Knowledge Transfer in Quadruple Helix Ecosystems: An Absorptive Capacity Perspective

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Abstract

Increased understanding of knowledge transfer (KT) from Universities to the wider regional knowledge ecosystem offers opportunities for increased regional innovation and commercialisation. The aim of this paper is to improve the understanding of the KT phenomena in an open innovation context where multiple diverse quadruple helix stakeholders are interacting. An absorptive capacity-based conceptual framework is proposed, using *a priori* constructs which portrays the multidimensional process of KT between universities and its constituent stakeholders in pursuit of open innovation and commercialisation. Given the lack of overarching theory in the field, an exploratory, inductive theory building methodology was adopted using semi-structured interviews, document analysis and longitudinal observation data over a three year period. The findings identify five factors, namely human centric factors, organisational factors, knowledge characteristics, power relationships and network characteristics, which mediate both the ability of stakeholders to engage in KT and the effectiveness of knowledge acquisition, assimilation, transformation and exploitation. This research has implications for policy makers and practitioners by identifying the need to implement interventions to overcome the barriers to KT effectiveness between regional quadruple helix stakeholders within an open innovation ecosystem.

1.0 Introduction

Traditionally, knowledge transfer (KT) between universities and regional stakeholders comprised of the 'pushing' or brokering of discipline-specific research outputs and/or the provision of more generalised education and skills development (Etzkowitz and Klofsten,

2005). However, in recent years, universities have been required to take on a more entrepreneurial role as core actors within regional innovation ecosystems resulting in new and diverse opportunities for KT (Etzkowitz and Leydesdorff, 2000; Arnkil et al, 2010;). Under the guise of a Triple Helix 'ecosystem', university, industry and government interactions were purported to be core elements of regional economic growth, within a knowledge-based economy (Urbano and Guerrero, 2013). However, a number of studies suggest that this largely normative KT process has not and is not delivering the expected levels of commercialisation in terms of GDP and increased jobs (Asheim and Coenen, 2005; Lawler, 2011). Cooke (2005), Arnkil et al (2010) and Kenney and Mowery (2014) suggest that Triple Helix-based KT process adds to the 'internalisation' or isolation of knowledge rather than enabling more widespread opportunities for open innovation. More recently, user-driven innovation models have emerged, which add a fourth helice leading to a quadruple helix ecosystem. This approach recognises the increased role that end-users and therefore society are playing in regional and project-based innovations (Carayannis et al., 2012; Leydesdorff, 2012). These end-users in essence create the 'pull' or demand for innovation which can lead to opportunities for open innovation (Galbraith et al. 2008; Chesbrough, 2011; Carayannis and Rakhmatullin, 2014). With the emergence of a quadruple helix ecosystem, regional innovation policy has stressed the need for universities to more fully engage in co-creational KT and open innovation with industry, government and end-users to enhance commercialisation efforts (Arnkil et al., 2010; RIS, 2014). However, KT between diverse stakeholders poses considerable challenges, where differing objectives, cultures and organisational processes and norms can impact the ability to acquire, assimilate, transform and exploit external knowledge. With the need to embrace and interact in a complex open innovation ecosystem, universities KT processes are in a state of transition (Alexander et al., 2012; Miller et al., 2014). However, there is a lack of understanding and conceptualisation as to how knowledge can be effectively transferred between universities

and regional quadruple helix stakeholders within an open innovation context (Holi et al., 2008; Chesbrough, 2010; Carayannis and Rakhmatullin, 2014). Thus the aim of this paper is to improve the understanding of the KT phenomena in a quadruple helix, open innovation context where multiple diverse stakeholders are interacting. To achieve this aim, an *ex ante* framework, derived from literature on KT between multiple stakeholders is proposed and applied to an in-depth case study. Based on the empirical findings, the initial framework has been revised and an *ex post* framework presented to aid understanding and conceptualisation of the core KT processes between universities and regional quadruple stakeholders which take place in an open innovation context.

2.0 Knowledge Transfer within an Open Innovation System

In recent years, universities have been expected to take on a more entrepreneurial role in KT within the regional knowledge ecosystem (Etzkowitz and Leydesdorff, 2000; Urbano and Guerrero, 2013) whereby they are considered as a core conduit for regional KT and innovation through their engagement in commercialisation activities (Van Looy et al., 2011).

Arnkil et al., (2010) suggest that the presence of a university and supporting regional innovation strategy (RIS) does not guarantee that KT will take place, rather it simply attempts to create conducive conditions for KT. Indeed, despite numerous governmental reports and initiatives over the past decade encouraging collaborations between regional stakeholders (e.g. Lambert Review, 2003; DTI, 2004; Sainsbury 2007; Wilson, 2012), key KT challenges in this context remain.

KT within a Triple Helix ecosystem is conceptualised as boundary spanning across academia, Industry and regional Government (Etzkowitz and Leydesdorff, 2000; Etzkowitz and Klofsten,

2005). However, with the emergence of the knowledge economy combined with the growing complexity and change of modern economic systems (MacGregor et al., 2010; Ivanova, 2014), quadruple helix structures have emerged recognising the role of end users/society as a core stakeholder within open innovation processes (Carayannis and Campbell, 2012; Leydesdorff, 2012). In certain scientific disciplines and sectors, the role of an 'extended peer user community' to aid innovation has been noted since the early 2000's (Mehta, 2004; Ivanova, 2014). Indeed, the emergence of living labs within regions identifies the benefits of user centred open innovation (Almirall and Wareham, 2008; Galbraith et al., 2008; Galbraith and McAdam, 2011). However, it is only in recent years that RIS's have stressed the need for the needs for end users/society to be more fully integrated into university KT processes (Arnkil et al., 2010; RIS, 2014). Limited studies to date have explored this changing role of universities where they are expected to engage in co-creational KT and exchange with quadruple helix stakeholder within an open innovation context (Alexander et al., 2012; Miller et al., 2014). Indeed, Schoonmaker and Carayannis (2013) identify that many universities still operate within triple helix structures, signalling the need to more fully understand the enablers and barriers of KT between diverse stakeholders within a quadruple helix open innovation ecosystem.

3.0 Conceptualising Knowledge Transfer between multiple stakeholders using an Absorptive Capacity lens

KT has been explored in a wide variety of practice based contexts, however, there is a lack of overarching or unified theory within the field (Gassman et al., 2010; Chesbrough, 2011) reflecting its relative immaturity. Hence there is a need for improved conceptualisation. Building on prior research (Tsai, 2001; Sun, 2010; Su et al., 2013) absorptive capacity is used as a lens to explore the process of KT. Absorptive Capacity has been used to explore why some

organisations transfer knowledge more successfully than others, particularly in regards to University based KT within an open innovation ecosystem (Easterby-Smith et al., 2008; McAdam et al., 2010). Furthermore, Absorptive Capacity is seen as playing a crucial role in intra and inter-organisational KT (Zahra and George, 2002; Lane et al., 2006). Hence Absorptive Capacity is put forward as a core construct in an initial *ex ante* theoretical framework.

