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

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 interaction between Quadruple Helix stakeholders within the university technology commercialisation process using a stakeholder lens. 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 how Quadruple Helix stakeholder interactions directly impact micro level activities and processes in universities. Accordingly, this paper adopts a micro level approach to explore the interaction between Quadruple Helix stakeholders within the university technology commercialisation process using a stakeholder lens. The paper commences with an overview 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 Quadruple Helix Stakeholder interactions 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.

Our Theoretical Framing - Stakeholder Management Processes

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 role of 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). Preeble (2005), consistent with Freeman (1984), argues that mapping stakeholders onto models and processes should identify the stakeholders and their relationships to the entity under consideration. Freeman's (1984: 46) approach also highlights that a two-way relationship needs to exist 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.

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 (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 prioritisation of Quadruple Helix 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 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).

Prior research identifies the complexity of developing more collaborative university technology commercialisation processes involving diverse stakeholder engagement (Miller et al., 2014; Sharif, Liu and Ismail, 2014; Rossi and Rosli, 2014). Indeed, Miller et al., (2014) identify that conflicting stakeholder demands can lead to disharmony and divergence in strategic decisions during commercialisation processes which can put a strain on scarce resources. Perkmann et al., (2013) argue that a wide range of individual, organisational and institutional factors may impact academic engagement with stakeholders during commercialisation processes. However, Ambros et al., (2008) found that tensions between conflicting stakeholder demands is more prominent at an individual as opposed to an organisational level where academics are faced with tensions between academic and commercial demands. Thus, a stakeholder lens is deemed apposite in order to understand the complexity of Quadruple Helix stakeholder's engagement in university commercialisation processes and so improve alignment with regional innovation policy.

Research Methodology

Given our intention to aid understanding of the complex phenomena of quadruple stakeholder relationships 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 with multiple stakeholders involved in university technology commercialisation processes of two universities within a peripheral region. 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 differing histories and approaches to university technology commercialisation. A heterogeneous purposeful sampling strategy was followed in order to select respondents who were information rich (Patton 2002) and consequently would be informative on the context under study. Table 2 identifies the interviewees which took part in the study and their associated codes. University stakeholders comprised of the academic entrepreneurs (AE) involved in university technology commercialisation, 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 and Discussion of Findings

From the empirical findings, an evidence Table (Miles and Huberman 1994) was extracted and subsequently 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.

[Insert Table 3 here]

Stakeholders and Key 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. C2AE2 noted, *'As an academic you have teaching and research - technology transfer and commercialisation doesn't always fit neatly with research'*. Concurring with prior literature, there appeared to be tension between a AEs ability to engage in both high quality research and academic enterprise (Rothaermel, Agung and Jiang, 2007; Perkmann et al., 2013). A number of AEs in Case 1 stated, they were judged by Research Excellence Framework (REF) outputs rather than

commercialisation success measures (Watermeyer, 2014), thus *'There is a real feeling that enterprise not a core initiative'* (C1AE1). The lack of perceived incentives or motivation internally within the university for academics to engage in university technology commercialisation was found to impact their willingness to disclose any commercially viable ideas, with some AEs in Case 1 preferring to release IP through internationally recognised publications, where it was deemed they would obtain greater reward and recognition internally. 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). This finding is consistent with Van Looy et al. (2011) and Hewitt-Dundas (2012) who stress that university type will impact engagement with university technology commercialisation activities. In contrast, in Case 2, C2AE3 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, C1 AE2 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 academics 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 et al. 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 (Van Looy et al. 2011; Hewitt-Dundas 2012). 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 AE had the power, urgency and legitimacy to engage in technology commercialisation (Table 3).

The core remit of each university and promotional mechanisms (Van Looy et al. 2011; Hewitt-Dundas 2012) 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. C1TTO2 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 (Bastalich, 2010; Watermeyer, 2014).

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 power as a result of recent innovation policy but lacked urgency and legitimacy to enforce this power as a result of university processes (McAdam et al. 2012; Miller, McAdam, and McAdam 2014). 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 (Rothaermel, Agung and Jiang, 2007; Miller, McAdam, and McAdam, 2014).

