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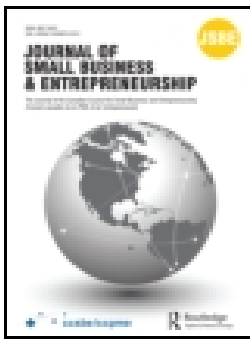
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## Dynamic capabilities and the entrepreneurial university: a perspective on the knowledge transfer capabilities of universities

Noel M. O'Reilly\*  and Peter Robbins 

*Department of Design Innovation, Maynooth University, Kildare, Ireland*

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In the knowledge economy, universities have a vital and growing role in supporting innovation and facilitating regional economic development through the addition of a 'third mission' of knowledge transfer activities to the core missions of teaching and academic research. Knowledge transfer capabilities appear to be influenced by the dynamic capabilities and culture of the host university. To date, knowledge transfer activities of universities have proven difficult to quantify with comparisons between institutions problematic. This paper addresses this gap in two ways. Firstly, the use of a ratio of published metrics gives greater insight into the relative degree of collaboration between universities and industry. Secondly, this research derives a measure of dynamic capabilities in Irish universities and correlates it with previously unpublished data on technology and knowledge transfer performance. The research finds a high correlation between universities with strong dynamic capabilities and their success in these dimensions of knowledge transfer.

**Keywords:** entrepreneurial university; dynamic capabilities; knowledge transfer; innovation culture

Dans l'économie de la connaissance, les universités ont un rôle essentiel et croissant l'innovation de soutien et en facilitant le développement économique régional par l'addition d'une 'troisième mission' des activités de transfert de la connaissance aux missions de noyau de l'enseignement et de la recherche scolaire. Les capacités de transfert de la connaissance semblent être influencées par les capacités et la culture dynamiques de l'université centre serveur. Jusqu'à présent, les activités de transfert de la connaissance des universités ont prouvé difficile à mesurer avec des comparaisons entre les établissements problématiques. Ce document adresse cete space de deux manières. Premièrement, l'utilisation d'un rapport de la métrique éditée donne une plus grande analyse dans le degré relatif de collaboration entre les universités et l'industrie. Deuxièmement, cette recherche dérive une mesure de capacités dynamiques aux universités irlandaises et la corrèle avec des données précédemment non publiées sur l'interprétation de transfert de technologie et de connaissance. La recherche trouve une corrélation élevée entre les universités avec des capacités dynamiques fortes et leur succès dans ces dimensions de transfert de la connaissance.

**Mots-clés:** Université entreprenante; Capacités dynamiques; Transfert de la connaissance; Culture d'innovation

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\*Corresponding author. Email: [noel.oreilly.2013@mumail.ie](mailto:noel.oreilly.2013@mumail.ie)

## Introduction

University knowledge transfer is the process of transferring, converting, and commercializing basic research, conducted in universities, as new technologies into industry and wider society. It is recognized as the critical linkage between industry and universities (Yuan et al. 2016) and constitutes the third mission of a university. The addition of a third mission of enterprise to the core missions of teaching and academic research in universities has become increasingly common in the last 20 years (Goldstein 2010). Universities are now seen as having an ever more important role in supporting innovation and facilitating regional economic development (Audretsch 2007). Universities operate within systems of innovation and this positions university knowledge transfer activities within a triple helix of university-industry-government relations (Yuan et al. 2016). A 2017 EU report (Measuring the contribution of higher education to innovation capacity in the EU) on the contribution of universities to the knowledge-based economy makes this point:

A key challenge for European policy-makers is therefore to determine the extent to which universities are realizing their innovation potential to meet the needs of the knowledge based economy. By distinguishing which institutions are or are not able to address the innovation agenda, policy-makers can develop a more nuanced set of engagement stimuli that can help to optimize their contribution, and in turn, the returns that European societies receive for their substantial public investments in higher education.

This paper helps address this specific challenge, certainly for Ireland, with potential for wider application of this framework. The paper firstly presents a ratio of knowledge transfer activities per research spend which can be used as a comparator for the knowledge transfer activities of different universities. This ratio, based on existing metrics and data (Scanlan 2017) is used to capture the knowledge transfer performance of the seven Irish universities for a given year and this data is subsequently correlated with survey data, for the same year, capturing the relative innovative culture ('innovation quotient') of the universities. Further, the research looks to extend this Rao and Weintraub (2013) 'innovation quotient' survey tool as representative of the dynamic capabilities paradigm.

Up to now, there has been no empirical research in Ireland to measure the innovation capabilities of the seven universities in the country and to correlate that metric with their actual output in terms of conventional industry engagement metrics. This paper fills this gap. While knowledge transfer activities are difficult to quantify and comparisons between institutions is problematic, expert organizations such the Association of European Science and Technology Transfer Professionals (ASTP-Proton) have developed comparators that, although not perfect, are widely accepted. In order to capture a snapshot of the relative knowledge transfer success across Irish universities, this paper develops a ratio of knowledge transfer activities (licences, options and assignments), normalized per 10 million euro of research spend, from the data presented in the 2014 Ireland Annual Knowledge Transfer Survey. This research proposes that this ratio, referred to as the 'external engagement' metric, gives insight into the relative degree of collaboration of universities with the external entrepreneurial ecosystem.

