Understanding Quadruple Helix Relationships of University Technology Commercialisation: A Micro Level Approach

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Abstract

Given recent demands for more co-creational university technology commercialisation processes involving industry and end users, this paper adopts a micro level approach to explore the challenges faced by universities when managing quadruple helix stakeholders within the technology commercialisation processes. To explore this research question, a qualitative research methodology which relies upon comparative case analysis was adopted to explore the technology commercialisation process in two universities within a UK region. The findings revealed that university type impacts Quadruple Helix stakeholder salience and engagement and consequently university technology commercialisation activities and process. This is important as recent European regional policy fails to account for contextual influences when promoting Quadruple Helix stakeholder relationships in co-creational university technology commercialisation.

Keywords: Quadruple Helix; Stakeholder Theory; Multiple Case Analysis; University-Industry Collaboration; University Entrepreneurship; University Technology Commercialisation

Introduction

It is now widely acknowledged that university technology commercialisation is a key priority of universities in addition to that of teaching and research (Etzkowitz 1998; Bastalich 2010; Watermeyer, 2014). More recently, the increased recognition of universities as core actors in regional and national innovation systems (McAdam et al. 2012) and changing complexity of societal needs has resulted in the emergence of Quadruple Helix Stakeholder Relationships in

the university technology commercialisation process (Carayannis and Campbell 2009; Carayannis and Rakhmatullin 2014). Whilst various stakeholders such as venture capitalists, government agencies and industry have been involved in university technology commercialisation processes since the early 1990's (Gibb 2010), these relationships have been ad hoc and transient. Indeed, recent European innovation policy now demands more co-creational university technology commercialisation processes involving industry and end users (Arnkil et al. 2010; Mian 2011). Consequently, the emergent Quadruple Helix Model of Stakeholder Relationships reflects a shift from the normative Triple Helix (government, university and industry) to include end users as a core stakeholder in regional innovation ecosystems (Carayannis and Campbell 2009 Leydesdorff 2011). Prior studies acknowledge that levels of innovation performance of the Triple Helix in terms GDP and jobs has been disappointing (Asheim and Coenen 2005; Lawler 2011). Indeed, under the guise of the Triple Helix, knowledge flows were said to be bi-directional which contrasts with the need for more co-creational engagement expected from regional innovation policy (Arnkil et al. 2010).

Accordingly, Universities are being set performance targets and measurements based on an accountable Quadruple Helix stakeholder framework, with such a focus aligning with localised regional policies aimed at enhancing stakeholder collaboration in order to build an innovation ecosystem (MacGregor, Marques-Gou, and Simon-Villar 2010; Ivanova 2014). Indeed, inherent within university technology commercialisation studies discourse, is the assumption that the influence of Quadruple Helix stakeholders is primarily strategic (Leydesdorff 2011; Ranga and Etzkowitz 2013), with this influence diminished at micro levels where operational practices take precedence (Urbano and Guerrero 2013). However, university technology commercialisation models and processes at the ground level will be influenced by stakeholders who not only give strategic guidance linked to funding provision, but also require that

performance measurement goals and targets are met to increase accountability and alignment between strategy and practice (Wilmott 2003; McAdam et al. 2012; Mate-Sanchez-Val and Harris 2014).

Extant research to date, albeit limited (Mate-Sanchez-Val and Harris 2014; Zahra, Wright, and Abdelgawad 2014) has focused on the influence of Quadruple Helix stakeholders at a macro regional context (MacGregor, Marques-Gou, and Simon-Villar 2010; Ivanova 2014) and acknowledges that regional and contextual variations are likely to cause variances in university technology commercialisation mechanisms, processes and outcomes within regions. However, little is known about the impact of Quadruple Helix stakeholder interactions on micro level activities and processes in general and technology commercialisation process in particular. Accordingly, this paper adopts a micro level approach to explore the following research question - *What challenges are faced by universities when managing the integration of quadruple helix stakeholders within the technology commercialisation processes?*

Within this paper, we make the following theoretical contributions; first, we provide novel insights into the quadruple helix phenomenon and its implications for the university commercialisation process. Second, through adoption of a stakeholder lens, we highlight the criticality of an academic entrepreneur's salience and engagement in determining the ultimate engagement with industry and end users. Third, we demonstrate the importance of contextual influences when exploring these Quadruple Helix stakeholder relationships; where the university type may impact the salience attributed and engagement levels.

The paper commences with an overview of extant literature identifying the challenges of quadruple helix stakeholder engagement. This is followed by a discussion of stakeholder management processes (i.e. stakeholder identification and mapping, stakeholder salience and engagement) which are viewed as an instrumentalist approach to advance understanding of how Quadruple Helix Stakeholders interact within university technology commercialisation processes. The following section then presents the methodological rationale and method; which is followed by critical evaluation of the case study findings. Finally, the implications for theory and practice are considered.

Challenges of quadruple helix stakeholder engagement

Despite greater engagement between quadruple helix stakeholders being prioritised on policy agendas, actual levels are somewhat disappointing (Muscio and Vallanti 2014). Indeed, developing more collaborative university technology commercialisation processes involving diverse stakeholder engagement is highly complex and still not fully understood (Markmann et al. 2008; Perkmann et al. 2013; Sharif, Liu and Ismail 2014; Rossi and Rosli 2014). Whilst the benefits to be derived from university, industry, end users and government collaboration is evident such as access to knowledge, development of scientific competence relevant to the marketplace, obtaining a competitive advantage through acceleration to the marketplace (Dooley and Kirk 2007) significant challenges remain regarding how to manage such relationships.

