant KE profile change patterns, which reduced the pool of universities that fit the required description to 34. Our sample of 12 represents over a third of the relevant pool of universities, and we can argue that our findings provide an acceptable degree of representativeness in relation to the set of UK universities that have changed their KE profiles. Nevertheless, carrying out further research on larger sets of institutions would be still valuable. A larger scale analysis carried out through a survey, and perhaps by exploiting information present in universities' strategic documents, would enable testing hypotheses in an inferential setting, and the development of causal, rather than purely associational, arguments.

Another limitation of this study is its specific focus on the UK higher education system. It would be worth conducting similar studies focussed on other higher education systems, perhaps characterized by lower (or higher) university independence from government control. Finally, despite our study's focus on the type of management interventions associated with different types of KE profile changes, many aspects of the process remain unexplored. Further research could shed light on, for example, the decision-making units in which strategic decisions relating to KE engagement profiles are taken, who implements the changes affecting KE profiles, and the impact of KE profile changes on stakeholders.

CRediT authorship contribution statement

Federica Rossi: Funding acquisition, Investigation, Methodology, Writing – original draft, Conceptualization, Data curation. **Abhijit Sengupta:** Conceptualization, Funding acquisition, Writing – review & editing, Investigation, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1

1. Secondary data analysis and sample selection

In this Appendix, we describe the process we used to construct our sample of universities to study. First, we built a panel dataset of 150 UK universities for eight consecutive years, using publicly available information from the Higher Education Statistics Agency (HESA). These constitute the entire set of universities submitting statistical information to HESA, for which complete information is available for the eight academic years 2008–09 to 2015–16. The dataset includes both general financial data on universities' main income sources (research income, tuition fees, endowments), and specific data on KE engagement drawn from the Higher Education Business and Community Interaction (HE-BCI) survey, which includes, among other data, the income the universities receive from different types of KE activities and from different types of stakeholders.

Second, using this panel dataset, we computed two types of indices to identify patterns of change in KE engagement: a diversification index, used to measure how broad is the range of KE channels and stakeholders of the university, and a differentiation index, used to measure how distant is the KE profile of the university from that of the 'average university' in the system. The two indices are described in section 2 of this Appendix. These indices were computed on the types of KE channels from which the universities received income (four categories were considered: collaborative research income, contract income, consultancy income and IP income), as well as on the types of stakeholders with which the universities engaged (three categories were considered: income from non-commercial organizations, from small and medium-sized commercial enterprises, from other

commercial enterprises).

Third, we identified universities that exhibited high standard deviations in the diversification and/or differentiation indices (in KE incomes and stakeholders) over the eight year period. This was done manually by listing out the eight year averages and standard deviations of their indices, combined with plotting scatter diagrams of the standard deviations of diversification and differentiation indices. We then selected those 34 universities which had exhibited the maximum changes in their KE profiles over time, either in terms of types of KE channels or in terms of types of stakeholders.

2. Diversification and differentiation indices

We measured a university's diversification of KE channels using the inverse of the Herfindahl index (Herfindahl, 1982) computed on the shares of income received from each KE channel by each university in each year. The index is $V_{jt}^{C} = \frac{1}{\sum_i \left(\frac{x_{jit}}{X_{jt}}\right)^2}$, where x_{jit} is the income from KE channel type i received by university j, and X_{jt} is the total KE income received by university j, in each period t. This index quantifies how broad is the range of KE channels from which the university receives income, and the relative weight of each type: the more "equal" the shares of the channels, the higher is the index. A low value of V_{jt}^{C} implies that the university is more specialized (low diversification) while a higher value implies that the university is more diversified. The index takes values between 1 and n, which is the overall number of channels it engages in.

We measured a university's diversification of KE stakeholders using the same index computed on the shares of income received from each type of stakeholder by each university in each year. This diversification index has found wide application in the higher education literature, where it has been used to measure, among others, diversification of teaching curricula (Rossi, 2009), and of product offerings and portfolio (Acar and Sankaran, 1999).

The differentiation index (Zwanziger et al., 1996), computed for each university in each year, tells us whether the mix of income from KE channels received by a university is more or less similar to the mix received by an 'average university': the index varies from 0 to 1, with zero indicating minimum differentiation from the 'average university' and 1 indicating maximum differentiation. The differentiation index, computed for each university j in each period t, D^{C}jt, is: $D_{jt}^{C} = \sum_i \left(\frac{x_{jit}}{X_{jt}} - \frac{x_{it}}{X_t}\right)^2$ where x_{jit} is the income from KE channel i received by university j, X_{jt} is the total KE income of university j, x_{it} is the income from KE channel i received by all universities, and X_t is the total KE income of all universities. A university with high value of this index receives income from a mix of KE channels that is very far from the national average. We also applied the same index to the analysis of types of stakeholders.

The diversification and differentiation index are inversely related (see e.g., Rossi, 2009): a university that is very diversified is more similar to the 'average university' and hence less differentiated, while a university that is more specialized is more differentiated from the rest.

Appendix 2. Semi-structured questionnaire used for interviews

General strategy and views of knowledge transfer

1. How important is knowledge exchange as a mission for the university? Does the university allocate resources to pursue a knowledge transfer strategy, and if so at what level (centrally, department etc.)? Is there a central knowledge transfer strategy?
2. How are knowledge exchange support activities organized within the university? What kind of support services are provided to business, other external stakeholders, and academics?
3. What are the main channels through which your university engages with business and with other stakeholders? Who are the main beneficiaries of the university's knowledge exchange activities? Are there different patterns in different department?
4. Have these channels changed over time? Have you reduced your knowledge exchange activities in some areas, and/or expanded in others? What has driven those changes?