This paper then explores to what extent knowledge transfer outcomes are linked to the innovative culture and dynamic capabilities of the host university. The

research looks to a large scale survey within the higher education sector in Ireland conducted in 2014 (Zhang, Larkin, and Lucey 2015) which utilized a survey tool devised by Rao and Weintraub (2013) to measure innovative culture within organizations. This data is correlated and discussed with respect to the 'external engagement' metric calculated by this research for the same year. The 'innovation quotients' of the Irish universities as measured by Zhang, Larkin, and Lucey (2015), are found to show a strong consistency with the 'external engagement' metric presented within this research. The implications of the link between an organizational level innovative culture and the success of university knowledge transfer is discussed. The research builds on the work of both Yuan et al. (2016) and Teece, Peteraf, and Leih (2016) arguing that university knowledge transfer is a function of the organizational dynamic capabilities and that knowledge transfer success can be correlated to the university's ability to orchestrate its resources in this dynamic environment. Further, this research considers the Rao and Weintraub (2013) 'innovation quotient' survey tool through the theoretic lens of dynamic capabilities theory and proposes the survey tool can also capture the relative dynamic capabilities of higher education institutions.

## Literature review

### *The evolution of the university*

Jencks and Riesman (1968) note how research became an accepted academic task within universities from the late nineteenth/early twentieth century. This coupling of teaching and research continued as the norm until the late 1990s when this 'undisputed model' (Nybom 2003) was affected by a new dynamic, namely that of the entrepreneurial university. This entrepreneurial role of universities has become gradually accepted as the third mission to the traditional missions of teaching and research. Etzkowitz and Leydesdorff (2000) contend that this new dynamic marked the dawn of a second academic revolution. Essentially, this revolution refers to the process by which public policy has sought to transform universities from ivory towers to more economically engaged and accountable institutions. The notion of universities working with industry is not new. However, the second academic revolution marked a new era in this engagement through its formalization in public policy (Jacobsson 2002).

Etzkowitz (2013) defines three stages and phases to the development of the university as an entrepreneur. In an initial phase (university entrepreneur one), the academic institution takes a strategic view of its direction and gains some ability to set its own priorities, either by raising its own resources through donations, tuition fees and grant income or through negotiations with resource providers. In a second phase (university entrepreneur two), the academic institution takes an active role in commercializing the intellectual property arising from the activities of its faculty, staff and students. In a third phase (university entrepreneur three), the academic institution takes a proactive role in improving the efficacy of its regional innovation environment, often in collaboration with industry and government actors. Although these stages usually occur in the order listed above, they may also take place in any sequence or even virtually simultaneously as the university turns its intellectual resources toward the creation of economic results from knowledge as well as knowledge for its own sake.

Prior to the evolution of the entrepreneurial university, the traditional mission of the university was focused on knowledge transfer through education and the advancement of knowledge through basic research. On top of this dual mission of teaching and research, the contemporary concept of the entrepreneurial university adopts the third mission of contributing to economic development. The entrepreneurial activities that a university can engage in to achieve this objective exist across a spectrum of 'soft' to 'hard' initiatives from the development of entrepreneurial graduates through to technology transfer, spin out company formation, and technology park creation (Philpott et al. 2011).

University knowledge transfer is the process of transferring, converting, and commercializing basic research conducted in universities as new technologies (Siegel, Veugelers, and Wright 2007). Knowledge transfer is composed of those activities involving engaging with the wider entrepreneurial ecosystem such as licensing agreements for the rights to university generated intellectual property (IP), creation of spin out companies, consultancy arrangements and the provision of incubation facilities to accommodate nascent spin-out entrepreneurs and enterprises. External pressures, such as the emergence of the knowledge economy, with the university as both a producer and disseminator of knowledge, have forced universities to expand their role in corporate innovation (Halilem 2010). Equally, the steady decline in university funding has increased the competition for public funds (Etzkowitz and Brisolla 1999). The goal of attaining some level of financial independence will increasingly depend on both the willingness and capacity of universities to collaborate with industry and other agents. Entrepreneurial activities, which may have hitherto been seen as individualistic and idiosyncratic, for certain faculty members and teams, have now become a key organizational objective that needs to be managed accordingly (Fisher and Atkinson-Grosjean 2002).

Rather than being subordinated to either industry or government, the university is emerging as an influential actor and equal partner in a triple helix of university-industry-government relations. The triple helix of innovation thesis states 'the university can play an enhanced role in innovation in increasingly knowledge-based societies' (Etzkowitz 2003). Blenker and Dreisler (2006) note that the concept of an entrepreneurial university developed separately to the triple helix of innovation and that the former is an idea with far more resonance in the US than in Europe. They point out that American universities are, and have traditionally been, based on private funds, with research, private funds and corporate contracts providing a substantial part of their income. American universities have a more automatic and natural orientation to the market while the European universities are predominantly state-financed and 'it takes a very strong political influence before any orientation towards a "market" emerges'. Hence, the challenges in developing an entrepreneurial culture in Irish universities should not be underestimated.