Perkmann et al. (2013) recent review of university-industry relations argues that a wide range of factors may impact upon engagement with stakeholders during commercialisation processes. These include technology transfer support and formal incentives, university quality, climate, discipline, organisational culture, public policy and regulation, organisational strategic agendas

which can all impact upon individual motivations and attitudes to collaborate with industry and end users. Similarly, Muscio and Vallanti (2014) identify that four main factors which influence university collaboration with industry, namely, misalignment between incentives and motives of researchers and firms causing conflict, ineffective academic processes or intermediaries to help engagement and interactions with external stakeholders at micro levels, disharmony between academic goals and technology commercialisation activities and inherent distance between academic research and business needs.

Miller. McAdam and McAdam (2014) identify that conflicting demands from both internal and external stakeholders can lead to disharmony and divergence in strategic decisions during commercialisation processes which can exert pressure on scarce resources. Furthermore, this research identifies that universities should exhibit characteristics of ambidexterity where their structures should be flexible enough to allow for both the advancement of basic science but also more co-creational engagement with external stakeholders to help align commercialisation efforts with the needs of society (Markmann et al 2008). However, this is often difficult for universities to achieve causing tensions at an organisational level but also at an individual level. In some universities, attempts at ambidexterity are evident with the development of different promotional paths for teaching, research, enterprise and technology commercialisation (Ambros et al. 2008). However, universities vary with regards the priority given to each of these pathways and prior research identifies mixed results regarding the success of trying to manage both academic rigor and commercialisation processes which engage with quadruple helix stakeholders (Tushman and O'Reilly 1997; Gibson and Birkenshaw 2004; Ambros et al. 2008). The engagement of quadruple helix stakeholder's in commercialisation processes requires considerable resources which is a key challenge for academics. Indeed, Gibson and Birkenshaw (2004) identify that universities need to create a supportive context where

academic entrepreneurs can make their own informed judgements about how they should allocate their time to meet the conflicting demands for alignment and adaptability.

Furthermore, Okamuro and Nishimura (2013) identify that the success of universities engagement with quadruple helix stakeholders is contingent not only on overarching organisational strategy but also on institutional design at a micro level which increase engagement levels and mitigate against conflicts caused by conflicting objectives. Organisational strategy reflects the inherent type of university, where universities can often be categorised in simple terms as being either more research intensive or applied (O'Kane et al. 2014). Indeed, organisational strategy ultimately dictates the resources spent on engagement with quadruple helix stakeholders and therefore will impact process, culture and norms at a micro level. At micro levels, challenges often centre on culture, expectations, norms and mind-sets (Belkhodja and Landry 2007; Muscio and Pozzali 2013; Nooteboom et al. 2007) which can all impact upon quadruple helix stakeholder knowledge transfer and engagement. University structures and polices are often insufficient to manage conflicting demands of stakeholders (Ambros et al. 2008) which causes challenges for universities to more fully engage with quadruple helix stakeholders at micro levels and align their technology commercialisation strategies with the demands of policy.

Stakeholder Management Constructs

To facilitate an exploration of the challenges of managing quadruple helix stakeholders during technology commercialisation at a micro level, a stakeholder lens is deemed appropriate. The development and use of stakeholder theory and concepts in university technology commercialisation has grown exponentially in recent years (McAdam et al. 2012; O'Kane et al. 2014). Building upon Miller, McAdam and McAdam (2014) it is posited that three key

stakeholder management constructs can facilitate our micro level exploration of the challenges of managing Quadruple Helix stakeholders in university technology commercialisation models and processes at micro levels, namely stakeholder mapping, salience and engagement.

The first construct, stakeholder identification mapping (Preeble 2005; Neville, Bell, and Whitwell 2011) draws upon the normative validity of stakeholder management whereby stakeholders are identified by their interests in the organisation and the organisation's interest in them (Donaldson and Preston 1995). Freeman's (1984:46) research highlights that a two-way relationship is required between the firm and its stakeholders; with a stakeholder defined as *'any group or individual who can affect or is affected by the achievement of a firm's objectives'*. This framework adopts a grouping approach to stakeholders with levels of homogeneity. Applied to the Quadruple Helix context, these groupings are government, university, industry and end user stakeholder groupings that may affect or be affected by university technology commercialisation activities at the ground level. Within each of these four groupings (making up the Quadruple Helix), there can be a number of stakeholders.

The second stakeholder construct to consider is salience which helps organisations to optimise resource use within a position of bounded rationality (Labelle and Aka 2012). Mitchell, Agle, and Woods's (1997) stakeholder salience model identifies that stakeholders can be classified and prioritised as having one or more attributes of power, legitimacy and/or urgency (Figure 1). Stakeholder Power is the extent to which a stakeholder can impose their willpower in a relationship. Legitimacy relates to social acceptance and expected structures or behaviours established over time. Urgency is the time sensitivity or criticality of a stakeholder's claim. There is a need for Universities to prioritise stakeholders based on the salience construct which focuses on stakeholder attributes and the development of stakeholder management strategies

(Frooman 1999; Neville, Bell, and Whitwell 2011) rather than assuming equanimity of all Quadruple Helix stakeholders and spreading resources too thinly (De Silva 2015).

The third stakeholder construct is that of stakeholder engagement where stakeholder(s) and a firm or entity interact in advancing or orchestrating a key organisational agenda (Labelle and Aka 2012). It is suggested, consistent with Greenwood (2007), that the process of Quadruple Helix stakeholder engagement is in effect an iterative alignment process where all aspects of university technology commercialisation processes must mutually adjust in a dynamic manner to accommodate Quadruple Helix stakeholder requirements. To orchestrate, or create and maintain these relationships, proactive stakeholder dialogue and engagement is necessary (Labelle and Aka 2012). Morsing and Schultz (2006, 324) state '*Stakeholder theory has developed a focus on the importance of engaging stakeholders in long-term value creation…the emphasis has moved from a focus on stakeholders being managed by companies to a focus on the interaction that companies have with their stakeholder*s'. Hence, in a university technology commercialisation context, engagement between Quadruple Helix Stakeholders and commercialisation processes is seen as a formative process of building relationships to enable mutual shaping and adjustment (Sharif, Liu and Ismail 2014).