At the technology disclosure stage, engagement between the different Quadruple Helix stakeholder groups in both cases appeared to be largely two way (Foster and Jonker 2005; Morsing and Schultz 2006). However, in Case 1, despite the two-way engagement, the high salience of the HOS often led them to exert their influence over a AEs engagement with university technology commercialisation (Mitchell, Agle, and Wood 1997; Frooman 1999), 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 (Mitchell, Agle, and Wood 1997) since they ultimately made the decision as to whether a technology was further developed (McAdam et al. 2010). In this activity, the interviews showed that tension was evident between Quadruple Helix stakeholders, stressing the complexity of stakeholder engagement (Nenonen and Storkbacka 2010). In Case 1, some AEs expressed their dissatisfaction over how technologies were appraised. C1AE3 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. Extant research (Rothaermel, Agung and Jiang, 2007; Urbano and Guerrero, 2013) recognises that TTOs often have a lack of resources spanning discipline areas, which can affect their initial assessments of technology disclosures. 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 (Arnkil et al. 2010). 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. As C2TTO1 noted '*I can just phone XX (industry) up and get their opinion which is based on how things are progressing in the secto*r'. 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 (Mitchell, Agle, and Wood 1997; Frooman 1999) (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 (Mitchell, Agle, and Wood 1997) since technology commercialisation was not considered to be high on the agenda for certain social science disciplines. The AEs in both cases were considered to lack power during technology appraisal and assessment however, possessed legitimacy. Furthermore, in Case 1 the AE lacked 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.

In both universities, Quadruple Helix stakeholder engagement appeared to continue to be two-way between the AE and the TTO and the TTO and industry/end users (Preeble 2005; Morsing and Schultz 2006). 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 (Arnkil et al. 2010; Leysdorff 2012) since '*there's no point developing technologies that no-one wants…or even what we want locally*' (GOV2). 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 /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 (Holmes and Moir 2007; Nenonen and Storkbaca 2010). 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 (McAdam et al. 2010). 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 (Hewitt-Dundas 2012). However, the two TTOs had high salience during activity where they exerted their influence on the AE to seek out additional funding to ensure the university had a return on their investment (Mitchell, Agle, and Wood 1997; Frooman 1999).

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 (Macho-Stadler, Perez-Castrillo, and Veugelers 2007; McAdam et al. 2005, 2010). 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 concurring with McAdam et al. (2010) and Mangematin, O'Reilly, and Cunningham (2014) 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 (Morsing and Schultz 2006; Edvardsson, Tronvoll, and Thorsten 2011).

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 had high salience (Mitchell, Agle, and Wood 1997). 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 (Frooman 1999; Holmes and Moir 2007). Thus, engagement at this stage was seen as often being co-creational in Case 2 (Prahalad and Ramaswamy 2004; Edvardsson, Tronvoll, and Thorsten 2011) (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 (Mitchell, Agle, and Wood 1997) and thus engagement appeared to be two-way (Edvardsson, Tronvoll, and Thorsten 2011).

Concurring with prior research (Nenonen and Storkbacka 2010; Miller, McAdam, and McAdam 2014) the high salience of multiple stakeholders in the cases (Table 3) was seen to cause conflict at this stage. Indeed, C1CE1 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 (Holmes and Moir 2007; De Silva, 2015).

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 agreement as opposed to the spin-out route. However, C1TTO2 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*' (C1TTO2). Thus government appeared to have high salience if they were a funder of a technology. In addition, in Case 1, it was identified that the university remit resulted in licences often being a more attractive option so that the AE could then return to focusing on their research. Thus, the HOS was seen to have high salience in Case 1. 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 (Frooman 1999; Miller, McAdam, and McAdam 2014).

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 (McAdam et al. 2010; Edvardsson, Tronvoll, and Thorsten 2011). 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'* (AE15). 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 had industry and end users in both cases had high salience to shape its development. However, C2AE3 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'* (C2AE3).

Furthermore, AE3 from Case 2 did not agree with the amount of equity a 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. GOV2 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'. GOV1 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…*' (GOV1). 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 (Frooman 1999; Nenonen and Storkbacka 2010; Miller, McAdam, and McAdam 2014). 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. Indeed, Holmes and Moir (2009) identify that when high salience stakeholders are collaborating, there is a need to improve communicative capacity to enhance the success of the engagement.

Conclusions

From the findings, it can be concluded that Quadruple Helix stakeholder salience plays a key role in influencing all stages of university technology commercialisation process. However, as shown in Table 3, the salience of each stakeholder varies at different stages and also varies according to university type, reflecting the complexity of commercialisation success. This is important with the growing interest as to how universities can develop more collaborative links with industry and end users. The internal culture, academic remit and corresponding performance mechanisms of the two universities was found to dictate the power, legitimacy and urgency of Quadruple Helix stakeholder groups involved in technology commercialisation

processes. 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). It was 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. However, there appeared to be a mismatch between the salience attributed to certain stakeholders and the expectations of operating within an effective Quadruple Helix ecosystem. For example, as shown in Table 3, AEs in Case 1 had low levels of salience in the initial stages of technology commercialisation. Furthermore, the academic remit in Case 1 which placed emphasis on research funding and high quality publications meant that engagement levels with industry and end users were lower than in Case 2. In contrast, the academic remit in Case 2 which recognises academic enterprise as a core route to promotion led to industry and end users being attributed higher levels of salience and engagement during technology commercialisation. The core premise of an effective Quadruple Helix ecosystem is co-creational knowledge transfer and engagement between universities, government, industry and end users, however, this research identifies that this ideal is difficult to translate on the ground level where organisational idiosyncrasies, cultures and policies dictate the salience attributed to stakeholders and consequently their engagement.

