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An Exploration of Open Innovation in University Technology Transfer

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Abstract: In addition to their well established teaching and research missions, universities are increasingly seen as essential contributors to economic development . The vanguard of this movement is the push toward technology transfer and research commercialization in order to develop a capacity to tap into and exploit the value of tacit and tangible intellectual property associated with research institutions.

Much research concentrates around open innovation from the perspective of the firm and universities are seen as passive contributors to the open innovation process as suppliers of knowledge. Little direction exists in terms of how open innovation can enhance and benefit university technology transfer processes however. Emerging thought suggests a more active role for universities where open innovation processes are applied to their core competency of basic research.

This paper explores current understanding from both perspectives and outlines conditions that contribute to dynamic innovation at the intersection of open innovation paradigms and university technology transfer processes. A case study is employed to illustrate theoretical concepts in action.

Keywords: technology transfer, university commercialisation, open innovation, university-industry networks

1 – Introduction

Whilst much research concentrates around open innovation as a new business paradigm, little direction exists in terms of how this new paradigm can enhance and benefit university technology transfer processes. Universities can be seen as part of a national innovation system as suppliers of knowledge (Vanhaverbeke, 2006). In this way the university plays a passive role in the open innovation process. Increasingly, universities are contributing to innovation in more dynamic ways such as through collaborations or leading regional networks. In other words, actually using open innovation processes to generate more and better research that can be brought to new markets in new ways.

Given such emerging trends, managing such newly created knowledge in the context of universities for economic development provides an interesting context for the application of current knowledge. Yet, little is known about the systems and processes used to optimise both passive and active participation in open innovation, especially for technology transfer. This highlights the need for further research and investigation..

This paper asks what challenges are apparent in applying the concepts of open innovation paradigms to university technology transfer processes and creates a contribution to defining some key framework conditions that support this space. The methodology includes observing the practical implications through the test case of the National University of Ireland, Galway (NUIG).

The problem can be defined by analyzing the trajectory of these key drivers and opening a discussion on the space and circumstance where they naturally intersect:

- A movement to generate socio-economic benefits in a dynamic and innovative knowledge economy where universities are increasingly seen as essential contributors to the knowledge value chain has been noted (Ektowitz, 2006, Mowery et al, 2001).
- University innovation systems rely upon vast reservoirs of tacit and tangible knowledge that is influenced at regional, local and international levels (OECD, 1997) However, university technology transfer processes rely upon selectively protecting and profiting from relatively few innovations. Open science traditionally discloses through publications without the need for IPR, however is there more value to be achieved here?
- Open innovation provides a natural platform for developing university innovation systems and the knowledge economy supply chain; however challenges exist in managing technology transfer using traditional mechanisms (Fabrizio, 2007). Universities have been seen as suppliers of knowledge assets rather than active users of open innovation processes. Little guidance exists on how universities can balance their active and passive roles.

This paper seeks to explore open innovation in the context of university technology transfer by exploring literature, discussing key themes and applying the findings to a case study selected from Ireland, namely, the National University of Ireland, Galway (NUIG).

The findings of this paper are timely given Ireland's current economic crisis and defined need to look toward knowledge economy outputs as an essential tool in recovery and growth following a period of unprecedented socio-economic change.

The exploratory research approach seeks to uncover literature in the area, discover how this applies to the case study and understand the main conditions necessary to support effective contributions from universities as passive suppliers of knowledge and active generators of knowledge.

Whilst the literature review reveals the high-level dynamics of both open innovation and university technology transfer, the findings specifically explore the Irish context and concentrate on contributing to framework conditions that might assist the emerging picture of a new economic mission for universities and the social imperative for economic growth in Ireland to find its form in open innovation.

The paper is structured to include a discussion of how the spheres of open innovation and university technology transfer intersect and an overview of emerging thought on the subject of entrepreneurial science. In the findings section four main framework conditions that could enable dynamic innovation are discussed whilst the need to investigate systems and tools to maximise the social benefit of university innovations is highlighted. The case study is introduced and findings are applied.