Absorptive Capacity is defined as the ability to recognize, assimilate and apply new external knowledge to advance commercialisation and competitiveness (Cohen and Levinthal, 1990). In practice, absorptive capacity is viewed as a knowledge-based dynamic capability (Zahra and George, 2002) where the ability to acquire, assimilate, transform and exploit knowledge has been found to be a source of sustainable competitive advantage. Table 1 describes the four dimensions of absorptive capacity and details their influencing factors.

[Insert table 1 around here]

Mariano and Walter (2015) identify that absorptive capacity can be explored as an organisational, group or individual based capability. However, individual and group level absorptive capacity is reliant upon organisational routines that facilitate knowledge transfer and communication which will lead to the transfer of learning at the organisational level (Cohen and Levinthal, 1990; Lane et al., 2006). Knowledge sources and recipients (i.e. stakeholders within an open innovation ecosystem) may vary in their Absorptive Capacity levels and hence this variation may impact KT effectiveness between organisations (Cohen and Levinthal, 1990; Zahra and George, 2002; Su et al., 2013). Within the literature, Absorptive Capacity has been used in a wide range of knowledge intensive organisational contexts (Mariano and Walter, 2015), and has become a useful construct to understand why some

organisations develop more innovative products and are more successful at innovation activities than others (Easterby-Smith et al., 2008; McAdam et al., 2010). However, there is a paucity of studies using absorptive capacity constructs to explore KT processes where an open innovation climate of inflows and outflows of knowledge coexist (Mariano and Walter, 2015). Hence there is an opportunity to at least partially address this knowledge gap and facilitate theoretical development and refinement through using absorptive capacity as a lens to explore the process of KT from universities to its respective regional stakeholders within an open innovation ecosystem.

4.0 *Ex Ante* Model Development

An *ex ante* model was developed using *a priori* concepts as suggested by Bendassolli (2013) from the extant literature. Figure 1 presents the *ex ante* model which uses an absorptive capacity lens to portray the process of knowledge acquisition, assimilation, transformation and exploitation (Zahra and George, 2002). Figure 1 suggests that KT from universities for commercialisation traditionally happens within a complex network of regional stakeholder interactions however, a knowledge validation decision needs to take place or what Zahra and George (2002) refer to as an 'activation trigger' to begin the process of KT. The KT literature identifies a number of influencing factors which can impact the effectiveness of KT. These can be grouped into the characteristics of the knowledge source and recipient, properties of knowledge, network characteristics and organisation context (Szulanski, 1996; Gupta and Govindarajan, 2000; Rothaermel et al., 2007; Mitton et al., 2007; Matzler and Meuller, 2011).

[Insert figure 1 around here]

Once 'buy in' has been achieved absorptive capacity is needed to recognise the value of new knowledge, acquire, assimilate, transform and apply that knowledge to commercial ends (Cohen and Levinthal, 1990; Zahra and George, 2002). Similar to the knowledge validation

decision, figure 1 identifies that capability development is mediated by various factors which are said to have varying impact on how knowledge flows between stakeholders at each KT stage (Zahra and George, 2002). Whilst a number of barriers and enablers to KT have been identified from literature forming this conceptual model, the lack of overarching theoretical conceptualisation of KT processes between diverse stakeholders in an open innovation context (Chesbrough, 2011) stresses the need for exploratory and inductive theory building to gain further understanding of the process of KT (Holi et al., 2008). This conceptualisation is particularly important to provide both theoretical and practical insights which will help facilitate universities progression towards effective mechanisms for open innovation and commercialisation within a quadruple helix ecosystem (Sharifi and Liu, 2010; Arnkil et al., 2010; Alexander et al., 2012).

Based on the conceptual framework shown in figure 1, and the need for increased understanding as to how knowledge can be effectively transferred between universities and regional quadruple helix stakeholders three questions have been identified.

RQ1) What factors enable or prevent university KT effectiveness in relation to the absorptive capacity constructs of knowledge acquisition, assimilation, transformation and exploitation?

RQ2) What role do diverse stakeholder relationships play in progressing KT through the absorptive capacity constructs of knowledge acquisition, assimilation, transformation and exploitation in the context of open innovation and commercialisation?

RQ3) How can KT theory and practice be progressed through empirical findings demonstrating the relevance and further development of a absorptive capacity lens to depict the multidimensional nature of the process of KT amongst multiple stakeholders.

5.0 Research Methodology

In order to scrutinise the conceptual model based on *a priori* concepts (Bendassolli, 2013), an interpretivist, qualitative methodology was employed in order to inductively build theory in an under researched context. A process view of absorptive capacity was used (Zahra and George, 2002; Easterby-Smith et al., 2008) utilising the four absorptive capacity dimensions (shown in figure 1 and table 1) as a lens to explore the knowledge flows and exchanges that take place between diverse stakeholders. Following Fromhold and Weker (2013) one intrinsic case study (Stake, 2000) was chosen in order to facilitate an in-depth nuanced understanding of the factors which enhance or limit the ability of universities to engage in effective co-creational KT between diverse stakeholders in a quadruple helix open innovation context. Data was collected longitudinally over a period of 3 years using a combination of semi-structured interviews, observations and document analysis to gain a holistic view of the challenges involved in diverse quadruple helix stakeholders collaborating (Yin, 2011). Semi-structured interviews were carried out with core stakeholders involved in university KT activities. Appendix one presents the profile of the interviewees and their respective codes. Insights into KT between the university and industry/ end users was obtained through interviews with enterprise co-ordinators and KTO staff who were boundary spanners bridging the university and industry and government stakeholders. This was triangulated (Eisenhardt, 1989; Yin, 2011) with observational analysis of KT meetings which took place monthly and comprised of internal (KTO staff, PI's, enterprise co-ordinators) and external stakeholders (government, industry, end users) involved in the case university's KT activities. In addition, publically available documents were analysed relating to KT from universities and regional quadruple helix stakeholder collaborations. These documents included governmental strategies and white papers focused on collaborative KT between universities and regional quadruple helix stakeholders for the purposes of innovation.

A method of open inductive coding (Miles and Huberman, 1994) was followed resulting in the researchers deriving empirically driven labels from the interviews and observational data. An iterative and reflexive process to data analysis was followed (Fereday and Muir-Cochrane, 2006) where data was collected and interpreted through constant referral to literature to aid theory development (Yin, 2011). Coding was carried out both manually and through NVivo 10, with reflective remarks added as memos to aid the richness of the data (Bazeley, 2007). Appendix 2 graphically presents the coding process.

6.0 Results and Discussion

Based on the empirical findings, Figure 2 presents the *ex post* model of KT from universities from an absorptive capacity lens. This model presents the dynamic interactions between the diverse stakeholders within the case study and thus aids refinement of the enablers and challenges of KT within a quadruple helix open innovation context.