### *The entrepreneurial university*

Since the late 1990s, the concept of the entrepreneurial university has drawn considerable attention from academic scholars and policy makers trying to define and describe the phenomenon (Clark 1998; Etzkowitz and Leydesdorff 2000; Gibb 2005; Kirby 2006; Nelles and Vorley 2010; O'Shea et al. 2007; Rothaermel, Agung, and Jiang 2007; Guerrero and Urbano 2012). A number of broad

frameworks have been developed which attempt to list and describe all the components of an entrepreneurial university (Etzkowitz 2008; Guerrero and Urbano 2012; Gibb 2012). Despite this, research on entrepreneurial universities has tended to focus too narrowly on issues such as the management of the technology transfer office (Siegel, Waldman, and Link 2003) or the role of university incubators (Clarysse et al. 2007). Leih and Teece (2016) note that with the pressure on universities to find alternative sources of funding and to become more entrepreneurial, some scholars are asking deeper questions about how universities can be managed more strategically, more effectively and more entrepreneurially.

The literature on entrepreneurial universities covers a broad range of areas in relation to the evolution of an entrepreneurial university, from reformulating the university mission and strategy to include realigning the university with real-world, pressing external challenges and demands right through to embedding entrepreneurship education throughout university curricula and developing an infrastructure to support graduate entrepreneurship (Williams and Kluev 2014). 'The research stream on the entrepreneurial university views entrepreneurial activity as a step in the natural evolution of a university system that emphasizes economic development in addition to the more traditional mandates of education and research' (Rothaermel, Agung, and Jiang 2007).

Thorp and Goldstein (2010) see the entrepreneurial university as being defined by both its culture of entrepreneurship and the development of an entrepreneurial mindset in all graduates. While looking at the phenomenon more broadly, Meyers and Pruthi (2011) propose five core elements of such an entity: (i) top-down vision, strategy and leadership, (ii) clearly defined entrepreneurship learning objectives that drive the curriculum, (iii) robust internal and external networks, (iv) a culture of innovation, and (v) experiential learning and knowledge transfer opportunities. They note that academic environments supportive of an innovative culture exhibit a high level strategic mindset, are risk tolerant and open to learning from mistakes, and display transparency and honesty in communication and decision making. Ropke (1998) considers the entrepreneurial university in terms of the institution, the faculty and the wider entrepreneurial ecosystem. He suggests that an entrepreneurial university can mean three things: (a) the university itself, as an organization, becomes entrepreneurial; (b) the members of the university are turning themselves somehow into entrepreneurs; and (c) the interaction of the university with the environment, the 'structural coupling' between university and region, follows an entrepreneurial pattern. It is upon the first element that our study will focus.

In their study, Kirby, Urbano, and Guerrero (2011) ranked organizational structure and university governance as the biggest barriers to universities becoming more entrepreneurial. They feel that without such entrepreneurial policies as clearly stated missions, realistic goals, and achievable objectives (the structure and governance element), coordinated entrepreneurial action is impossible. Leih and Teece (2016) posit that universities must integrate resources and coordinate strategies to deal with challenges and exploit opportunities in their external environments. Audretsch (2014) comments 'the role of the entrepreneurial university is to create new businesses, ventures and commercialization where it previously did not exist, or at least to increase the amount of technology transfer from the university to private and not-profit firms and organizations'. Therefore, entrepreneurial

universities try to provide several university policies and an adequate atmosphere in which the university community can explore, evaluate, and exploit knowledge that could be transformed into new ventures (Guerrero and Urbano 2012).

An entrepreneurial university is a natural incubator that, by adopting a coordinated strategy across critical activities (e.g. teaching, research and entrepreneurship), tries to provide an adequate atmosphere in which the university community (e.g. academics, students and staff) can explore, evaluate and exploit ideas that could be transformed into social and economic entrepreneurial initiatives (Kirby, Urbano, and Guerrero 2011). As an organizational archetype, the entrepreneurial university is characterized by the adoption of new structural arrangements aimed at enhancing internal collaborations (coupling) and fostering external partnerships (bridging). Its distinctive features include: a diversified funding base and the reallocation of resources around strategic areas; a strengthened central steering core (formal leadership structures); a focus on inter- and multidisciplinary collaborations across teaching and research; technology transfers and collaborative partnerships along an extended developmental periphery and changes in governance structures like the inclusion of external parties on university boards (Clark 1998; Pinheiro and Stensaker 2013).

### *Understanding innovative capabilities in universities*

Over 50 years ago, a study looking at the innovation practices of higher education institutes declared: 'Universities are the source of constant intellectual and scientific innovation for the society as a whole, and yet, as many observers have noted, university personnel are highly reluctant to accept changes in the operation of the university itself' (Rourke and Brooks 1964, 155). George Osborne (UK chancellor of the exchequer) stated in 2012 'you don't get innovation by a plan imposed by government and you can't measure it by just counting patents or even just spend on research and development. You get innovation when great universities, leading-edge science, world class companies, and entrepreneurial start-ups come together'. The relationship between the innovative capabilities of an organization and the development of an innovative culture has been extensively researched. The accepted thesis is that the development of innovative capabilities, and indeed those dynamic capabilities required to be innovative, need to be underpinned by a culture highly supportive of these capabilities. Regarding the capability of higher educational institutions to develop their knowledge transfer capabilities, much of the research has focused on the development of external linkages with industry and the broader entrepreneurial ecosystem. The, generally internal, capabilities which drive and support these linkages have been largely neglected in the literature by comparison. Teece, Peteraf, and Leih (2016) define dynamic capabilities as 'an organization's abilities to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments'. Yuan et al. (2016) have extended the dynamic capabilities theory to university knowledge transfer processes and propose future researchers should develop methods to measure dynamic capabilities in a university context. They propose that greater success in university knowledge transfer is enabled through universities developing their dynamic capabilities. Dynamic capabilities not only enable universities to 'orchestrate' their activities to generate superior benefits but also help them



maintain their leadership in innovation-based competitive environments. Lawson and Samson (2001) propose that innovation management can be viewed as a form of organizational capability and highlight this innovative capability, the 'innovation imperative', as a critical organizational capability in the knowledge economy. Indeed, Kuczarski (2003) highlights organizational metrics around innovative capabilities as critical to an organization's success.