This paper will contribute to a fuller understanding of open innovation and university technology transfer systems whilst specifically outlining the Irish context and applying existing knowledge to a particular case.

2 – Methodology

This paper provides a platform for the investigation into open innovation and university technology transfer by using an exploratory research approach to identify and explore new theoretical insights.

In line with the objectives of this paper, a literature review of current techniques and practices in IP commercialization at universities was undertaken. This process identified themes particular to the University sector and highlighted areas of potential process innovation that arise from connecting theoretical frameworks with the evolving paradigms of open innovation and research commercialization at universities. A review of governmental and institutional policy and strategy related to research and development was undertaken in order to contextualise the diverse factors inherent in the growth of commercialization activity. This review focused on international, European and Irish policies with further input from OECD reports. An investigation of policy and strategy on an institutional level at NUI Galway was also carried out using published reports.

During this stage, it emerged that much analysis of Open Innovation was taking place at firm level, however emerging research sought to further the scope and understanding of the subject by using alternative units of analysis, for example national and regional innovation systems (Vanhaverbeke, 2006) of which universities play a significant role (OECD, 2001).

Using a case study approach in this paper would serve the dual purposes of illustrating theoretical concepts and expanding the depth and breadth of knowledge in the

area by using a university as the unit of analysis. Research suggests that a holistic understanding of organisations can be developed by using a case study methodology (Fox-Wolfgramm, 1997) which examines a phenomenon in its naturalistic context (Pekkari et al, 2009). The case study of NUI Galway was selected because firstly, it was the first dedicated Technology Transfer Office in Ireland and secondly, there is evidence to suggest that its processes are highly effective given its low ratios of patents per research million by comparison both nationally and internationally. With this in mind, primary data was also collected during several structured, qualitative interviews with the NUI Galway Technology Transfer Office. Such firsthand data enabled triangulation and provided a robust background from which to build findings.

This research is not without limitations. Whilst the findings are soundly grounded in a theoretical framework and applied to one case, this is highly contextualised study which considers one case of an Irish university. That said, one recommendation of this study is that the approach, methodology and findings be replicated with other national and international cases in order to validate and affirm the concepts and conclusions herein and perhaps discover more about universities as active and passive participants in open innovation processes.

3 – Discussion

Open Innovation and University Technology Transfer

Open innovation, simply put, is a means of leveraging external knowledge and resources in order to profit from delivering more innovative products and services to new and existing markets. Enkel, Gassman and Chesborough (2009) cite three core open innovation processes that are used to achieve this:

1. Outside-in process: where external knowledge sourced from customers or suppliers for example enable innovation within the firm. The authors note here that the locus of knowledge creation is not within the firm
2. Inside-out process: The firm earns rent from externally marketing Intellectual Property Rights (IPR) portfolios and transferring ideas into outside environments. Here the authors observe that the locus of exploitation is outside the firm.
3. Coupled process: where co-creation with complimentary partners such as innovation communities, consumers, universities and other industries gives rise to new innovations.

According to Perkman & Walsh (2007) the basic assumptions of open innovation are that firms increasingly innovate by using external knowledge. With both processes 1 and 3, universities play a role as an external source of information for firms (OECD, 1997) (Enkel et al 2009) (Thursby & Thursby, 2009).

In open innovation research, some generic economic and social benefits from universities have been noted including educating graduates, generating scientific knowledge and creating instrumentation infrastructures (Perkman & Walsh, 2007). Here we see universities playing a passive role in the open innovation processes. The concepts

of open networked and interactive innovation (Perkmann & Walsh, 2007) suggest that relationships between universities and firms play a stronger role in generating innovations.

Universities have always maintained a primary function in creating and disseminating knowledge (Thursby & Thursby, 2007) yet intellectual property rights (IPR) systems mean that now income can be generated from intangible assets. Whilst IPRs give people an incentive to produce socially desirable new innovations (Greenhalgh & Rogers, 2007) along with the income that purposeful innovation can yield, universities can also attract funds for sponsored research and gain status from having technology transfer structures in place (Thursby & Thursby, 2007).