[Insert figure 2 around here]

6.1 Quadruple helix stakeholder knowledge transfer with the aim of commercialising university research

From the findings, it was evident that the case university had made progress over the period of research to improve collaboration and relationships between industry and end users to align with demands from regional innovation policy (Arnkil et al., 2010; Wilson, 2012; RIS, 2014). Indeed, it was identified that university funding was increasingly dependent upon the level of collaborative activities with quadruple helix stakeholders (McAdam et al., 2012; RIS 2014). However, the data identified a number of enablers and challenges existed in relation to KT between stakeholders. These are represented as latent factors within figure 2 and largely mirror the core enablers and barriers of KT identified from literature within the *ex ante* model which

illustrates the ongoing importance of these factors when engaging in more open innovation practices. Drawing upon Zahra and George, (2002) figure 2 highlights the distinction between potential absorptive capacity (PACAP) and realised absorptive capacity (RACAP) where the former refers to a firm's receptivity to acquiring and assimilating knowledge whereas the latter refers to the ability to transfer and exploit knowledge (Yeoh, 2009). Kirby (2006) identify that universities often have high PACAP as a result of the knowledge inherent within academics. In addition universities often have huge investments in R&D which provides prior knowledge for absorptive capacity. However, the empirical research identified enablers and barriers of both PACAP and RACAP development. These are summarised in table 2 and will be discussed in the sections which follow.

[Insert table 2 around here]

6.2 Enablers and Challenges for effective Knowledge Transfer

Whilst the core enablers and challenges within the case study appeared to align with prior literature, figure 2 differs from the *ex ante* model to show the interdependent nature of the latent factors which mediate both engagement in KT and the effectiveness of KT between diverse stakeholders. It was found that a combination of those factors may have either a positive or negative impact on knowledge acquisition, assimilation, transformation and exploitation (see table 2). Prior research often fails to represent the dynamic nature of factors which mediate the flow of knowledge between stakeholders (Volberda et al., 2010), with Mariano and Walter (2015) noting that KT is often taken for granted with less known about how absorptive capacity is created and developed. Therefore this research extends knowledge and understanding of the interdependent nature of enablers and barriers of KT.

6.2.1 Human-centric Characteristics

A number of personal characteristics and skills were found to affect stakeholders from engaging in KT and sharing (hence affecting knowledge validation, acquisition, assimilation, transformation and exploitation as shown in figure 2 and table 2). Concurring with prior

literature, human-centric characteristics of stakeholders such as the ability to network and individual attitudes and traits were found to affect KT (Cohen and Levinthal, 1990; Zahra and George, 2002; D'Este and Patel, 2007; Perkmann et al., 2013).

The networking capability of academic entrepreneurs was identified as a mediator of collaborative open innovation processes. Concurring with past research, it was identified that some academics continue to have a lack of expertise which prevents them from engaging in effective networking and KT with industry and end users (Lockett et al., 2003; Mosey and Wright, 2007). *"Everyone have their own personal mechanisms for networking and I suppose academic scientists are not exactly known for their interpersonal skills... I don't think there is anything that can be done"* (PI12). PI4 who had successfully developed collaborations with industry and end users to help commercialise a medical device noted the benefits that relationships with quadruple helix stakeholders can have. Industry and end users were used as a source of knowledge in the early stages of technology development, helping scope out the potential market for the technology and aiding patent applications, facilitating the development of potential absorptive capacity (PACAP- acquisition and assimilation of knowledge) (Zahra and George, 2002; McAdam et al., 2010). PI4 noted that these relationships continued to develop during the commercialisation process, where industry and end users helped co-create prototypes. The KTO staff identified that the transformation of knowledge and consequently commercialisation (i.e. realised absorptive capacity, RACAP, Zahra and George, 2002) was said to be more successful when PIs had two-way and co-creational flows of knowledge (Foster and Jonker, 2005) with industry networks and interaction with end users from the beginning of commercialisation projects signalling the benefit of embracing open innovation. However, it was identified that collaborative projects involving diverse quadruple helix stakeholders were not as common as they should be *"The majority of projects are driven by the PI with little*

interaction with industry until the later stages when they are seeking funding" (KTO2). Hence, these findings suggest the need to implement interventions to develop the networking skills of academics.

Within the case study, it was noted that intrinsic mind-sets and attitudes of individual stakeholders affected their willingness to engage in KT (Alexander et al., 2012; Perkmann et al., 2013) limiting knowledge acquisition. It was recognised by all interviewees that within the case university, academics are often working in academic silos, therefore there is a need for them to be more opportunistic. PI5 noted "*It is really up to us to engage with it and make an effort to meet different people and that is where the opportunities for collaboration arise"*. However, through the interviews and observations, it was found that these mind-sets and attitudes to collaborate with industry and end users were influenced by the organisational context. Concurring with prior research, the university remit appeared to shape individual knowledge sharing behaviours (Rothaermel et al., 2007; Perkmann et al., 2013) signalling the interdependence between these two factors which is explored further in the next section.

6.2.2 Organisational factors

It was evident that organisational factors played a key role in affecting KT between the various quadruple helix stakeholders (see figure 2 and table 2). The emergence of a dedicated KTO within the case university identified the commitment of the university to develop internal procedures which enable academic entrepreneurs to engage in KT through open innovation activities. Furthermore, it was noted that during the research period, the case university had developed a wide range of industry and end user engagement activities, namely, knowledge transfer partnerships, breakfast clubs and seminar series. However, concurring with Perkmann et al., (2013) and Miller et al., (2014), the academic remit of teaching and producing high

quality research publications was found to deter some academics from collaborating fully in open innovation activities with quadruple helix stakeholders. *"They keep expecting more and more from us, I do not know how they expect us to teach, produce 3 and 4 star publications and have time to network with industry and engage in commercialisation when over 50% of the time it does not result in something fruitful"* (PI2). It was noted by the KTO that the academic remit often leads to missed opportunities for commercialisation of knowledge due to the inherent need for many academics to publish which results in the release of their IP (Perkmann et al., 2013). However, internal promotional mechanisms did appear to be changing with one academic (PI9) highlighting that they had received their senior lectureship by engaging in KT activities with industry. Furthermore, it was noted that university funding was being linked to the impact they are having on society. "*Impact is a buzz word but no one really knows what it entails but will require closer interaction between academics research and the needs of society. We are in the process of redeveloping our processes where academics are required to consider the impact of their research before they start it. This should lead to more collaborative projects in the future*" (KTO1). Thus it was evident that internal processes and practices were undergoing development to align with the need for more collaboration between quadruple helix stakeholders. However, many PIs identified that it would take a long time to change the norms of publishing.