Morsing and Schultz (2006) identify a threefold approach to stakeholder engagement where the type of engagement determines the resources required and the outcomes. The first approach is a one way dialogue with stakeholders, where either the stakeholder or the organizational entity transmits requirements with minimal need for interchange (Foster and Jonker 2005). This approach normally involves low salience stakeholders. The second approach is two-way stakeholder engagement which involves a meaningful exchange of information and knowledge sharing usually involving stakeholders with medium salience levels. The third approach to

stakeholder engagement involves the stakeholder(s) with high levels of salience and the organizational entity going beyond a two way exchange to that of joint design or co-creation. Overall, it is suggested that increasing levels of stakeholder salience demands higher levels of engagement and resource allocation (Foster and Jonker 2005; Morsing and Schultz 2006).

Research Methodology

Given our intention to aid understanding of the complex phenomena of how quadruple stakeholder relationships are managed in the university technology commercialisation process (Sharif, Liu and Ismail 2014), a qualitative research methodology was deemed appropriate. To orchestrate this, a case study approach was adopted. Accordingly, in-depth interviews were carried out during 2013-15 with multiple stakeholders involved in university technology commercialisation processes of two universities within the same peripheral region. Areas of discussion during these interviews included the interaction between the different stakeholder groupings, barriers and enablers of effective stakeholder interaction and the role played by each stakeholder at the varying stages of the commercialisation process. These interviews were augmented with publically available documents such white papers and documentation available from the regional universities websites. Table 1 provides the characteristics of the two universities showing their historical differences and approaches to university technology commercialisation.

Our sampling was purposive (Seawright and Gerring 2008; Gartner and Birley 2002; Pratt 2009) and theoretical in having the characteristics that fitted our investigation (McKeever, Jack, and Anderson 2015). Thus, a sample of stakeholders was selected who were deemed representative of the quadruple helix stakeholder groupings within the university technology commercialisation process. Table 2 identifies the interviewees which took part in the study,

their fields of specialism and their associated codes. University stakeholders comprised of the academic entrepreneurs (AE) who are defined as academics who engage in formal technology commercialisation activities resulting in patents, sale of intellectual property through mechanisms such as licences or results in new ventures such as spin outs (Shane 2004), technology transfer office staff (TTO) and head of schools (HOS). Insights to salience and engagement of industry and end users were gained through the enterprise co-ordinators and TTO staff which was triangulated with document analysis of government strategies and white papers. Government stakeholders consisted of several operational and strategic government staff members from the local regional development agency involved in programmes aimed at university technology commercialisation.

[Insert table 1 and 2 around here]

Cross-case analysis was deemed appropriate as it facilitates the comparison of commonalities and difference in the events, activities, and processes (Yin 2014). A method of inductive coding (Miles and Huberman 1994) was then adopted which resulted in an initial process of open coding which was then synthesised into themes and subthemes through an iterative process of analysis and reflection through making use of 'theoretical coding' (Glaser 1992) parallel to the collection of data. This iterative process of data analysis built up a chain of evidence by means of data triangulation from the interviews and documents; thus helping alleviate some of the limitations of associated with case study research (Konecki 2008).

Results

From the empirical findings, an evidence Table (Miles and Huberman 1994) was extracted which reflects the themes used to structure the discussion of the findings (Table 3). Within

Table 3, the left hand column provides a brief description of the key micro level university technology commercialisation activities present at each university and the salience and engagement of each stakeholder is outlined. These themes included Technology Disclosure; Technology Assessment, Appraisal and Patenting; Seeking Funding & Further Concept Development and Commercialisation Entity.

[Insert Table 3 here]

Challenges of Managing Quadruple Helix Stakeholder's at Micro Level2 University Technology Commercialisation Activities

Our micro level exploration revealed that university technology commercialisation activity was influenced to varying degrees by Quadruple Helix based stakeholder salience and engagement; with salience and engagement dependent on commercialisation stage and the university type.

Technology Disclosure

It was evident throughout the interviews that the ability of AEs to engage in university technology commercialisation processes was dictated by their university remit. An AE in Case 2 noted, *'As an academic you have teaching and research - technology transfer and commercialisation doesn't always fit neatly with research'*. A number of AEs in Case 1 stated, they were judged by Research Excellence Framework (REF) outputs rather than commercialisation success measures, thus *'there is a real feeling that enterprise not a core initiative'* (AE in Case 1). The lack of perceived incentives or motivation internally to engage in university technology commercialisation led some AEs in Case 1 preferring to release IP through internationally recognised publications, where it was deemed they would obtain greater reward and recognition. Hence, AEs in Case 1 were considered to have low salience, whereby they possessed the power to engage in commercialisation activities (Mitchell, Agle,

and Wood 1997) however, they lacked urgency and legitimacy due to their University's remit (Table 3).

In contrast, in Case 2, an AE highlighted that they had gained their academic promotion to senior lecturer and professorial levels by engaging in university technology commercialisation activities. In fact, academic enterprise was identified as a core and legitimate route for promotion within Case 2. This support meant that AEs in Case 2 appeared to have high salience, possessing the power, legitimacy and urgency to disclose their technology (Table 3) (Mitchell, Agle, and Wood 1997; McAdam et al. 2012).