Some authors have identified a tension between the primary function of open science, or publication of basic research, and the commercial intent of patents. Fabrizio (2006)(2007) observes that industrial patents often cite university-based basic research and suggests that perhaps firms ability to access such knowledge is being impeded by an increase in formal IP claims by universities on their research results.

Other researchers notice that this tension may in fact contribute to the dynamics of innovation. Stephan (2008) notes the complementarity between publishing and patenting when a 'win win' based on industry collaboration means that both the academic reward structure and the innovation associated with patenting can be realised. The challenge seems to be managing the balance between protection and disclosure.

Entrepreneurial Science: At the Frontier of Open Innovation and University Technology Transfer

University research has evolved to follow principles of communalism and reward through recognition (Thursby & Thursby, 2007) as such defined as open science. Innovation on the other hand implies a commercial context (Lane & Flag, 2010), that of utility and the assumption that there is a commercial application involved.

Greenhalgh & Rogers (2007) define a new context of entrepreneurial science, one which may be grounded at the fringes of , as yet untapped in terms of value, particularly to the vital SME sector. It is within this context of entrepreneurial science that the diversity of knowledge, and its application to a variety of markets becomes possible. This paper proposes that the interactions, knowledge transfers and potentials might become more possible at earlier stages of the process, especially using combinative and complimentary assets in a more meaningful way to basic research.

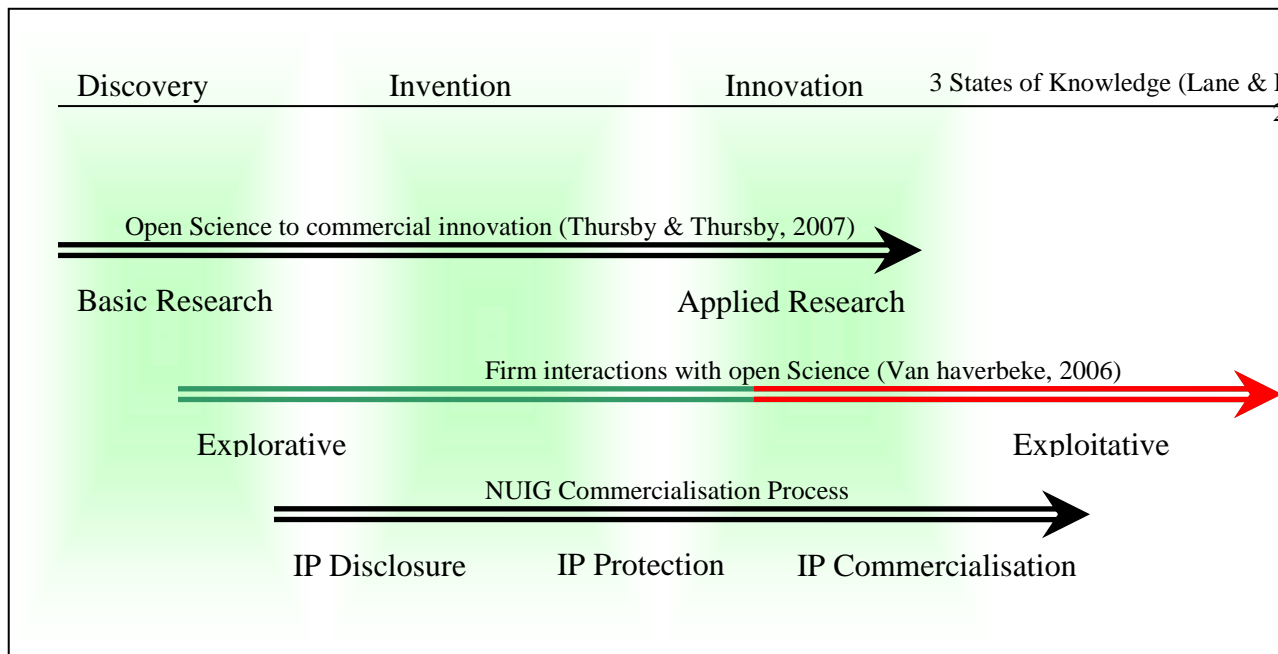
As literature has revealed, and Fig 1 illustrates, knowledge has three states; Discovery, Invention and Innovation (Lane & Flag, 2010). The continuum of basic and applied research can be mapped onto these states if viewed in a linear progression toward value creation as shown. In this regard, the continuum ranges between basic research or traditionally open science and applied research, that which demonstrates commercial intent (Thursby & Thursby, 2007).