Tidd and Bessant (2009) describe innovation as 'the process of turning opportunity into new ideas and of putting these into widely used practice'. Benneworth and Zeeman (2017) define innovation as 'the result of a set of activities by which different kinds of knowledge are combined to create solutions and interventions to solve problems, ultimately making society a better place'. Wang and Ahmed (2007) define organizational innovativeness as 'the ability of organizations to behave innovatively through the combination of strategic orientation with innovative behavior and process'.

Researchers have developed tools and methodologies to assess and measure the related constructs of innovative capability, culture of innovation and indeed the innovativeness of an organization. Danks, Rao, and Allen (2017) note that most contributors to the literature, rather than seeking to define innovative culture *per se*, have focused on detailing the contributory factors to a culture of innovation within organizations. It can be contended that the contributory factors to a culture of innovation are those same determinants of innovation which contribute to dynamic capabilities within organizations (Sun et al. 2012).

Dombrowski et al. (2007) note eight cultural elements which facilitate the development of sustainable innovative capabilities within organizations: innovative mission and vision statements, democratic communication, safe spaces, flexibility, collaboration, boundary spanning, incentives, and leadership.

Dobni (2006) contends that the innovative capability of an organization is dependent on the inclination of senior management to encourage innovation, the development of strategic resources supportive of innovation, and the propensity to innovation of the employees. Dobni (2008) defines innovation culture as a multi-dimensional context which includes the intention to be innovative, the infrastructure to support innovation, operational level behaviors necessary to influence a market and value orientation, and the environment to implement innovation. To this end, Dobni (2008) developed an 'innovation orientation scale' based on an exploratory factor analysis of seventy defined constructs of innovation.

Rao and Weintraub (2013) further developed an assessment tool which captures the ideas of the previous innovative culture models discussed but distills the assessment into six factors. The 'innovation quotient' instrument facilitates measurement of the culture of innovation, through a multifactorial survey assessing the lived experience of employees of the innovative capabilities of organizations. They propose that innovative culture is built upon the dynamically linked capabilities of resources, processes, values, behavior, climate, and success as outlined in Table 1.

Rao and Weintraub (2013) note that the innovative determinants of resources, processes and success are easier to, and more often, measured than the people-oriented areas of value, behaviors, and climate. These determinants can be considered applicable to capturing the participants' perception with regard to the

Table 1. 'Innovation quotient' building blocks, descriptions and factors (Rao and Weintraub, 2013).

Building block	Description	Factor
Resources	Organizational systems and human capital for ideating, co-creating and collaborating with the innovative ecosystem	People Systems Projects
Processes	Techniques and methodologies for seizing and capturing innovative value from ideation through innovation implementation	Ideate Shape Capture
Success	Considers how success is captured externally	External Enterprise Individual
Values	Reflected in strategic orientation of institution	Entrepreneurial Creativity Learning
Behaviors	Describing how people act in the service of innovation	Energize Engage Enable
Climate	Captures innovative climate of the organization regarding support for risk taking and independent thinking	Safety Simplicity Collaboration

dynamic capabilities of organizations. Each of the six building blocks comprises three factors (18 total) with each factor comprising three elements (54 survey questions total). To determine the innovative quotient, the average for each element, factor and finally the average for each block is calculated leading to a final total average innovation quotient. Zhang, Larkin, and Lucey (2015) consider the innovation quotient tool satisfactory for the assessment of the culture of innovation in higher education institutions (HEI's) notwithstanding its design as a tool for commercial organizations.

Danks, Rao, and Allen (2017) have noted growth in interest in the literature in recent years in the culture of innovation in organizations. They attribute this interest to the presence of an innovative culture being shown to be a predictor of organizational innovativeness. According to Tushman and O'Reilly (1997), organization culture lies at the heart of innovation.

### *Dynamic capabilities and the entrepreneurial university*

This paper considers whether correlation can be seen in universities between an institution wide innovative culture and success in knowledge transfer activities. This paper further contends that a culture supportive of innovation is one which engages in capabilities at the heart of the dynamic capabilities model- namely those capabilities to sense seize and transform.

Dynamic capabilities is a highly established theory for guiding research in the field of strategic management (Teece 2011), but has just been introduced to the entrepreneurial university paradigm. Following Winter (2003), a capability is a collection of organizational routines that enable an organization to perform some set of tasks on a repeatable or consistent basis (Pisano 2015). Dynamic capabilities

are seen by Helfat et al. (2007) as ‘the capacity of an organization to purposefully create, extend or modify its resource base’. Our approach to understanding universities’ entrepreneurial capabilities draws on Teece, Peteraf, and Leih (2016) definition of dynamic capabilities as ‘an organization’s (or institution’s) abilities to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments’.