It was interesting to note the disparity of AE salience between the two universities at this stage considering the AEs important role in initiating the university technology commercialisation process and the fact that they ultimately possess the knowledge and skills which can be a source of revenue for the university and wider society (McAdam et al. 2010). Indeed, an AE in Case 1 identified '*it's a bit of a dilemma for academics because how they are measured is based on their research and when you are doing something entrepreneurial you have to do it in your own time'*. Thus, alignment to salient Quadruple Helix stakeholders at this early stage was limited by ineffective reward and recognition systems in Case 1. Whilst AE's in Case 2 received allowances in their work load allocation for enterprise and university technology commercialisation, this provision was only available to academics in Case 1 during later stages of the commercialisation process, typically requiring sabbatical leave. Consequently, during the disclosure stage, the HOS in Case 1 possessed high salience (Table 3), whereby they could exert their power, influence and urgency (Michell, Agle and Wood 1997; Frooman 1999) to discourage academics from disclosing a technology and instead encourage them to publish which is core to the research remit of the university. In contrast, in Case 2, the HOS was deemed

to be a discretionary stakeholder with low salience (Mitchell, Agle and Wood 1997) at the disclosure stage since the university mechanisms permitted academics to pursue various different academic remits. Therefore, even if the HOS preferred academic staff to focus on publications and the generation of research income, which many AEs stated they were under pressure to do (despite internal performance mechanisms valuing other streams), the HOS did not have the power to influence an academic's choice to pursue technology commercialisation. Consequently, the AE had power, urgency and legitimacy to engage in technology commercialisation (Table 3).

The core remit of each university and promotional mechanisms also had an effect on the salience of the TTO staff at the initial disclosure stage. In Case 1, the TTO was found to have low salience since they did not possess the power or legitimacy to promote technology commercialisation as a core activity within the university (Table 3) (Mitchell, Agle, and Wood 1997; McAdam et al. 2012). However, they did possess urgency, in that they had performance targets set at the university level which had to be met to prevent funding being reduced (McAdam et al. 2012). In Case 2, the TTO was found to have high salience (Mitchell, Agle, and Wood 1997) since internal promotional mechanisms gave them the power and legitimacy to encourage academics to engage in technology commercialisation (Table 3). In Case 1, it was interesting to note the devolved systematic approach to performance measurements from the Macro (regional), to the micro (ground) level. A TTO in Case 1 stated that the performance criteria at the micro level was a 'black box' particularly in relation to REF; thus leading to ambiguity and misalignment at the micro level.

Recent policy demands to include end users and industry throughout the technology commercialisation processes was noted during the interviews. However, in Case 1, the

university remit meant that there was a lack of motivation for AEs to engage with these stakeholders. This meant industry and end users had low salience at these initial stages where they were found to possess legitimacy as a result of recent innovation policy but lacked urgency and power as a result of university processes. In Case 2, industry and end users did appear to possess legitimacy as a result of academic enterprise being a core route to promotion however, levels of engagement with industry and end users still needed to increase which TTOS1 identified would take time to instil the cultural change necessary. Interestingly, at the disclosure stage, government was not perceived to be as a core stakeholder. Whilst government took an interest in technology disclosures and regional policy was putting pressure on more co-creational technology disclosures, government lacked power and legitimacy at this early stage in the commercialisation process in both cases.

At the technology disclosure stage, engagement between the different Quadruple Helix stakeholder groups in both cases appeared to be largely two way. However, in Case 1, despite the two-way engagement, the high salience of the HOS often led them to exert their influence over AEs engagement with university technology commercialisation, which consequently was found to impact upon their motivation to engage with industry and end users due to pressures to publish and apply for research funding. In contrast, AEs in Case 2 were found to have more freedom to engage in university technology commercialisation and had more resources devoted to engagement with industry and end users as a result of their academic remit.

Technology Assessment, Appraisal and Patenting

Following the disclosure of a technology, the next stage in the commercialisation process was assessment and appraisal by a commercialisation executive who was often discipline specific. This assessment would then lead to a decision as to whether to patent a technology or not

progress it further. During these stages, the TTO in both universities was considered to have high salience since they ultimately made the decision as to whether a technology was further developed. In this activity, the interviews showed that tension was evident between Quadruple Helix stakeholders, stressing the complexity of stakeholder engagement.

In Case 1, some AEs expressed their dissatisfaction over how technologies were appraised. An AE in Case 1 noted, *'If you have a technology that does not fall directly in there it is very hard convincing them there is something'.* In fact, a common sentiment amongst the AEs was that external experts should be sought and consulted for every disclosure to overcome internal subjectivity. However, the TTOs in both cases identified that any deficits in knowledge was supplemented by external industry sources on a contractual basis. Consequently, industry and end users were considered a key stakeholder in contributing to technology assessment and appraisal. However, as mentioned, Case 2 had stronger engagement with industry and end users due to enterprise and industry liaison being high on their internal promotion agenda. As a result, TTO staff within Case 2 often had well developed personal industry networks which they consulted to gauge interest in disclosed technologies. A TTO in Case 2 noted '*I can just phone XX (industry) up and get their opinion which is based on how things are progressing in the sector*'. Consequently, industry and end users were considered to have high salience in Case 2 since they possessed the power and legitimacy to influence the outcome at this stage of the commercialisation process (Table 3).

Whilst Case 1 did have contacts with industry, these were less developed and often industry specific. In Case 1, industry possessed power and legitimacy but lacked urgency since technology commercialisation was not considered to be high on the agenda for certain social science disciplines. In Case 1 the AE lacked power and urgency since academic enterprise was

not high on the remit of this research intensive university; consequently, in Case 1 the AE had low salience whilst in Case two they had moderate salience since they had power due to the flexible promotional mechanisms.