Furthermore, firm interactions with open science can also be mapped along the three states of knowledge. Vanhaverbeke (2006) proposes that university IPR portfolios can impede the flow of knowledge from university to industry, in essence stopping access until the university IP is protected by patents. Thus creating a delay in generating social benefits (shown in the red).

Traditionally, open science would enable access at a far earlier stage (shown in green). Primary research from NUIG demonstrates that the commercialization process

runs along an iterative cycle between the depth and diversity of basic research and the reach and focus of industry markets since as Thursby & Thursby (2007) point out, the norms of science are not sufficient to induce the investment necessary to develop a commercial application. Perhaps there is a balance to be struck in terms of the value of open science and the commercial potential of applied research.

Fig 1 – Synthesis of research on university technology transfer and open innovation literature



As the NUIG commercialisation process and theoretical research in the field shows, research that is closer to market is more highly codified and governed by process. Conversely, the risk of market failure increases the closer to basic research (Thursby & Thursby, 2007), however on this end of the continuum, there is less codification and more ‘fuzzy’ boundaries between university knowledge and industry (Fichter, 2009). In particular, literature is showing that SME’s can benefit from such informal knowledge (Lee et al, 2010). The framework conditions in the next section are designed to provide a more structured approach to examining this space and encouraging thought on how this space can add value using multidisciplinary, innovative and entrepreneurial science.

The Challenges

Failures in both macro and micro innovation systems pose a challenge to effectively utilising university knowledge to drive innovation. From policy based failures that do not support university-industry interactions, to bottlenecks that impede technology transfer offices from effectively engaging with industry (Swamidass & Vulasa, 2008).

Several challenges have been noted in this debate:

- Balancing the management of IPR portfolios: Greenlagh & Rogers (2007) note that IPR owners do not always capture the full social reward of inventions since other firms are prevented from supplying substitutes. The value of university based open science is that, as a valuable knowledge, it can be used without being used up (Greenlagh & Rogers (2007) yet unequal access to information (Fabrizio, 2007) might impede market forces.
- Academic rewards: Stephan (2008) notes that there have been changes in the academic reward system. Whilst academics achieve a relatively flat salary over time, the scope exists to enhance this with informal research services such as consulting or formal, codified outputs such as patents. Literature notes no tension between fundamental and applied science (Stephan, 2008) (Thursby & Thursby, 2007) However impediments such as fear of disclosure and trust within networks¹ (Vanhaverbeke, 2006) can lead to challenges.
- Knowledge Flows: Apart from open science and codified technology transfer, transferring tacit knowledge plays an essential role in the dynamics of innovation. A blended system where both formal IP and tacit knowledge associated with technologies (Fabrizio, 2006) can drive further value from the university-industry interrelationship. Much work has been achieved in measuring knowledge transfer outputs (EU, 2009) yet further scope exists in optimising the interrelationships between different channels of knowledge flow with potential to gain from multidisciplinary, entrepreneurial science.

4 – Findings

Four Framework conditions

As we have discussed in the introduction, Patrucco (2008) notes that collective knowledge presumes the dynamic interaction between macro characteristics of the system and the micro-behaviors of the firm, yet there are no tools evident that assist technology or knowledge transfer offices to achieve such dynamic interaction and manage the challenges outlined.

This research has found four framework conditions that could support such dynamic interaction in this space and ameliorate the challenges outlined in the previous section.