6.2.3 Knowledge characteristics

The characteristics of the knowledge being transferred was found to influence its ability to be acquired, absorbed and exploited. Consistent with past research (Siegel et al., 2003; Wright et al., 2009) the main type of knowledge being transferred during open innovation processes was business-related knowledge. This ranged from sales, marketing, finance, legal and experiential business knowledge; which has tacit and 'sticky' elements and is therefore often hard to

acquire, transfer and absorb (Szulanski, 2002). Hence the opportunity to increase collaboration of industry and end users at earlier stages of technology commercialisation processes was suggested as beneficial by the interviewees to increase PACAP and was found to help strengthen efforts to raise venture capital. Tacit and experiential knowledge was thought to be based on personal attitudes, abilities and experience (hence human centric characteristics); therefore was difficult to acquire and absorb (Nonaka and von Krough, 2009). KTO staff were aware of academics deficiencies in knowledge *"I know that whilst academics may be very good in their own research area and the specific areas they specialise in. Not very many of them have actually formed and sustained relationships with industry"* (KTO3). Furthermore, it was noted that that complex or 'sticky' knowledge, such as that required for innovation was said to require rich communication channels such as face to face communication to facilitate its acquisition and absorption (Szulanski, 2002; Nonaka and von Krough, 2009). Indeed, Vandekeckhove and Dentchev, (2005) identify that open communication helps reduce knowledge asymmetry which is essential when multiple diverse stakeholders are interacting, with varying objectives in an open innovation context. As noted, over the research period, the KTO had implemented a wide range of activities to connect academics with industry however, the findings suggest the need for further opportunities to enhance physical interaction between academics, end users and industry to overcome tacit knowledge gaps and increase commercialisation success (Gassmann et al., 2010; McAdam et al., 2010).

6.2.4 Power relationships

It was noted throughout the longitudinal research period that KT between multiple diverse stakeholders in pursuit of open innovation was complex and often difficult. Consistent with prior research (Easteby-Smith et al., 2008; McAdam et al., 2012), this source of conflict was often the result of varying aims and objectives. From the case study findings (and as shown in

figure 2 and table 2) it was found that power relationships had an effect on both stakeholder willingness to engage in KT (hence impacting the acquisition and assimilation of knowledge, PACAP) and the effectiveness of KT, (which was found to have a consequential impact on the ability to convert PACAP to RACAP, Yeoh, 2009), hence influencing commercialisation success.

As noted in section 6.2.2, the university remit challenged the ability to fully embrace open innovation activities, where the need to publish often conflicted with the priorities and objectives of industry and end users during collaborative open innovation projects (Van Looy et al., 2011; Hewitt-Dundas, 2012). KTO3 noted, "*well academic publications run directly counter to the commercialisation task. That is one of the great ironies at the heart of the academic research system".* However, it was identified that IP applications can be sough quite quickly thus it was stressed that greater communication between quadruple helix stakeholders was needed to eliminate potential conflict (Foster and Jonker, 2005; Van Wijlk et al., 2008).

It was suggested by several academics and KTO staff that government do not fully understand the challenges involved in KT between universities, industry and end users in the pursuit of open innovation;*"...the nature of the stuff coming out of the universities labs at that stage is a very fragile concept and you can't directly take those things and in 6 months time be employing 100 people ... You are looking at ideas and discoveries which on the day that they are disclosed to us that no one can put their hand on their heart that that is worth investing in or not... They think it (referring to Government) is perhaps an automatic one rather than a kind of hand holding, steering, developing, mentoring type one"* (KTO4). GOV2 admitted that there was a lot of bureaucracy governing quadruple stakeholder collaborations which was driven by disappointing results from previous KT programmes and innovation strategies. It was evident

from the interviews and document analysis that Government were trying to exert their power to influence how quadruple stakeholder interactions should progress through aligning funding for activities which involve open innovation between quadruple helix stakeholders. Government appeared to have stakeholder power since they had the power to withhold/withdraw funding (Frooman, 1990; Mitchell et al., 1997). This finding runs counter to the premise of a functioning quadruple helix, where all stakeholders should have mutual interdependence (Arnkil et al., 2010; Carayannis et al., 2012; Miller et al., 2014).

6.2.5 Network characteristics

Within the case study it was identified that KT quadruple helix stakeholders was aided through the case university's KTO. The KTO staff considered their role to be invaluable in helping eliminate any cultural or language problems between diverse knowledge groups. Therefore the KTO appeared to be 'boundary spanners' and played an important role in aiding KT (Zahra and George, 2002; Tortoriello and Krackhardt, 2010).

The ability to effectively engage in KT was also found to be mediated by the need to build trust between quadruple helix stakeholders; however, this was considered to be a challenge when under-developed processes for PI, industry and end user engagement meant that they continue to interact in an ad-hoc manner (McAdam et al., 2012; Miller et al., 2014). It was identified that to facilitate a fully functioning quadruple helix ecosystem, trust is essential. However, complex IP issues within the case university was said to often constrain KT between PIs, industry and end users. PI14 identified the need to embrace a more trusting culture within the case university to encourage more open innovation activities. *"I think it's important as a model for whatever academic community or social community who undertake with no hidden agendas, just for sheer joy of finding out what other people do and then having a one to one or*

whatever conversation with them that you are not going to steal their ideas. The trust has to be built before partnerships can foster" (PI14). The ability to build personal relationships based on trust was said to be essential not only as a source of prior knowledge but also in helping to convert ideas into products and services (i.e. PACAP to RACAP conversion). Thus there is a need for universities to review IP policies to facilitate open and collaborative interaction and KT between PIs, industry and end users.

6.2.6 Learning from knowledge transfer

In contrast to figure 1, the feedback loop in figure 2 presents a continuous cyclical process where it was observed that KT and learning is cumulative and path dependent (Cohen and Levinthal, 1990; Lane et al., 2006). However, it was found that learning mechanisms within the case university required further development. Whilst it was evident that academics reflected on past commercialisation failures, there appeared to be a lack of internal systems and procedures which captured knowledge from past unsuccessful commercialisation efforts so that lessons could be learned for future KT efforts (Cohen and Levinthal, 1990; Easterby-Smith et al., 2008). Thus in the case study, single loop learning appeared to still prevail at the university level (Argyris and Schon, 1978) which could be considered a key barrier to KT since the case university did not appear to alter their processes or policies as a result of 'lesson's learned' through prior KT with stakeholders in the pursuit of innovation. This suggests the need for universities to develop appropriate knowledge capture and management systems which can be used as a source of prior knowledge for future collaborative projects.

7.0 Conclusions and recommendations for further research

Empirical studies on KT and absorptive capacity to date show serious shortcomings signalling the need for further conceptualisation and development (Holi et al. 2008; Chesbrough, 2011;

Carayannis and Rakhmatullin, 2014). Indeed, in an open innovation context, where multiple diverse stakeholders are interacting, new challenges emerge (Chesbrough et al., 2011) identifying the need for improved knowledge and understanding of the processes of KT between diverse quadruple helix stakeholders. Within this article we aimed to contribute to this discourse by exploring how knowledge can be effectively transferred between universities and their constitute stakeholders within an open innovation quadruple helix context. The proposed model (figure 2) identifies a number of interdependent factors can enable or restrain KT effectiveness, namely human centric factors, knowledge characteristics, organisational factors, power relationships and network characteristics. These factors were found to both determine the initial decision to engage in KT and mediated the acquisition, assimilation, transformation and exploitation of knowledge (see table 2) when quadruple helix stakeholders are engaging in commercialisation activities.