In both universities, Quadruple Helix stakeholder engagement appeared to continue to be two-way between the AE and the TTO and the TTO, industry and end users. Government continued to have low salience lacking power and legitimacy at this micro level stage since all these process were conducted largely internally without a need for government intervention. However, it was stressed by government that more co-creational collaboration and engagement with industry was needed to enhance the chances of commercialisation success and to facilitate the shaping of technologies from an early stage to meet the needs of both the region and society since '*there's no point developing technologies that no-one wants…or even what we want locally*' (GOV). Government considered industry and end users to be high salience definite stakeholders from the initial disclosure stages and as a core source of knowledge facilitating technology appraisal and assessment however, there was a mismatch between the low and moderate salience industry and end users actually had in both the Case Universities and the expectations of government.

Seeking Funding and Further Concept Development

Funding support for technology commercialisation appeared to come from a wide range of Quadruple Helix stakeholders, each with their own priorities. Both universities had internal 'proof of concept' funds administered through their respective TTOs to support very early stage technologies so they could be developed to a point where larger funding streams could then be applied for. At this stage, market research was also carried out by both the technology commercialisation staff and the AE. It was evident that in Case 1, AEs continued to lacked

urgency and had low salience since technology commercialisation was not high on the University's remit. However, the two TTOs had high salience during this activity where they exerted their influence on the AE to seek out additional funding to ensure the university had a return on their investment.

Tension and hostility was apparent at this stage in both universities as AEs believed it was the responsibility of the TTO to progress the technology from the business side and for them to continue to develop the technology. Indeed, TTO micro level activities in both universities had performance targets set at a university level which were linked to wider regional (macro) goals, therefore the TTO in both universities were subject to pressure from the regional and university levels to progress technologies. However, the AE was identified as the driving force to progress the technology through the different stages of commercialisation. This finding was interesting since in case 1, the AE did not appear to have much power until external funding had been obtained. This disparity over the role of the AE and the lack of salience that he/she had in the early stages of the commercialisation process stressed the need for greater co-creational engagement of the AE in early stage technology commercialisation activities.

The search for funding often involved the TTO and AE engaging with members of industry and end users including external consultants who developed market research reports on particular industries. This engagement was more established in Case 2, where industry and end users had high salience. Industry and end user engagement and investment at this stage often led to their direct input in shaping the development of the technologies exerting their salience to achieve their own objectives. Thus, engagement at this stage was seen as often being co-creational in Case 2 (Table 3). Engaging with industry was found to help identify the demand for the product, key competitors and potential companies interested in investing in, or licensing,

the technology (McAdam et al. 2005). In contrast, within Case 1, due to the lack of urgency of the AE to commercialise, industry and end users appeared to have moderate salience where they lacked legitimacy and thus engagement appeared to be two-way.

The high salience of multiple stakeholders in the cases (Table 3) was seen to cause conflict at this stage. Indeed, a CE in Case 1 identified, '*you have multiple stakeholders, all of which want reporting metrics, a surprising number of them being mutually exclusive. It's the nature of the beast*'. However, there appeared to be a misalignment between the salience levels and engagement between certain stakeholders. For example, engagement between government and the AE appeared to be a one-way or at best a two-way dialogue leading to unresolved conflicting objectives in relation to timescales and outcomes ultimately leading to lack of direction and misuse of scarce resources.

Commercialisation Entity

The last core commercialisation activity was the selection of the most appropriate commercialisation route. Potential routes typically included licencing agreements, joint ventures formed between the university and industry or spin-offs. It was identified that the commercialisation entity was largely dictated by the nature of the technology, with certain technologies lending themselves to the licencing agreements as opposed to the spin-out route. However, a TTO in Case 1 identified that other influences dictated the process of commercialisation. '*You go with what funders want. At the moment (government agency) seem to want spin-out companies and they are providing a lot of money so spinout companies are very much an option*' (TTO in Case 1). Thus government appeared to have high salience if they were a funder of a technology. However, it was identified by both TTOs that a technology would only be developed into a spin-out company if it was the optimal solution since it was a

very resource intensive and risk laden process. It was noted that the economic performance measures set at the regional level often dictated the commercialisation entity route adhered to. Thus, it was suggested that the funders of the technology had an influence over its progression to market.

There was tension amongst some of the AEs in both cases surrounding the actual rules and procedures that the TTO had for commercialisation reflecting the divergence of goals between the stakeholders and a lack of effective engagement. In one instance, a particular AE from Case 2, wanted to spin-out a company but technology commercialisation processes within that institution stated that a viable spin-out company required having potential customers identified in order to avoid the funding culture dependency. The AE perceived the technology commercialisation processes to be flawed since if there was sufficient number of potential customers they would not need funding support: *'The point was to help us get to that stage and they wouldn't let us spin it out so I am still a bit peeved about that. Actually I didn't go back to the TTO for about three or four years after that'* (Case 2 AE). Thus the AE in both universities did not appear to have high salience to control the commercialisation route, they had legitimacy and urgency but ultimately lacked power. Both universities had spin-out entities which acted as a platform for technologies within their respective universities to spin-out. These entities were made up of members of industry and academia who then sat on the board of the newly formed spin-out company and consequently industry and end users in both cases had high salience to shape its development. However, an AE in Case 2 did not appear satisfied with this perceived bureaucratic structure in controlling complex technology development. *'I will never have a company where they will own enough to control it. A non-technical person to run a highly technical company is not on'* (AE in Case 2).