1 - Depth and Breadth of Innovation Systems

The OECD notes that the quality of the public research infrastructure and its links to industry may be one of the most important national assets for supporting innovation and that core knowledge flows through such innovation systems (OECD, 1997). Literature (Van haverbeke,2006) (Lee et al, 2010) reveals that at the level of national and regional innovation systems firms should build ties that are wide and deep.

¹ Evidence of these challenges was also documented during structured qualitative interviews with senior Technology Transfer Staff at NUIG

Deep ties enable companies to tap into existing knowledge resources such as customers, affiliates, joint ventures and public research. Wide ties enable firms to find as yet untapped technology and markets (Van haverbeke, 2006). Using the university as the unit of analysis, it can follow on that they too should leverage innovation systems to delivery diversity of and access to knowledge.

Patrucco (2008) outlines how wide and deep ties can be measured using statistical data:

Indicator	Measure
Wide ties	industry collaborations
Deep ties	citations from patent applications

2 - Effective IPR Policies

IPR management is the key outcome of university based technology transfer offices yet literature reveals several challenges in successfully managing IPR assets in the market.

Patrucco (2008) notes that the production of technological knowledge is an interactive and collective process of learning in which universities are engaged as actors. Within this context, IPRs give an incentive to produce socially desirable new innovations (Greenhalgh & Rogers, 2007), however a balance must be maintained for universities, as public research organisations, between maximising revenue and maximising the public benefit that lies between open science and the IPR system. (European Commission, 2009)

The European Commission (2009) outlines key performance criteria which can measure this balance.

Table 1 – Measurement of balanced IPR management

Indicator	Measure
Core Performance Indicators	<ul style="list-style-type: none"> Research agreements Invention disclosures Patent applications Patent grants Licenses executed Licence income earned Spin-offs established
Supplementary Indicators	<ul style="list-style-type: none"> Knowledge transfer involving SMEs Knowledge transfer involving domestic firms Knowledge transfer involving own region Exclusive licenses Share of valid patents that have not been licenced Patent share of license income Technology areas for patenting

3 – Formal and Informal Networking

Research on open innovation increasingly emphasises the role of communities (Fichter, 2009) or networks. The OECD (2001) have documented that initial inventions do not become useful until they are combined with many different complimentary assets and activities and are brought to the market. Within the new context of entrepreneurial science, and from the university perspective that has been discussed in this paper, such complimentary assets and activities can be found within formal and informal research collaborations (Patrucco, 2008) to create a truly multidisciplinary approach to science.

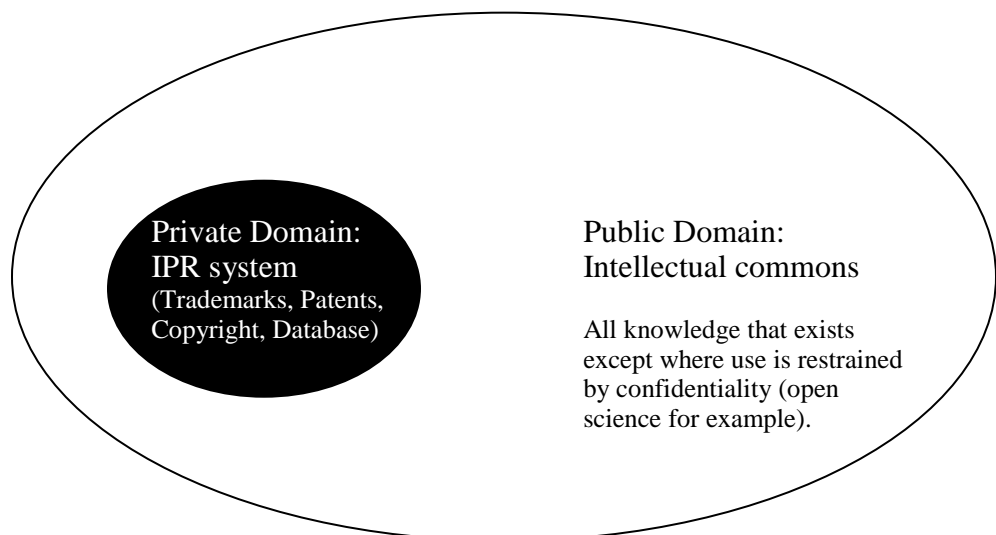
Such multidisciplinary, inter-organisational approaches increase the diversity of and access to knowledge through what the OECD (2001) call ‘networks of practice’ which have access to the continuum of knowledge whilst being capable of combining diverse resources.