It was identified that an open innovation context presents significant challenges for KT where diverse quadruple helix stakeholder groups, each with organisational-specific traditions, experiences and idiosyncratic practices create specific challenges impacting KT effectiveness (Mitton et al., 2007; Fromhold-Eisebith and Weker, 2013). In particular, the impact of power relationships were found to significantly impact KT, where a dominant stakeholder, such as government can exert their power which impinges upon the balance of the quadruple helix and has the potential to affect KT behaviours. A defining feature of an effective quadruple helix is mutual interdependence between all stakeholders (Leydesdorff, 2012; Carayannis et al., 2012) however, it was evident in the case study that the different stakeholders often tried to exert their salience (Frooman, 1999; Miller et al, 2014) creating an imbalance of power. This contest for power had the ability to affect KT willingness, behaviours and effectiveness at all stages of

commercialisation. Therefore there is a need to more fully identify and address power relationships in open innovation projects involving diverse quadruple helix stakeholders.

The empirical findings identified that the KTO played a key boundary spanning role, helping mediate relationships between the diverse stakeholders and progress KT through the absorptive capacity constructs of knowledge acquisition, assimilation, transformation and exploitation in the context of open innovation and commercialisation. Thus it is suggested that in a quadruple helix open innovation context, there is a need for intermediaries to help eliminate the barriers of KT (Howells, 2006; Mitton et al., 2007) and champion the value of KT.

Furthermore, the case study findings identified that attempts to more fully collaborate with quadruple helix stakeholders signalled that the case university was attempting to embrace open innovation. However, it was identified that the case university needed to more address the conflicting priorities of the academic remit of teaching which was thought to limit KT between the university and their constitute stakeholders (Alexander et al., 2012; Perkmann et al., 2013; Miller et al., 2014). If universities are to fully embrace their core role in a quadruple helix ecosystem, more supportive organisational promotional mechanisms facilitating academics to build relationships with industry and end users is needed.

Increased pressure on universities to develop more collaborative open innovation processes between quadruple helix stakeholders (Arnkil et al., 2010; Leydesdorff, 2012), raises questions as to how KT can be effectively managed with an increased number of diverse stakeholders expected to mutually collaborate. Within this study, our model (figure 2) is useful since it helps conceptualises of the multidimensional nature of the process of KT and proposes that absorptive capacity is a meaningful construct to identify the flows of knowledge between

diverse stakeholder groups in pursuit of open innovation practices. Within this research, a single case study approach was followed in order to explore the applicability of a priori concepts (Bendassolli, 2013). Single case study approaches do not lend themselves to empirical generalisation across different contexts (Yin, 2012) however, the proposed model and absorptive capacity constructs can be reinterpreted and reconstructed in varying contexts thus facilitating theoretical generalisation (Eisenhardt, 1989). It is suggested that future research should develop the proposed model into testable propositions to be used in other contexts where multiple quadruple helix stakeholders are engaging in KT thus facilitating empirical generalisation and development of the KT field. In addition, future research should also explore intermediaries, mechanisms and platforms which may help balance power relationships in a quadruple helix open innovation context which will help aid KT effectiveness and commercialisation success.

References

Alexander, A. T., Pearsons, S. R., Fielding, S. N. and Bessant, J. R. (2012) The Open Innovation Era. Are University Services up to the Challenge? *In:* BITRAN, I. and CONN, S. (eds.) *The XXII ISPIM Conference– Action for Innovation: Innovating from Experience* Barcelona, Spain: Wiley and Sons.

Almirall, E. and Wareham, J., 2011. Living Labs: Arbiters of mid- and ground-level innovation. Technology Analysis and Strategic Management 23 (1), 87-102.

Argyris, C. and Schon, D.A. (1978) Organisational Learning: A theory of action perspective. Addisson Wesley Longman Publishing: London.

Arnkil R., Järvensivu A., Koski, P. and Piirainen, T. (2010) Exploring Quadruple Helix – Outlining user-oriented innovation models. University of Tampere, Institute for Social Research, Work Research Centre. Available online: https://tampub.uta.fi/bitstream/handle/10024/65758/978-951-44-8209-0.pdf?sequence=1 (accessed 17/12/14).

Asheim, B.T. and Coenen, L. (2005) Knowledge bases and regional innovation systems: comparing Nordic clusters. *Research Policy*, 34(8), 1173–90.

Bazeley P. 2007. Qualitative Data Analysis with NVivo. Sage: London.

Bendassolli, P.F. (2013) Theory Building in Qualitative Research: Reconsidering the Problem of Induction. *Forum Qualitative Sozialforschung*, 14(1), 25-36.

Carayannis, E.G., Barth, R.D. and Campbell, D.F.J. (2012) The quinuple helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, 1, 1–12.

Carayannis, E.G. and Rakhmatullin, R. (2014) The Quadruple/Quintuple Innovation Helixes and Smart Specialisation Strategies for Sustainable and Inclusive Growth in Europe and Beyond. *Journal of the Knowledge Economy,* 5(2), 212-239.

Carayannis, E.G., Barth, R.D., and Campbell, D.F.J. (2012) The quintuple helix innovation model: global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, 1, 1–12..

Chesbrough, H. (2011) Bringing open innovation to services. *MIT Sloan Management Review*, 52, 85-91.

Cohen, W.A. and Levinthal, D.A. (1990) Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, 35(1), 128-152.

Cooke, P. (2005) Regionally asymmetric knowledge capabilities and open innovation: Exploring Globalisation 2—A new model of industry organisation. *Research Policy,* 34, 1128-1149.

Daghfous, A. (2004) Absorptive Capacity and the Implementation of Knowledge-Intensive Best Practices. *SAM Advanced Management Journal*, 69 (2), 21-27.

D'Este, P. and Patel, P. (2007) University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy,* 36(9), 1295.

DTI (2004) Science and Innovation Investment Framework 2004-2014. Available online: http://news.bbc.co.uk/nol/shared/bsp/hi/pdfs/science_innovation_120704.pdf (accessed 20/12/14).

Easterby-Smith, M., Lyles, M. A., and Tsang, E. W. K. (2008) Inter-organizational knowledge transfer: current themes and future prospects. *Journal of Management Studies*, 45, 677–690.

Eisenhardt, K. (1989) Building theories from Case study research, *Academy of Management Review*, 14, 532-550.

Etzkowitz, H. and Klofsten, M. (2005) The innovating region: Toward a theory of knowledge based regional development. *R&D Management,* 35, 243–255.

Etzkowitz, H. and Leydesdorff, L. (2000) The dynamics of innovation: from national systems and 'Mode 2' to a triple helix of university-industry-government relations. *Research Policy,* 29, 109-23.

Fereday, J. and Muir-Cochrane, E. (2006) Demonstrating rigour using thematic analysis: A hybrid approach to inductive and deductive coding and theme development. International Journal of qualitative methods, 5(1), 1-11.

Foster, D. and Jonker, J. (2005) Stakeholder relationships: the dialogue of engagement. Corporate Governance: The international journal of business in society, 5(5), 51-57.

Fromhold-Eisebith, M. and Weker, C. (2013) Universities function in knowledge transfer: a geographical perspective. *The Annals of Regional Science,* 51(3), 621-643.

Frooman, J. (1999) Stakeholder influence strategies. *Academy of Management Review*, 24(2), 191–205.