Furthermore, an AE from Case 2 did not agree with the amount of equity an AE had to give to the university when commercialising a technology. The tensions over equity and IP valuation at micro levels were shared by Government. A government interviewee identified '*one of the issues we have identified is the evaluation of IP in the early stage and their unrealistic expectations compared to the expectations of industry*'. They went on to identify that valuation of IP between government, industry and universities were inconsistent. It was noted '*what would improve the commercialisation process within universities would be some independent process whereby IP is valued, independent of industry, independent of academia…*' (GOV). This issue of a miss-match between equity valuations was recognised by both universities as a deterrent to licencing technologies. The sources of conflict and disharmony between the various high salience Quadruple Helix stakeholders concurs with prior literature which identifies that each high salience stakeholder will try to exert their power to achieve their own objectives. However, there did appear to be co-creational engagement in Case 1 in later stages of the commercialisation process. It was suggested by both the government staff and the strategic TTO staff members in Case 1 that a collaborative platform may aid relations between Quadruple Helix stakeholders in the future.

Discussion

From the findings it was evident that Quadruple Helix stakeholder salience plays a key role in influencing micro level technology commercialisation processes which ultimately impacts upon stakeholder engagement. As shown in Table 3, the salience of each stakeholder varies at different micro level stages and also varies according to university type, reflecting the complexity of engaging with quadruple helix stakeholders to aid commercialisation success (Miller et al. 2016). This is important given the growing interest as to how universities can develop more collaborative links with industry and end users in line with policy demands

(MacGregor et al. 2010; Ivanova 2014). Concurring with prior literature, university type, which determined the academic remit was a key influencing factor impacting upon the ability of the case universities to engage with quadruple helix stakeholders at micro levels (Ambros et al. 2008; Okamoro and Nishimura 2013; Perkmann et al. 2013; Muscio and Vallanti 2014).

It was evident that Case 1 struggled to balance the conflicting demands of different remits, reflecting an inability to be ambidextrous due to the organisational context (Gibson and Birkenshaw 2004; Markmann et al. 2008; Ambros et al. 2008). This meant that AE's, TTO's, industry and end users lacked legitimacy at initial micro level stages of the technology commercialisation process, with legitimacy only emerging for many stakeholders in the later commercialisation stages (O'Kane et al. 2014; Miller et al. 2016). Furthermore, the academic remit and focus on publications and research funding meant that many AEs in Case 1 lacked the motivation to not only disclose technologies but also impacted upon expectations and norms regarding engaging with industry and end users (Nooteboom et al. 2007; Muscio and Pozzoli 2013). In contrast, the internal promotional mechanisms which recognise academic enterprise and technology commercialisation in Case 2 meant that all stakeholders possessed legitimacy from the initial micro level stages. This meant that the AE, TTO had high salience and industry and end users had moderate salience compared to those stakeholders all having low salience in Case 1. This higher salience meant that there was greater engagement and interaction between the quadruple helix stakeholders in Case 2 from the initial stages of the technology commercialisation process (Okamuro and Nishimura 2013).

It was evident that the internal culture, academic remit and corresponding performance mechanisms of the two universities continued to dictate the power, legitimacy and urgency of Quadruple Helix stakeholder groups involved at each micro level technology

commercialisation stage (Mitchell, Agle and Wood 1997; Miller, McAdam and McAdam 2014). Recognition of relative salience levels is important for optimisation of resources (Labelle and Aka 2012) which are becoming increasingly restricted due to many universities experiencing a reduction in government funding (McAdam et al. 2012).

It was also identified that stakeholder engagement mechanisms were instrumental in aligning Quadruple Helix stakeholders across all of stages of technology commercialisation. Concurring with prior literature (Foster and Jonker 2005; Morsing and Schultz 2006), higher salience stakeholders did require higher levels of stakeholder engagement to ensure university technology commercialisation activity was aligned with stakeholder needs. Hence, it is evident that there is a need for a continual stage based assessment of stakeholder salience to reduce the chances of misaligned micro level activity and hence misuse of scarce resources (De Silva 2015). However, there appeared to be a mismatch between the salience attributed to certain stakeholders and the expectations from policy of operating within an effective Quadruple Helix ecosystem. The core premise of an effective Quadruple Helix ecosystem is co-creational knowledge transfer and engagement between universities, government, industry and end users (Arnkil et al. 2010; Mian 2013) however, this research identifies that this ideal is difficult to translate at the ground level where organisational idiosyncrasies, cultures and policies dictate the salience attributed to stakeholders and consequently their engagement.

Concluding remarks

The research question on which this paper rests explored the challenges faced by universities when managing quadruple helix stakeholders within the technology commercialisation processes. This resulted in the adoption of a qualitative research methodology which relied upon comparative case analysis to explore the technology commercialisation process in two

universities within a UK region. The findings revealed that university type impacts Quadruple Helix stakeholder salience and engagement at micro levels and consequently university technology commercialisation activities and process. This is important as recent European regional policy fails to account for contextual influences when promoting Quadruple Helix stakeholder relationships with the aim of co-creational university technology commercialisation.

The contributions made in this paper represents progressive coherence (Locke and Golden-Biddle, 1997) in that they facilitate 'next stepping' (Gephart 1986) of stakeholder theory through the micro level exploration of the use of stakeholder constructs to address calls for research at a micro level (Ambros et al. 2008; Bjerregaard 2009) to help understand Quadruple Helix relationships within a university context (Sharif, Liu and Ismail 2014). Accordingly, we make the following contributions. First, we provide novel empirical insights into the quadruple helix phenomenon and the implications it has for the university commercialisation process at a micro level. Second, through adoption of the stakeholder lens, it was evident that the academic entrepreneur's perceived power, legitimacy and urgency with respect to technology commercialisation was critical in determining the ultimate engagement with industry and end users, particularly at the initial technology disclosure stage. However, university remit determines the norms, motives and expectations regarding engagement with industry and end users which may be a hindering factor for some universities. This leads to our third contribution where we stress the importance of contextual influences when exploring these Quadruple Helix stakeholder relationships; where the university type may impact the salience attributed and engagement levels. From a managerial viewpoint, this paper provides insights into how TTO managers involved in university technology commercialisation can maximise the effectiveness of Quadruple Helix relationships dependant on commercialisation stage and university type.