Indicator	Measurement
informal science-industry relations	Company Visits External Events Attended Networking Events

4 – Optimised Knowledge Flows

As Figure 2 demonstrates, the sum of all knowledge is not simply what is protected by the IPR system. For the purposes of this research, universities can be seen as availing of the IPR system, yet also disclosing under what is known as open science.

Fig 2: Everything known in the world and who owns it, adapted from Dutfield (2000)



A key indicator from within the literature (Patrucco, 2008) is the socialisation of knowledge meaning how universities convey IP protected information in the public domain. Indicators have been taken by cross referencing the literature with published reports from NUIG in order to provide meaningful measures that relate to knowledge flows.

Indicator	Measurement
socialisation of knowledge	Confidential Disclosure Agreements Material Transfer Agreements Technology Showcasing Events

5 - The Case of National University of Ireland, Galway

Case Introduction - National University of Ireland, Galway (NUIG) Research & Commercialisation Structures

NUIG was established in 1845 as Queen's College Galway and claims over 15,000 students attending its seven faculties in Arts, Science, Engineering, Celtic Studies, Medicine and Health Sciences and Law. NUI Galway has defined five areas of research specializations in Biomedical Science & Engineering, Informatics, Physical and Computational Science, Environment, Marine & Energy; Applied Social Science and Public Policy and Humanities in Context. Many research clusters and centres have evolved from its highly effective research strategy and a strong focus exists for developing links with industry partners in areas of regional and national strategic importance.

Additionally NUI Galway was the first university in Ireland to establish an incubation facility for start-up campus companies. The incubation centre caters for up to 24 start-up companies in the Information and Communications Technology, software development and e-learning areas and in addition a bio-incubation facility exists to foster innovation in the biotech, medical device and drug delivery sectors. The university also has links with offsite incubation facilities.

In 2005 NUI Galway became the first university in Ireland to establish a dedicated Technology Transfer Office. Its objective is to support the commercialization of all university intellectual property in order to maximize the benefit to society, the inventor and the university itself. Since its launch some five years ago, the Technology Transfer Office (TTO) has had substantial successes in realizing research commercialization outcomes in licensing, invention disclosures, industry collaborations and spin-outs (refer table 2). This contributes to attracting industry involvement and research funding to align with its research mission.

Table 2: actual and (target) outcomes – courtesy of the NUI Galway Technology Transfer Office

Metric	2004	2005	2006	2007	2008	2009
Invention Disclosures	8	10	27	36 (24)	53 (29)	58 (33)
New Patents	8	8	6	20 (15)	32 (20)	17 (22)
All Patents Filed	4	6	20	45	57	48
Licence/ Options	0	1	4	23 (4)	12 (5)	16 (6)
Spin-outs	0	0	3	4 (4)	0 (4)	7 (5)
Industrial Collaborations	8	15	18	40	26	36

Irish Context for University Research

Ireland is poised to invest \$5 billion in research driven innovation between 2006 and 2013 as part of its National Development Plan (IGPO, 2007). This investment in technology and innovation is designed to double the number of Ph.D. graduates and attract young people into research careers in knowledge-driven companies and aimed at fostering the new knowledge economy through our research institutions. The investment, which will be implemented between 2006 and 2013, is certainly linked to commercialization outcomes and the sheer body of knowledge that will be generated and tested as part of PhD programmes. Additionally investment in knowledge and innovation at an EU level will be stimulated by the research Framework Programme 7 which encompasses the new Competitiveness and Innovation Framework (EESC, 2008).