Dynamic capabilities relate to the organizations ability to *sense*, *seize*, and *transform*, to generate and exploit internal and external organizational-specific competences, and to address the organization’s changing environment (Teece et al. 1997). Dynamic capabilities enable the organization to (1) identify and develop opportunities and requirements (*sense*); (2) reconfigure and mobilize resources and capabilities to capture this added value (*seize*); (3) continually improve and renew (*transform*). Dynamic routines encourage diverse and novel combinations of resources through organizational learning (Lei, Hitt, and Bettis 1996). Both individual managers and the top management team are key contributors to dynamic capabilities (Adner and Helfat 2003). Culture and the ability to implement collective organizational change are also integral to dynamic capabilities (Teece 2014). Dynamic capabilities are a combination of organizational capabilities and routines coupled with entrepreneurial management and leadership (Augier and Teece 2008).

Having reviewed the two concepts of dynamic capabilities and industry/university engagement, we hypothesize that universities with a greater culture of innovation are more likely to have higher outputs in the area of technology transfer and broader engagement with industry (H1). Dynamic capabilities has been operationalized as a culture of innovation (Rao and Weintraub 2013) and industry engagement is operationalized as those elements of engagement measured in the 2014 KTI Annual Knowledge Transfer Survey.

*H1: Innovation culture in universities is correlated with knowledge transfer success.*

## **Research context**

Brennan, McGovern, and McGowan (2007) note how Irish and UK universities are under increasing pressure to produce economic benefit for their national economies through knowledge transfer activities. In 2014, Julie Sinnamon, (CEO of the government agency, Enterprise Ireland) commented ‘it is important that we have a national perspective on the performance and management of the Irish knowledge transfer system’. The Irish government national policy statement on entrepreneurship (2014) comments: ‘the recent evolution of Science, Technology and Innovation policy has increased emphasis on industry academic collaboration and commercialization of research that will support a culture of innovation and entrepreneurship in Ireland. For Ireland’s national system for entrepreneurship to function effectively it will be essential to measure and monitor entrepreneurial activity at all stages of the process. This assessment should take the form of an in-depth analysis to assess the individual indicators and data for Ireland compiled across international benchmarks’.

The development of institutional comparators for knowledge transfer and other benchmarks of the entrepreneurial university have, as stated earlier, proved difficult

to standardize. While knowledge transfer activities are difficult to quantify and, therefore, comparisons between institutions are problematic, knowledge transfer organizations such as the American Association of University Technology Managers (AUTM) and the Association of European Science and Technology Transfer Professionals (ASTP-Proton) have developed comparators. These organizations capture metrics on certain knowledge transfer activities, normalize these against research spend per research producing organization (RPO) and use these as RPO comparators. Typically, metrics such as the numbers of patents filed, inventions reported, spin outs completed and numbers and types of collaborations with industry are captured. However, Scanlan (2017) notes the rather unrefined state of these metrics, highlighting that they do not consider the core mission of the RPO, the size and age of the RPO or the technology transfer office (TTO), or the type of research undertaken.

In Ireland, the Annual Knowledge Transfer Survey (AKTS) provides (equivalent to the AUTM and ASTP-Proton surveys) an overview of relevant metrics and performance indicators for the knowledge transfer activities from Irish state funded RPOs. All Irish Universities have dedicated support from technology transfer offices since 2007 with University College Cork (UCC), Dublin City University (DCU) and NUI Galway establishing theirs by 1988 and Trinity College Dublin (TCD), University College Dublin (UCD), University of Limerick (UL) and Maynooth University (MU) establishing their TTO's between 2005 and 2007 (Zhang, Lucey, and Larkin 2016). Our research uses these figures.

## **Methodology**

### **Research goal**

A variety of research methods have, in the past, been used to research this area but to date no single method has been found to have more efficacy than any other. This paper follows the approach of Yuan et al. (2016) who compare two independent variables. To investigate the phenomenon more deeply, the authors used a quantitative research design. The first step is devise measures of the concepts being measured (Bryman 2008). Our goal in this research is to determine the relationship between the dynamic capabilities of each of the Irish universities, which we measure as innovation culture, (the independent variable) and each university's output in terms of technology transfer performance (the dependent variable).

It is clear that the role of the entrepreneurial university is not simply confined to assessing an organizational culture conducive to producing new knowledge, but also disseminating this new knowledge to industry and society (Guerrero and Urbano 2012) and our research design aims to measure both elements. Kalar and Antonic (2015) note that the entrepreneurial university needs to create a culture of innovation that encourages academics to disseminate their knowledge through channels that are less conventional and more entrepreneurial in nature. Few studies examine the culture or climate for innovation that facilitates such outcomes, and how this might be developed at the university level. An entrepreneurial scale or metric, called ENTRE-U has been developed through research with Canadian academics (Todorovic, McNaughton, and Guild 2011) and it helps explain the difference in technology transfer performance between different departments within universities. The ENTRE-U model suggests that four factors (Research Mobilization, Unconventionality, Industry Collaboration, and University Policies)

can successfully predict department level commercialization activity in terms of both generating spinouts and filing patents.