Practices and interactions within the university

5. How do you as an organization encourage relationships among researchers within your university? What kind of strategies do you follow to encourage researchers from different backgrounds talking and exchanging ideas with each other? What kind of events do you organize (if any) to encourage this?
6. How do you as an organization encourage departments to interact with each other within your university? What kind of strategies do you follow to encourage this? What kind of events do you organize to encourage this?
7. Same as above, at faculty levels.
8. In your assessment, do researchers in your university collaborate across departments?
9. What proportion of your research is inter-disciplinary? What strategies do you follow to encourage inter-disciplinarity within the organization?
10. In your opinion, what has been the pattern of interactions/collaborations among research faculty in your university – at department level, at faculty level and at organizational level? Think over the last 10 years if possible.
11. Internal recruitment patterns, career paths, promotions, organizational processes such as research centres etc. and how these have changed in the last 10 years; How aware are academics of knowledge exchange, what incentives do they have for engaging in it? (financial incentives; promotion; time off teaching; others?)
12. Incentives for managers to engage in knowledge exchange?
13. how affected are you by external events at departmental, faculty and organizational levels?
    a. student fees
    b. innovation policy changes in UK
    c. introduction of TEF
    d. impact agenda and corresponding changes in REF

Assessment of metrics and best practices

14. Do you think that the reporting of knowledge exchange activities through the HEBCI allows you to provide a fair and comprehensive representation of the university's knowledge exchange performance? If not, what do you think is missing or should be reported differently?
15. What are the other universities that are more similar to you in terms of knowledge exchange engagement? Are there any best practices in knowledge exchange that you are aware of and that have inspired you to change your approach? How do you become aware of best practices?

Appendix 3

Analysis of necessary conditions

	Outcome variable: Specialization		Outcome variable: Reorientation		Outcome variable: Diversification	
Conditions tested:	Consistency	Coverage	Consistency	Coverage	Consistency	Coverage
Belief	0.500	0.533	0.250	0.133	0.556	0.333
~Belief	0.500	0.444	0.750	0.333	0.444	0.222
Interactive	0.500	0.444	0.625	0.278	0.556	0.278
~Interactive	0.500	0.533	0.375	0.200	0.444	0.267
Boundary	0.625	0.588	0.500	0.235	0.333	0.176
~Boundary	0.375	0.375	0.500	0.250	0.667	0.375
Diagnostic	0.438	0.467	0.500	0.267	0.444	0.267
~Diagnostic	0.563	0.500	0.500	0.222	0.556	0.278

Truth table for outcome variable: Specialization

Belief	Interactive	Boundary	Diagnostic	number	raw consist.	PRI consist.	SYM consist
0	1	1	1	11	0.455	0.455	0.455
1	0	0	0	9	0.556	0.556	0.556
0	1	1	0	3	0.667	0.667	0.667
0	1	0	0	2	0	0	0
1	0	0	1	2	0	0	0
0	0	0	0	1	0	0	0
1	1	0	0	1	0	0	0
0	0	1	0	1	1	1	1
1	0	1	0	1	1	1	1
1	1	0	1	1	1	1	1
1	0	1	1	1	1	1	1
1	1	1	0	0			
0	0	0	1	0			
0	1	0	1	0			
0	0	1	1	0			
1	1	1	1	0			

Truth table for outcome variable: Reorientation

Belief	Interactive	Boundary	Diagnostic	number	raw consist.	PRI consist.	SYM consist
0	1	1	1	11	0.273	0.273	0.273
1	0	0	0	9	0.111	0.111	0.111
0	1	1	0	3	0.333	0.333	0.333
0	1	0	0	2	0.5	0.5	0.5
1	0	0	1	2	0.5	0.5	0.5
0	0	0	0	1	1	1	1
1	1	0	0	1	0	0	0
0	0	1	0	1	0	0	0
1	0	1	0	1	0	0	0
1	1	0	1	1	0	0	0
1	0	1	1	1	0	0	0
1	1	1	0	0			
0	0	0	1	0			
0	1	0	1	0			
0	0	1	1	0			
1	1	1	1	0			

Truth table for outcome variable: Diversification

Belief	Interactive	Boundary	Diagnostic	number	raw consist.	PRI consist.	SYM consist
0	1	1	1	11	0.273	0.273	0.273
1	0	0	0	9	0.333	0.333	0.333
0	1	1	0	3	0	0	0
0	1	0	0	2	0.5	0.5	0.5
1	0	0	1	2	0.5	0.5	0.5
0	0	0	0	1	0	0	0
1	1	0	0	1	1	1	1
0	0	1	0	1	0	0	0

(continued on next page)

(*continued*)

Belief	Interactive	Boundary	Diagnostic	number	raw consist.	PRI consist.	SYM consist
1	0	1	0	1	0	0	0
1	1	0	1	1	0	0	0
1	0	1	1	1	0	0	0
1	1	1	0	0			
0	0	0	1	0			
0	1	0	1	0			
0	0	1	1	0			
1	1	1	1	0			

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