From a policy perspective, the findings from this research extend beyond its initial UK context by highlighting the micro level challenges involved in implementing recent European policy initiatives and the importance of co-creational Quadruple Helix stakeholder relationships within university technology commercialisation. The theoretical constructs used to map salience and engagement are applicable in other regions and to other university types and thus will help universities align their stakeholder engagement strategies with expectations of European policy initiatives.

Given the research question on which this paper rests, a case study approach was deemed appropriate. It is important to note at this juncture, that case study research does not lend itself to empirical generalizability (Yin 2014) however, through the adoption and application stakeholder constructs, analytical generalisation was achieved. Although, all regional contexts are unique and are not subject to generalisation, the analytical critique developed within this paper, could be further enhanced by future research encompassing cross sectional theory testing using large survey data in other countries to explore the relationships between stakeholder salience (power, legitimacy, urgency) and engagement type (one, way, two way and co-creational) in influencing successful collaborative university technology commercialisation.

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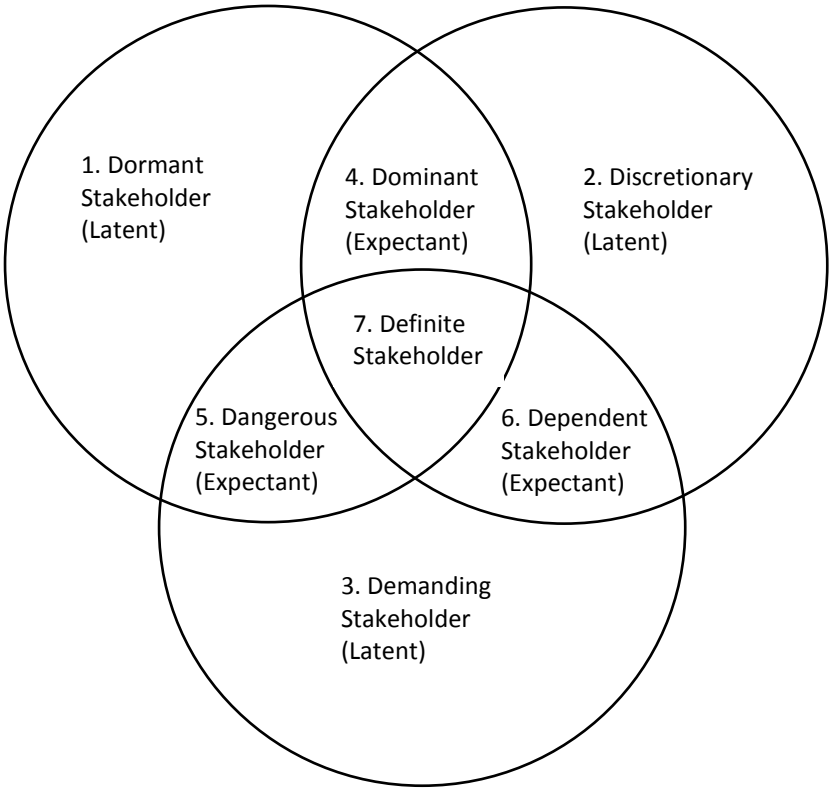

- Quadruple helix stakeholders are latent if they possess only one attribute and therefore will have low salience. Latent stakeholders include dormant stakeholders who have power, discretionary stakeholders who possess legitimacy and demanding stakeholders who only have urgency but no power or legitimacy.
- Quadruple helix stakeholders are expectant if they possess two attributes and therefore will have moderate salience. They include dominant stakeholders who possess power and legitimacy, dependent stakeholders lack power but both have urgency and legitimate claims and dangerous stakeholders have both urgency and power but lack legitimacy.
- Quadruple helix stakeholders are definitive if they possess power, legitimacy and urgency simultaneously and therefore will have high salience.

Figure 1 Stakeholder Salience Model (text at side applied to a quadruple helix context, adapted from Mitchell et al. 1997)

Table 1: Characteristics of the two regional universities

	Case 1	Case 2
Age	Established in 1908	Established in 1994
Grouping	Russel Group	University UK
Focus	Research led and research intensive where excellence in research is seen as the leading driver of the University in other areas	Emphasis on a broad three strand contribution based on teaching and learning, research and academic enterprise
Aims	Centres of excellence for basic and applied research to entrain funding and to inform teaching, learning and academic enterprise	Emphasis on increased inclusivity through a broad teaching and learning provision with an applied academic enterprise agenda supported by applied research in specific STEM fields
Academic staff pathways	Career progression and reward for Academic staff is based on REF criteria in terms of research based publications (typically 12 star plus for most disciplines). Academic enterprise is viewed as an additional activity	Academic staff are encouraged to major on two of the three career path routes; academic enterprise, research and teaching and learning. Those included in academic enterprise are requested to engage in a wide range of funded activities (e.g. KTPs, Innovation Vouchers)
Current FTE student numbers	Approx. 25000	Approx. 25000
Campus	Single Campus	Multi Campus
Academic Staff	Approx. 2500	Approx. 1700
Undergraduate fees - set by regional government	£3575	£3575