Galbraith, B., Mulvenna, M., McAdam, R., & Martin, S. 2008. Open Innovation in Connected Health: An Empirical Study and Research Agenda. In *Proceedings of the ISPIM 2008 Conference on Open Innovation: Creating Products and Services through Collaboration,* Tours, France.

Galbraith, B. and McAdam, R. (2011) The promise and problem with open innovation. *Technology Analysis and Strategic Management,* 23(1), 1-6.

Gassmann, O., Enkel, E. and Chesbrough, H. (2010) The Future of Open Innovation. *R&D Management,* 40(3), 213-221.

Gupta, A.K. Govindarajan, V. (2000) Knowledge Flows within the Multinational Corporation. Strategic Management Journal, 21, 473-496.

Hewitt-Dundas, N. (2012) Research intensity and knowledge transfer activity in UK Universities. *Research Policy*, 41(2), 262-275.

Holi, M., Wickramasinghe, R. and van Leeuwen, M. (2008) Metrics for the Evaluation of Knowledge Transfer Activities at Universities, UNICO Report. Available online: http://ec.europa.eu/invest-in-research/pdf/download_en/library_house_2008_unico.pdf (accessed 18/12/14).

Howells, J. (2006) Intermediation and the role of intermediaries in innovation. *Research Policy*, 35, 715-728.

Ivanova I. (2014) Quadruple Helix systems and symmetry: A step towards helix innovation system classification. Journal of the Knowledge Economy 5 (2): 357-369.

Kenney, M. and Mowery, D. (2014) *Public Universities and Regional Development: Insights from the University of California System*. Palo Alto, CA, Stanford University Press.

Kirby, D. A. (2006) Creating entrepreneurial universities in the UK: Applying entrepreneurship theory to practice. The Journal of Technology Transfer, 31(5), 599-603.

Lane, P.J., Koka, B.R. and Pathak, S. (2006) The reification of absorptive capacity: A critical review and rejuvenation of the construct. *Academy of Management Review*, 31(4): 833-863.

Lambert. R. (2003) Lambert Review of Business–Industry Collaboration. Final Report, December, HMSO.

Lawler, C. (2011) The capitalisation of knowledge: a triple helix of university-industry government. *Studies in Higher Education,* 36, 746-747.

Leydesdorff, L. (2012) The triple helix, quadruple helix and an n-tuple of helices: explanatory models for analyzing the knowledge-based economy. *Journal of the Knowledge Economy,* 3, 25–35.

Lockett, A. Wright, M. and Franklin, S. (2003) Technology Transfer and Universities' Spin-Out Strategies. *Small Business Economics,* 20, 185-200.

Macgregor, S.P. Marques-Gou, P. and Simon-Villar, A. (2010) Gauging Readiness for the Quadruple Helix: A Study of 16 European Organisations. *Journal of the Knowledge Economy,* 1 (3), 173-190.

Mariano, S. and Walter, C. (2015) The construct of absorptive capacity in knowledge management and intellectual capital research: content and text analysis. *Journal of Knowledge Management,* 19(2), 372-400.

Matzler, K. and Müller, J. (2011) Antecedents of Knowledge Sharing – Examining the Influence of Learning Orientation and Performance Orientation on Knowledge Sharing. *Journal of Economic Psychology*, 32(3), 317-329.

McAdam, M., McAdam, R., Galbraith, B., and Miller, K. (2010) An exploratory study of principal Investigator roles in UK university proof-of-concept processes: An absorptive capacity perspective. *R&D Management,* 40, 455.

McAdam, R., Miller, K., McAdam, M. and Teague, S. (2012) The development of University Technology Transfer stakeholder relationships at a regional level: Lessons for the future. *Technovation,* 32, 57-67.

Miles, M.B, Huberman, A.M. (1994) Qualitative data analysis, 2nd edition. Sage Publishing, Thousand Oaks.

Miller, K., McAdam, M., McAdam, R. (2014) The changing university business model: A stakeholder perspective. *R&D Management*, 44 (3) 265-287.

Mitton C., Adair, C.E., McKenzie E, Patten, S.B. and Waye P.B. (2007) Knowledge transfer and exchange: review and synthesis of the literature. *Milbank Quarterly,* 85 (4):729-68.

Mitchell, R. K., Agle, B. R. and Wood, D. J. (1997) Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts. *The Academy of Management Revie*w, 22 (4), 853-886.

Nadler, J., Thompson, L. and Boven, L.V. (2003) Learning negotiation skills: Four models of knowledge creation and transfer. *Management Science*, 49(4), 529-540.

Nonaka, I. and von Krogh, G. (2009) Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory. *Organization Science*, 20(3), 635-652.

Perkmann M, Tartari V, McKelvey M, Autio E, Brostrom A, D'Este P, Fini R, Geuna A, Grimaldi R, Hughes A, Krabel S, Kitson M, Llerena P, Lissoni F, Salter A, Sobrero M. 2013. Academic engagement and commercialisation: A review of the literature on university Industry relations. *Research Policy*, 42(2): 423–442.

RIS (2014) National/Regional Innovation Strategies for Smart Specialisation. Cohesion Policy 2014-2020, European Commission. Available online: http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/smart_specialisation_en.pdf (accessed 10/12/2014).

Rothaermel, F.T., Agung, S.D. and Jiang, L. (2007) University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change,* 16, 691-791.

Sainsbury Report (2007) *The Race to the Top: A Review of Government's Science and Innovation Policies.* London: HMSO.

Schoonmaker, M. and Carayannis, E. (2013) Mode 3: A Proposed Classification Scheme for the Knowledge Economy and Society. *Journal of the Knowledge Economy*, 4 (4), pp. 556-577.

Sharifi, H. and Liu, W. (2010) An Exploratory Study of Management of University Knowledge Transfer Offices in the UK. AIM Research. Available online: http://www.aimresearch.org/uploads/File/Publications/Academic%20Publications%202Emerging_landscape.pdf (accessed 19/12/14).

Siegel, D. S., Waldman, D. and Link, A.N. (2003) Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study. *Research Policy,* 32(1): 27–48.

Stake, R.E. (2000) *Case studies.* In: Denzin, N.K. and Lincoln, Y.S. (eds.), *Handbook of Qualitative Research*, Thousand Oaks, CA: Sage Publications.

Su, Z., Ahlstrom, D., Li, J. and Cheng, D. (2013) Knowledge creation capability, absorptive capacity, and product innovativeness. *R&D Management,* 44 (5), 473-485

Sun, P.Y.T. (2010) An examination of the relationship between absorptive capacity and organisational learning, and a proposed integration. *International Journal of Management Review,* 12(2), 130-150.

Szulanski, G. (1996) Exploring internal stickiness impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17, 27-43.

Szulanski, G. (1996) Exploring internal stickiness impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17, 27-43.

Szulanski, G. (2002) *Sticky Knowledge: Barriers to Knowing in the Firm*. London: Sage.

Tsai, W. (2001) Knowledge transfer in intra-organizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, 44, 996-1004

Tortoriello, M. and Krackhardt, D. (2010) Activating cross-boundary knowledge: the role of Simmelian ties in the generation of innovations. *Academy of Management Journal*, 53(1), 167-181.