The contribution of this paper is an example of progressive coherence (Locke and Golden-Biddle, 1997) in that it facilitates ‘next stepping’ (Gephart, 1986) in terms of moving the current debate forward through the micro level exploration of the use of stakeholder constructs to address calls for research to help Quadruple Helix relationships within a university context

(Sharif, Liu and Ismail, 2014). In so doing, it demonstrates the need to consider contextual influences when exploring Quadruple Helix stakeholder relationships; where the university type may impact the salience attributed and engagement levels. 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. From a practitioner viewpoint, this paper provides insights into how practitioners involved in university technology commercialisation can maximise the effectiveness of Quadruple Helix relationships dependant on commercialisation stage and university type.

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, the analytical critique developed within this paper, could be further enhanced by future research encompassing cross sectional theory testing using large survey data in relation to 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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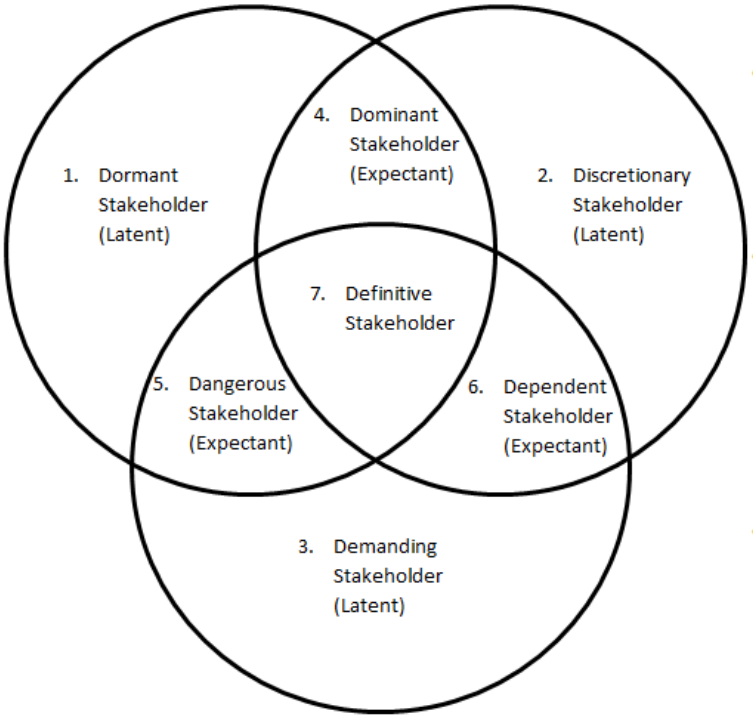

- Latent stakeholders have little salience as they possess only one attribute and include dormant stakeholders who have power, discretionary stakeholders who possess legitimacy and demanding stakeholders who only have urgency but no power or legitimacy.
- Expectant stakeholders possess two attributes and moderate salience to managers as a consequence. Thus, dominant stakeholders possess power and legitimacy and form the dominant coalition of the enterprise. Dependent stakeholders lack power but have both urgent and legitimate claims. Dangerous stakeholders have both urgency and power but lack legitimacy.
- Definitive or definite stakeholders have a high degree of salience as managers perceive power, legitimacy and urgency to be present simultaneously.

Figure 1 Stakeholder Salience Model (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	Russell Group	Universities UK
Focus	Research led and research intensive where excellence in research is seen as the leading driver of the University in all 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 teach and 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 specified STEM fields
Academic staff pathways	Career progression and reward and recognition for Academic staff is based on the REF criteria in terms of research based publications (typically 12star plus for most disciplines). Academic Enterprise is viewed as an additional activity along with Teaching and Learning.	Academic Staff are encouraged to major on two of the three Career path routes: academic enterprise, research and teaching and learning. Those including Academic Enterprise are requested to engage in a wide range of funded activities (e.g. KTPs, University Technology Transfer Innovation Vouchers).
Current FTE Student Numbers	Circa 25000	Circa 25000
Campus	Single campus	Multi Campus (n=4)
Undergraduate Fees - set by regional government for both Universities	£3,575	£3, 575
Non-Student Fee Funding	Primary emphasis 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 disciplines.
Academic Enterprise strategy	- Activities in support of research - Focus University technology Transfer activities in support of the research agenda. - An emphasis on entraining organizations based on research spin off activity	- Academic pathway - Emphasis on University technology transfer funding to be self sustaining. - An emphasis on engagement with local SME businesses.