While the ENTRE-U model is helpful, the ambition of this paper is to assess the culture of innovation across all of Ireland's universities. Our level of analysis is not the department but the institution as a whole. Zhang, Larkin, and Lucey (2015), from an Irish standpoint, reinforce the position that Irish universities are in transition 'from basic research to applied orientation; from highly autonomous to more closely connected to other actors; and from teaching and research to a contributor in the economic development'.

### *Study population and sampling*

This study examines the performance of Irish universities. In Ireland, there are seven universities. These are the research sites and hence this study was able to survey them all and achieve a census of all the institutions.

### *Research design and data collection*


The study correlates two sets of pre-existing, secondary data from two separate surveys. Although both surveys were measuring different phenomena, they were both conducted at the same time (2014) and carried out on the same survey population. The first, (Zhang, Larkin, and Lucey 2015) presents a survey based on the Rao and Weintaub (2013) model of innovation culture. The questionnaire was issued to the presidents of all the country's seven universities. The invitation to participate in the survey was mediated through Ireland's Higher Education Authority and they asked each university president to circulate the survey to their staff. A reminder was sent two weeks later and the survey achieved a response rate of 6.8% (which is comparable to other survey response rates in the higher education sector in Ireland).

From this data the authors calculated, based on the Rao and Weintaub (2013) methodology, the innovation quotient for each of the universities (the independent variable). This is the data that approximates the dynamic capabilities of each of the seven universities. Separately, the second dataset is developed from the data presented from the 2014 Ireland Annual Knowledge Transfer Survey (AKTS). Scanlan (2017) presented an interpretation of the annual monitoring of standard metrics, normalized to research spend for the seven universities in Ireland. The data set comes from a set of institutes in Ireland from 2014 and from the AUTM and ASTP annual reports from 2014. This data gives us our performance metrics for technology transfer and for industry engagement. This research focused on the licenses, options and assignments (LOA) data per university for 2014. Typically, metrics such as the numbers of patents filed, inventions reported, spin outs completed and numbers and types of collaborations with industry are captured.

### *Data analysis*

This research triangulates data from two separate empirical, survey data sets as articulated in Table 2. Triangulation provides us with 'a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study' (Creswell and Miller 2000). Olsen

Table 2. Triangulation of source data.

	Innovation Culture in Irish Universities	Tech Transfer Performance
Source of Data	Zhang et al, 2015	Scanlan, 2017
Research Sample	Census of Irish Universities	Census of Irish Universities
Date of Survey	2014	2014
Survey Instrument	Rao and Weintaub, 2013	Annual Knowledge Transfer Survey 2014
		

(2004) argues that triangulation goes beyond validation and develops a richer understanding of the phenomenon. Howe (2012) considers data triangulation, the mixing of quantitative and qualitative data sets, useful to both consider the comparative elements of the data sets and also to allow consideration of the data within a broader theoretical framework. Patton (2002) notes that ‘triangulation strengthens a study by combining methods or data, including using both quantitative and qualitative approaches’.

## Results

The number of licenses, options and assignments is a clear validated metric for the level of entrepreneurial engagement by a university with industry within the triple helix framework. It captures the commercialization activities where university derived intellectual property is converted to commercial ownership or use. Interestingly, Leydesdorff and Meyer (2006) note how the number of patents filed by universities has an inverse relationship with the level of research partnership with industry.

In order to capture a snapshot of the relative innovative capabilities and cultures across Irish universities, this research developed the ratio of LOAs normalized per ten million euro of research spend from the data presented in the 2014 Ireland Annual Knowledge Transfer Survey (as shown in Table 3). The ratio of LOAs per normalized research spend gives insight into the degree of collaboration with the external entrepreneurial ecosystem and can be used as a metric to consider the relative degree of knowledge transfer activity of research producing organizations. This measure is referred to as the ‘external engagement’ metric.

When we look at the Irish 2014 data, DCU is the exceptional performer. This should not be surprising as the university refers to itself as Ireland’s ‘university of enterprise’, and has strategically positioned itself to develop strong relationships with industry. University of Limerick (UL) is also noteworthy as an outstanding

Table 3. 2014 Ireland Annual Knowledge Transfer Survey (AKTS) data normalized per €10 million investment.

University	IDFs	Patents	LOAs	Spinouts	Total research expenditure
DCU	9.43	3.71	7.14	0.86	€35,000,000
UL	11.23	2.32	3.48	0.77	€25,830,000
UCD	8.19	2.85	2.98	0.37	€80,570,000
TCD	6.14	2.30	2.85	0.55	€91,185,609
UCC	8.10	2.15	2.50	0.24	€83,900,000
MU	6.70	1.44	2.87	0.96	€20,897,000
NUIG	7.67	1.15	2.88	0.38	€52,171,636

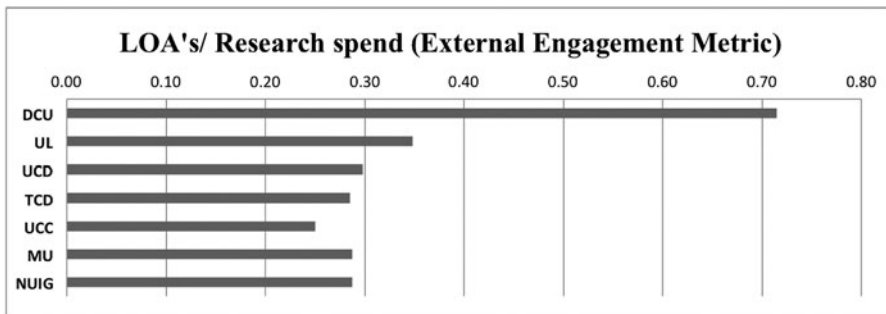


Figure 1. 2014 LOAs per research spend (normalized to €10m) in Irish universities.

performer. UL is also a very outward facing institution with the cornerstone of its strategic plan to collaborate with industry, alumni and the general entrepreneurial ecosystem both locally and internationally.