Urbano, D. and Guerrero, M. (2013) Entrepreneurial Universities: Socioeconomic Impacts of Academic Entrepreneurship in a European Context. *Economic Development Quarterly*, 27, 40-55.

Van Looy, B., Landoni, P., Callaert, J., van Pottelsberghe, B., Sapsalis, E. and Debackere, K. (2011) Entrepreneurial effectiveness of European universities: An empirical assessment of antecedents and trade-offs. *Research Policy,* 40 (4), 553-564.

Vandekeckhove, W. and Dentchev, N.A. (2005) A network perspective on stakeholder management: Facilitating entrepreneurs in the discovery of opportunities. *Journal of Business Ethics,* 60, 221-232.

van Wijk, R., Jansen, J. and Lyles, M. (2008) Inter-and intraorganizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences. *Journal of Management Studies*, 45(4), 830-853.

Volberda, H.W., Foss, N.J. and Lyles, M.A. (2010), Absorbing the Concept of Absorptive Capacity: How to Realize Its Potential in the Organization Field. *Organization Science,* 21(4), 931-951.

Wilson, T. (2012) A Review of Business–Industry Collaboration. London: Department for Business, Innovation and Skills. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/32383/12-610-wilson-review-business-university-collaboration.pdf (accessed 18/12/2014).

Wright, M., Piva, E., Mosey, S. and Lockett, A. (2009) Academic entrepreneurship and business schools. *Journal of Technological Transfer,* 34 (6), 560-587.

Yeoh, P. (2009) Realized and potential absorptive capacity: Understanding their antecedents and performance in the sourcing context. *Journal of Marketing Theory and Practice*, 17(1): 21-36.

Yin, R. K. (2011) *Case study research: Design and methods,* (4th ed.). Thousand Oaks, CA: Sage.

Zahra, S. A. and George, G. (2002) Absorptive capacity: A review, reconceptualization and Extension. *Academy of Management Review*, **27**(2), 185-203.

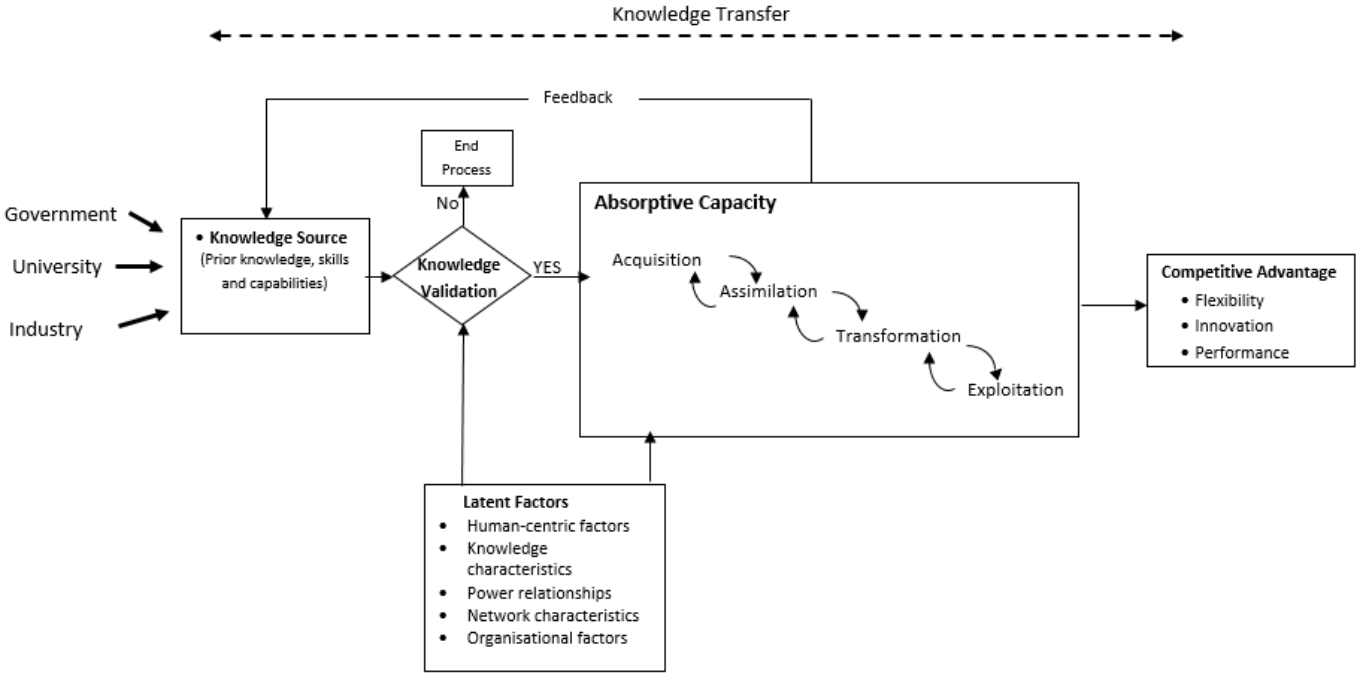

Figure 1: *Ex Ante* Absorptive Capacity based conceptual framework for knowledge transfer from universities

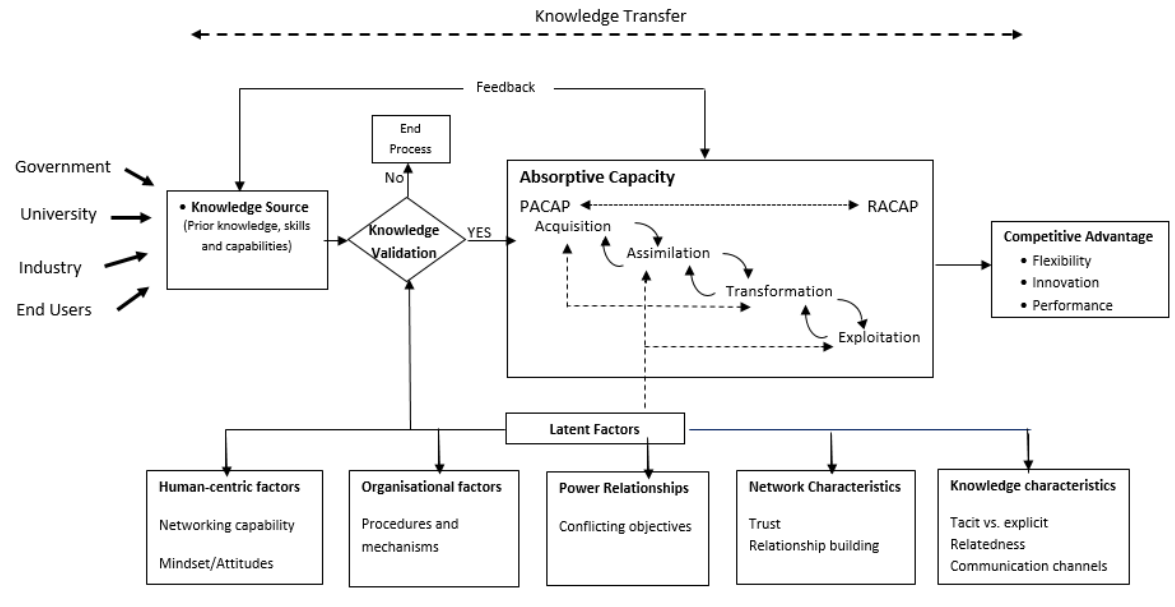

Figure 2: *Ex Post* Absorptive Capacity based conceptual framework for knowledge transfer from universities