Table 2: Profile of Respondents

Code	Case	Job Title
C1AE1	1	Academic Entrepreneur
C1AE2	1	Academic Entrepreneur
C1AE3	1	Academic Entrepreneur
C1AE4	1	Academic Entrepreneur
C1AE5	1	Academic Entrepreneur
C2AE1	2	Academic Entrepreneur
C2AE2	2	Academic Entrepreneur
C2AE3	2	Academic Entrepreneur
C2AE4	2	Academic Entrepreneur
C2AE5	2	Academic Entrepreneur
C1TTO1	1	Technology commercialisation executive
C1TTO2	1	Technology commercialisation executive
C1TTOM	1	Technology commercialisation manager
C2TTO1	2	Technology commercialisation executive
C2TTO2	2	Technology commercialisation executive
C2TTO3	2	Technology commercialisation executive
C2TTOM	2	Technology commercialisation manager
C1BL1	1	Industry/ end user business liaison staff member
C1BL2	1	Industry/ end user business liaison staff member
C2BL1	2	Industry/ end user business Liaison staff member
C1S	1	Research and enterprise strategic staff member
C2S	2	Research and enterprise strategic staff member
GOV1	1&2	Government commercialisation executive
GOV2	1&2	Government commercialisation executive
GOV3	1&2	Government commercialisation executive
GOV4	1&2	Government managerial staff member
GOV5	1&2	Government strategic staff member

Table 3: Evidence Table

Key Micro Level Activity	Case 1 Stakeholder and Salience	Micro Level Engagement Levels	Case 2 Key Stakeholder and Salience	Micro Level Engagement Levels
Technology Disclosure	AE - Low/dormant – possesses power, lacks urgency and legitimacy due to university remit	Two-way	AE - High/definitive – possesses power, legitimacy and urgency	Two-way
	TTO – Low/demanding – possesses urgency but lack legitimacy and power due to university remit		TTO – High/definitive – possesses power, legitimacy and urgency	
	HOS – High/ definitive – possesses power, legitimacy and urgency		HOS – Low salience/ discretionary – possesses legitimacy	
	Industry/End Users - Low/dormant – possesses power, lacks urgency and legitimacy		Industry/End Users - Moderate/Dominant – possess power and legitimacy	
Technology Assessment, Appraisal and Patenting	TTO - High/definitive – possesses power, legitimacy and urgency	Two Way	TTO - High/definitive – possesses power, legitimacy and urgency	Two Way
	Industry-Moderate/Dominant – possess power and legitimacy		Industry-High/Dominant – possesses power, legitimacy and urgency	
	AE – Low salience/ discretionary – possesses legitimacy		AE – Moderate/Dominant – possess power and legitimacy	
	Industry/End Users - Low/dormant – possesses power, lacks urgency and legitimacy		Industry/End Users - Moderate/Dominant – possess power and legitimacy	

Seek funding and further Concept Development - **Proof of principal** - **Proof of Concept** - **Venture capitalists** - **Private funding** - **Internal funding/competitions** - **Research councils** - **Sector specific government bodies**	TTO- High/definitive – possesses power, legitimacy and urgency	Two-way	TTO- High/definitive – possesses power, legitimacy and urgency	Two-way/ Co-creational
	GOV - High/definitive – possesses power, legitimacy and urgency		GOV - High/definitive – possesses power, legitimacy and urgency	
	AE - Low salience/ discretionary – possesses legitimacy		AE - High/definitive – possesses power, legitimacy and urgency	
	Industry - Moderate/dangerous – possesses power and urgency		Industry - High/definitive – possesses power, legitimacy and urgency	
Commercialisation Entity	AE - Moderate/dependent – possesses legitimacy and urgency	Two-way/ Co-creational	AE - Moderate/dependent – possesses legitimacy and urgency	Two-way/ Co-creational
	TTO - High/definitive – possesses power, legitimacy and urgency		TTO - High/definitive – possesses power, legitimacy and urgency	
	Industry - High/definitive – possesses power, legitimacy and urgency		Industry - High/definitive – possesses power, legitimacy and urgency	
	GOV - High/definitive – possesses power, legitimacy and urgency		GOV - High/definitive – possesses power, legitimacy and urgency	
	HOS - High/definitive – possesses power, legitimacy and urgency		HOS - High/definitive – possesses power, legitimacy and urgency	