The relationship between the innovative capabilities of an organization and the development of an innovative culture has been extensively researched. The accepted thesis is that the development of innovative capabilities, and indeed those dynamic capabilities required to be innovative, is strongly linked to the institution developing a culture highly supportive of these capabilities. In October 2014, Zhang, Larkin, and Lucey (2015) utilized the Rao and Weintraub (2013) ‘innovation quotient’ survey tool and surveyed all Irish universities to measure the relative ‘innovation quotients’ across the academic institutions. The innovation quotients of the Irish universities as measured by Zhang, Larkin, and Lucey (2015), Figure 2 shows a strong consistency with the ‘external engagement’ metric developed within this research (Figure 1). DCU is seen in both studies as the outstanding performer across both surveys with UL noteworthy as strongly the second highest performer across both metrics. The performance of TCD and MU are relatively very similar across both assessments with a relatively weaker performance from UCC. Similarly, the relative performance of UCD and NUIG are very similar in both assessments. A very distinct and clear pattern of performance in ‘external engagement’ can be seen relative to the ‘innovation quotient’ of each university. The similarity of ranking of each university (in Figures 1 and 2) showing a high degree of correlation between them. In short, our hypothesis is supported by the data. Universities with a



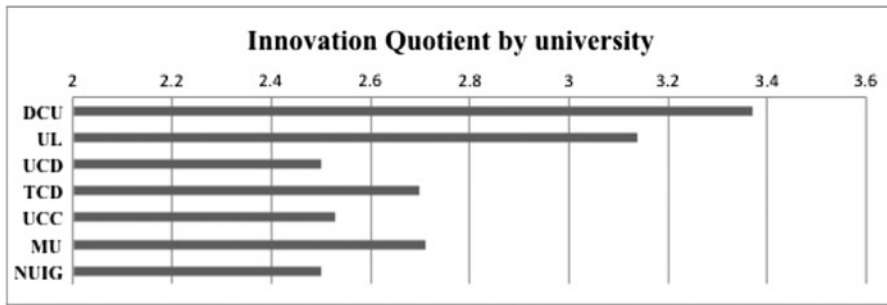


Figure 2. 2014 Innovation quotients of Irish universities (Zhang, Larkin, and Lucey 2015).

superior culture of innovation also have a better performance in the metrics of industry engagement.

### Discussion

This paper highlights the role of a principal element of an entrepreneurial university, a culture of entrepreneurship and innovation within the university, as an enabling factor in the success in knowledge transfer outcomes. It advances Meyers and Pruthi's (2011) definition of the entrepreneurial university in linking the development of a top down university strategy supportive of a culture of innovation with the realizing of knowledge transfer opportunities. Further, the paper underpins the need to identify and measure the determinants of entrepreneurial capabilities to develop a richer understanding of the contribution of entrepreneurial universities to the triple helix innovative ecosystem.

This study offers three principal contributions. Firstly, this paper contributes to our ability to assess the success of research producing organizations (RPO) in engaging in knowledge transfer through the development of the 'external engagement' metric. The development of this ratio allows a richer understanding of the performance of RPOs in knowledge transfer relative to their research expenditure. Secondly, the research has examined the knowledge transfer performance metrics of Ireland's seven universities and has correlated each institution's relative performance with its 'innovation quotient' (Zhang, Larkin, and Lucey 2015) for the same year. Significantly the research results supported hypothesis H1 and identified a direct correlation between the university innovative culture and its success in knowledge transfer.

Finally, through leveraging both the dynamic capabilities framework and the Rao and Wintraub's (2013) innovative assessment survey tool, this research proposes a new theoretical framework for the consideration of the dynamic capabilities of academic institutions in knowledge transfer. The development of an innovative culture and also those dynamic capabilities which support knowledge transfer are seen to have much potential to explain the relative success of universities in knowledge transfer. This work supports Yuan et al. (2016) and Leih and Teece (2016) in the assertion that the dynamic capabilities perspective leads to a greater understanding of the enablers of university technology transfer. Knowledge transfer allows universities to capture financial value from their research activities. Yuan et al. (2016), considering university knowledge transfer



Table 4. Dynamic capabilities linked to innovation quotient.

Dynamic capability	Innovation quotient 'building block'
Sense	Resources
Seize	Behaviors, Climate, Processes, Success
Transform	Values

through the lens of dynamic capabilities theory, note that universities with more developed dynamic capabilities perform better in knowledge transfer. Teece, Peteraf, and Leih (2016) also argue that it is the universities that develop strong and unique dynamic capabilities in knowledge transfer that are most successful in university technology transfer.

Specifically, the success of university knowledge transfer can be regarded in terms of the institutions ability to coordinate and mobilize its dynamic capabilities. Knowledge transfer capability can be considered a result of the universities ability to *sense* and *seize* opportunities and *transform* its resource capabilities to meet the demands of the innovation ecosystem (Augier and Teece 2008).