Non student fee funding	Primary focus on UK Research Council funding with a secondary focus on EU funding (e.g. FP7 and Horizon 2020)	Emphasis on applied funding from academic enterprise and applied research activities, with research council funding in specific STEM fields
Core research strengths	Medicine, life and health sciences, engineering and physical sciences	Life and health sciences, engineering and physical sciences.
Patents granted over the past 5 years	91	68
Spin out companies over past 5 years	11	8
Licence income over past 5 years	Approx. £1,400,000	Approx. £800,000
Academic enterprise strategy	• Activities in support of research • Focus university Technology transfer activities in support of the research agenda • An emphasis on entraining organisations based on research spin off activities	• Academic pathway • Emphasis on technology transfer funding to be self-sustaining • Emphasis on engagement with local SME businesses

Table 2: Profile of Respondents

Respondent Type and Code	Case	Area of Specialism	Reporting for which helix in the Quadruple Helix
Academic Entrepreneurs (AE)	5 from Case 1	3 from Engineering and Physical Sciences 1 from Medicine 1 from Life and Health Sciences	University
	5 from Case 2	3 from Engineering and Physical Sciences 2 from Life and Health Sciences	
Head of School (HOS)	2 from Case 1	1 from Engineering and Physical Sciences 1 from Life and Health Sciences	University
	2 from Case 2	1 from Engineering and Physical Sciences 1 from Life and Health Sciences	
Technology Commercialisation Executives (TTO) Staff	2 from Case 1	1 responsible for Engineering and Physical Sciences and 1 responsible for Life and Health Sciences	University
	1 from Case 2	1 responsible for Engineering and Physical Sciences and 1 responsible for Life and Health Sciences	
Technology Commercialisation Managers (TTOM)	1 from Case 1	General	University, Industry and End User
	1 from Case 2	General	
	2 from Case 1	General	Industry and End Users

Industry/ End User Business Liaison Manager (BL)	2 from Case 2	General	
Research and Enterprise Strategic Staff Member (RES)	1 from Case 1	General	University, Industry and End User
	1 from Case 2	General	
Government Commercialisation Executive(GOV)	3 responsible for both Case 1 and Case 2	1 responsible for Engineering and Physical Sciences, 1 responsible for Life and Health Sciences and 1 responsible for Arts, Humanities and Social Sciences	Government
Government Managerial Staff Member (GOVM)	1 responsible for both Case 1 and Case 2	General	
Government Strategic Staff Member (GOVS)	1 responsible for both Case 1 and Case 2	General	

Table 3: Evidence Table

Key Micro Level Activity	Case 1 Key Stakeholders and Salience	Micro Level Engagement Levels	Case 2 Key Stakeholders and Salience	Micro Level Engagement Levels
Technology Disclosure	AE - Low/Dormant – possess power, lacks urgency and legitimacy	Two - Way	AE - High/Definitive – possess power, legitimacy and urgency	Two-Way
	TTO – Low/Demanding – possesses urgency but lacks legitimacy and power		TTO – High/Definitive – possess power, legitimacy and urgency	
	HOS – High/Definitive – possess power, legitimacy and urgency		HOS – Low/Discretionary – possess legitimacy, lacks power and urgency	
	Industry and End Users – Low/Discretionary – possess legitimacy, lacks power and urgency		Industry and End Users – Moderate/Dominant – possess power and legitimacy	
	GOV - Low/Demanding – possesses urgency but lacks legitimacy and power		GOV - Low/Demanding – possesses urgency but lacks legitimacy and power	
Technology Assessment, Appraisal and Patenting	AE – Low/Discretionary – possess legitimacy	Two-Way	AE – Moderate/Dominant – possess power and legitimacy	Two-Way
	TTO – High/Definitive - possess power, legitimacy and urgency		TTO - High/Definitive – possess power, legitimacy and urgency	
	HOS - High/Definitive – possess power, legitimacy and urgency		HOS - Low/Discretionary – possess legitimacy, lacks power and urgency	
	Industry and End Users – Moderate/Dominant – possess power and legitimacy		Industry and End Users - High/Definitive – possess power, legitimacy and urgency	
	GOV – Low/Demanding – possesses urgency but lacks legitimacy and power		GOV - Low/Demanding – possesses urgency but lacks legitimacy and power	

Seek Funding and Further Concept Development	AE – Low/Discretionary – possess legitimacy	Two-Way	AE - High/Definitive - possess power, legitimacy and urgency	Two-Way/Co-Creational
	TTO - High/Definitive - possess power, legitimacy and urgency		TTO - High/Definitive - possess power, legitimacy and urgency	
	HOS - High/Definitive – possess power, legitimacy and urgency		HOS - High/Definitive – possess power, legitimacy and urgency	
	Industry and End Users– Moderate/Dangerous – possess power and urgency		Industry and End Users - High/Definitive - possess power, legitimacy and urgency	
	GOV - High/Definitive - possess power, legitimacy and urgency		GOV - High/Definitive - possess power, legitimacy and urgency	
Commercialisation Entity	AE – Moderate/ Dependent – possess legitimacy and urgency	Two-Way/Co-Creational	AE – Moderate/Dependent – possess legitimacy and urgency	Two-Way/Co-Creational
	TTO - High/Definitive - possess power, legitimacy and urgency		TTO - High/Definitive - possess power, legitimacy and urgency	
	HOS - High/Definitive - possess power, legitimacy and urgency		HOS - High/Definitive - possess power, legitimacy and urgency	
	Industry and End Users - High/Definitive - possess power, legitimacy and urgency		Industry and End Users - High/Definitive - possess power, legitimacy and urgency	
	GOV - High/Definitive - possess power, legitimacy and urgency		GOV - High/Definitive - possess power, legitimacy and urgency	