Table 1: Absorptive Capacity Dimensions and Influencing Factors

Dimension/Capabilities	Description	Influencing Factors
Acquisition	Ability to search, and develop connections to external knowledge sources	Prior internal knowledge, Prior external knowledge' Prior investments, Human resources, Communication
Assimilation	Ability to understand, interpret, comprehend and learn from external knowledge	Level of education, Diversity of backgrounds, Organisational structure, Internal communication, Human resources
Transformation	Ability to internalise and convert external knowledge	Level of education, Diversity of backgrounds, Organisational structure, Organisational culture, Internal communication, Human resources
Exploitation	Ability to use and implement new knowledge	Organisational structure, Bureaucracy, Responsiveness

Source: (Zahra and George, 2002; Daghfous, 2004; McAdam et al., 2010)

Table 2: Enablers and Barriers of Knowledge Transfer

Theme	Sub-Theme/Sub elements	Effect on KT	ACAP Dimension	Independent Theme	Findings
Human-Centric Factors	Networking Capability	Positive /Negative	Acquisition Assimilation (PACAP)	• Organisational Factors • Power Relationships • Network Characteristics	• The ability to network was thought to be essential in aiding KT activities. However with all capabilities, the stakeholders, particularly the academics, varied in their abilities to network. • The unwillingness or ability to engage in networking was found to hinder KT activities.
	Skills and resources	Negative			• Many academics were lacking the skills, and time to network with industry. This meant they often had RACAP but then lacked the skills and resources to commercialise their technologies (hence lacking RACAP).
	Attitudes	Positive/ Negative			• Being opportunistic was an enabler of KT. • University remit and organisational context was found to hinder engagement in KT.
Knowledge Characteristics	Knowledge Relatedness	Positive/ Negative	Acquisition Assimilation (PACAP)	• Human-Centric Factors	• Synergy between knowledge sources is needed where there are sufficient knowledge similarity to aid absorption and internalisation but also a degree of diversity between a knowledge source and recipient to enhance their willingness to engage in knowledge transfer. • Diverse knowledge sources can be difficult to absorb and internalise.
	Type of knowledge	Negative			• The main type of knowledge sought was business related knowledge. This ranged from sales, marketing, finance, legal and experiential business knowledge; which is all inherently tacit and 'sticky' therefore often hard to acquire, transfer and absorb. • Some academics feel they have all the knowledge they need to commercialise a technology and do not need any help – 'not invented here syndrome. • KTO staff members thought that certain academics were not actively networking enough to gain the knowledge needed to help commercialise their technologies.
Power Relationships	University Remit	Negative	Acquisition Assimilation Transformation Exploitation (PACAP & RACAP)	• Organisational Factors	• The need to balance teaching, research and KT was a challenge. Academics stressed that it was usually impossible to do all three at the same time due to resource constraints. • There was a feeling amongst some of the Academics that the university doesn't support technology KT enough. • There was more of a push within the university towards teaching and research activities. This perceived lack of support or pressure could potential negatively influence certain Academics from engaging in KT for the purposed of open innovation.
	Incentives	Negative			• Perceived lack of incentives associated with KT negatively influenced both PIs willingness to engage in UTT and also affected their efforts within KT if they had decided to undertake commercialisation activities
	Conflicting Objectives	Negative			• The KTO, academics and Government all appeared to have varying objectives, with each trying to exert their power • While government programmes are beneficial to aiding KT activities the KTO and academics thought they were not flexible enough due to their time constraints of funding rounds • It was felt that the KTO staff did not have the skills to properly assess technologies, that the KTO process was too slow and that there was not enough incentives to engage with KT activities

Network Characteristics	Role of KTO	Positive/ Negative	Acquisition Assimilation Transformation Exploitation (PACAP & RACAP)	• Human-Centric Factors • Organisational Factors • Power Relationships	• They played the role of a broker and 'boundary spanner' by connecting academics with various networks and knowledge sources both internal and external to the university • However, the perceived value of this role varied with some academics thinking the KTO did not do enough
	Role of Government	Positive/ Negative			• The role government appeared to play was limited with respect to their interactions with the academic entrepreneurs, however with regards funding to enhance KT, their role was very important • However performance measurement were considered to be ambiguous and strict rules for funding mechanism were found to be restrictive; resulting in missed opportunities
	Role of University	Negative			• The case universities procedures, mechanisms and environment was found to potentially de-motivate some academic from engaging in knowledge transfer and collaborative innovation activities
	Relationship building	Positive			• The ability to build strong relationships with quadruple helix stakeholder facilitated knowledge transfer and exchange • Relationship building led to knowledge access • Allowed knowledge to be externally retained in networks (relative capacity)
	Trust	Positive/ Negative			• Trust mediated the willingness of stakeholder to engage in KT. • A lack of trust was found to prevents knowledge openness hence limited stakeholder engagement • Academic rivalry and research pressures resulted in some academics finding it hard to know who to trust within the university
Organisational Factors	Procedures/ Mechanisms	Positive/ Negative	Acquisition Assimilation Transformation Exploitation (PACAP & RACAP)	• Power Relationships	• Dedicated KTO helped bridge KT and communication between quadruple helix stakeholders • University remit and lack of incentives to engage in open innovation and KT impacted upon academic entrepreneur's willingness and ability to engage in KT.

Appendix A: Profile of Respondents

Code	**Job title**
PI1	Academic entrepreneur/ Principal investigator
PI2	Academic entrepreneur/ Principal investigator
PI3	Academic entrepreneur/ Principal investigator
PI4	Academic entrepreneur/ Principal investigator
PI5	Academic entrepreneur/ Principal investigator
PI6	Academic entrepreneur/ Principal investigator
PI7	Academic entrepreneur/ Principal investigator
PI8	Academic entrepreneur/ Principal investigator
PI9	Academic entrepreneur/ Principal investigator
PI10	Academic entrepreneur/ Principal investigator
PI11	Academic entrepreneur/ Principal investigator
PI12	Academic entrepreneur/ Principal investigator
PI13	Academic entrepreneur/ Principal investigator
PI14	Academic entrepreneur/ Principal investigator
EC1	Enterprise co-ordinator
EC2	Enterprise co-ordinator
KTO1	Operational knowledge transfer office staff
KTO2	Operational knowledge transfer office staff
KTO3	Managerial knowledge transfer office staff
KTO4	Strategic knowledge transfer office staff
Gov1	Government knowledge transfer liaison staff
Gov2	Government knowledge transfer liaison staff
Gov3	Government knowledge transfer liaison staff
Gov4	Government knowledge transfer manager

Appendix B: Coding Process