Even these amounts of investment will not unlock the true value of Ireland's knowledge and innovation potential. In 2007 the EU recognized that in itself FP7 would only represent 1/50th of the target amount required to truly drive forward the knowledge economy. In fact, the Lisbon Strategy, and subsequent Barcelona agreement (EESC, 2007) outlines that the target amount for investment in research and development and the amount judged to be necessary in order to drive forward the knowledge economy is 3% of GDP with 2/3 coming from private sector.

Based on the planned levels of investment from national and EU sources, universities could therefore expect a massive upsurge in knowledge creation associated with their mission of teaching and research alone. Additionally, the desire in the EU to increase funding to the Barcelona target will mean that there will be a clear future for knowledge creation and associated enterprise well into the future, particularly in terms of industry-university partnerships given the funding focus on private sponsorship of research.

Application of Framework Conditions to NUI Galway Case Study

The most effective way to demonstrate how the framework conditions applied to the case study chosen is to highlight each condition and plot the available data against each indicator as shown in Table 3 below.

Table 3: Application of framework conditions to NUIG Case

Framework Condition	Indicator	NUIG Application
Innovation Systems	Industry collaborations Citations from Patent Apps	NUIG have recently included the number of industry collaborations as a soft metric associated with Technology Transfer initiatives. In 2009 there were 36 recorded collaborations. Whilst no information was recorded on citations from Patent applications.
IPR System (core)	Research agreements Invention disclosures Patent applications Patent grants Licenses executed Licence income earned Spin-offs established	As table 1 demonstrates, NUIG is delivering well using an IPR system that delivers on patents, licenses and spinouts. It is important to note that the translation rate for inventions to patents has slowed due to a quality process that provides a legal and market perspective on inventions with potential patents. Additionally, the quality and quantity of spin-offs has been improved by using guidelines.
Knowledge Flows	Confidential Disclosure Agreements (CDA) Material Transfer Agreements Technology Showcasing Events	Again, NUIG have developed internal metrics that measure the growing quantity and quality of knowledge flows and technology communication. There were 157 CDAs, 47 Material Transfer Agreements and 13 technology showcasing events in 2009.
Formal and Informal Networks	Company Visits External Events Attended & Networking Events Hosted	As a measure of how university-industry networks are progressing at NUIG, 165 company visits were initiated and 58 (50 external and 8 internal) networking events were conducted.

6 – Conclusion

Summary

In this paper we have discussed how university technology transfer processes can benefit from including open innovation principles using a case study to demonstrate and highlight findings from a framework grounded in theory. The key themes of open

innovation and university technology transfer were discussed. A diagram representing the synthesis of literature on the subject was presented which indicated where further value might lie as yet untapped.

Four framework conditions were uncovered through literature that might serve to guide universities in the application of open innovation paradigms as a source of knowledge to firms, but also contribute to a new understanding of how open innovation can be used to leverage the three core processes of open innovation (Outside-in, Inside-out and Combined) where the unit of analysis was the university itself. The case was introduced within the context of Ireland before the framework conditions were applied to the case.

In concluding, it appears that there is yet more economic value to be gained from transferring university knowledge using open innovation processes; however this might not come in the form of traditional IPR exchanges. Rather in the space defined where the possibilities of basic research communicated through open science can be moulded into products and services using combinative, multidisciplinary approaches to science, or entrepreneurial science that is facilitated by universities.

Suggestions for further research

Whilst the paper examines the university within the context of current units of analysis used in open innovation research, namely as a source of knowledge within national innovation systems, the concepts herein also indicate that universities could drive further value from their knowledge networks by directly applying open innovation principles. For example, in the firm-based unit of analysis, universities play a role as sources of information, however using a university-based unit of analysis, the actors and agents of national innovation systems play their role as external sources of innovation for universities. For this reason, testing the framework conditions using a broader set of cases would yield interesting results from two perspectives; firstly to strengthen the validation of findings from this paper, but also to use the university-based unit of analysis in approaching research on open innovation.

In addition, the development of tools and checklists to successfully manage within this space would be of benefit in order to drive economic value from previously unknown or untapped knowledge and to increase the combinative capability of university research.

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