Sensing considers a universities absorptive capacity (Cohen and Levinthal 1990) and ability to identify opportunities for research commercialization. Seizing capabilities capture financial value through the knowledge transfer capabilities of the technology transfer office. Transforming capabilities are those capabilities of the university to reconfigure its internal resources, structures and competences to best meet the requirements of the external innovation ecosystem.

To date, no measure of dynamic capabilities has been reported in the literature regarding university knowledge transfer. While universities dynamic capabilities are not directly measured in this research, a strong correlation between university knowledge transfer capability and 'innovation quotient' is highlighted. The six building blocks of the Rao and Weintraub (2013) 'innovation quotient' survey tool can be seen to capture the key dimensions of the dynamic capabilities construct as shown in Table 4.

This research argues the 'innovation quotient' can be used as a proxy to also capture the dynamic capabilities of a higher education institution. This research also argues that the strong correlation identified in this research between the knowledge transfer capability (the 'external engagement' metric) and the 'innovation quotient' of Irish universities further supports this thesis.

## Conclusions

The primary objective of this research was to contribute to extant theory that university knowledge transfer is a function of organizational dynamic capabilities (Yuan et al. (2016); Teece, Peteraf, and Leih (2016)) through consideration of the hypothesis that the innovation culture in universities is correlated with their knowledge transfer success. Further, this research sought to respond to a call from policy makers (EU 2017) to determine the extent to which universities are realizing their innovation potential.

To achieve these goals, we present a ratio showing the relative degree of collaboration of Irish universities with their external entrepreneurial ecosystem. We compare this data with a separate survey showing the innovation quotient (Rao

and Weintaub 2013) of the seven Irish universities. We find these data support our hypothesis that universities with a superior culture of innovation also have a better performance in the key metrics of industry engagement. This research offers evidence further supporting the thesis of Yuan et al. (2016) that the knowledge transfer performance varies proportionately with the dynamic capabilities possessed by universities.

If policymakers and funders of higher education need to segment universities to identify those most likely to facilitate local, regional or even national economic development, this tool will help them in that triaging process. Equally, for policymakers attempting to assess which universities are more likely to deliver the national innovation agenda, this paper offers a framework for identifying the likely top performers. Prior to this paper, there was no empirical research in Ireland to correlate industry engagement of universities with their innovation quotient or their dynamic capabilities and hence this study represents a considerable advance in the field.

One key factor that appears in almost all the established entrepreneurial university frameworks is 'mission and strategy' (Markuerkiaga, Errasti, and Igartua 2014). This research advances theory related to the entrepreneurial university paradigm through the proposal of a strategic framework for the development of the entrepreneurial capabilities of universities. The findings also have important policy implications. Policy makers concerned with the strategic management of university knowledge transfer capabilities should note the direct correlation between knowledge transfer outcomes and the innovative quotient of the institution.

### **Limitations and further research directions**

One of the limitations of this research is the assumption that the theoretical essence of the dynamic capabilities model is adequately captured in the Rao and Weintaub (2013) construct of Innovation Culture. Laaksonen and Peltoniemi (2018) note how the growing popularity of using dynamic capabilities to explain organizational performance has triggered high levels of academic interest in finding empirical approaches to measuring such capabilities. As yet though, no single measure exists. Dynamic capabilities theory refers to three core competencies: sensing, seizing, and transforming (Teece 2018), and while the Innovation Culture model captures six elements, they include markers for these three among them.

Second, this research considers knowledge transfer through the singular prism of outward technology transfer. Further, the 'external engagement' metric developed within this research of the number of licenses, options and assignments per €10 million research spend is a clear, validated but relatively primitive metric for the level of entrepreneurial engagement by a university with industry.

Finally, this research triangulates two other, separate studies. These studies were carried out with the same survey population of Irish universities and in the same year but they were not carried out as part of a single study. Hence, any more detailed comparisons could be problematic.

In terms of avenues for future research, one route might be to extend this research to other countries through the use the annual metrics on knowledge transfer developed by the Association of University Technology Managers

(AUTM) and the Association of European Science and Technology Transfer Professionals (ASTP-Proton) for research producing organizations in the USA and Europe respectively as a primary data set.

Further research should look to consider the impact of institutional innovation culture and the dynamic capabilities of the university with respect to the absorptive capacity of the university and inward technology transfer and not just outward engagement.

Another fruitful avenue would be to link the dynamic capabilities theory to the three phases or stages of entrepreneurial orientation universities experience (Etzkowitz 2013). Such research could reveal if they have a differential potency depending on the stage of maturity of the host institution. Such knowledge would be valuable to funders and policymakers.

Finally, with such interest in defining ways to measure dynamic capabilities: the discovery of an appropriate measure for the specifics of a university setting would be a considerable step forward in the field and this recommends itself as a worthwhile area of scholarly research.

### Disclosure statement

No potential conflict of interest was reported by the authors.

### Notes on Contributors

**Noel O'Reilly** is a PhD candidate in the Department of Design Innovation at Maynooth University, Ireland under the supervision of Dr. Peter Robbins. Noel obtained a BSc in analytical science and a M.Sc. in management from Dublin City University. Noel's research interests include the entrepreneurial university, strategic management, innovation and design thinking. His current research is a phenomenological study of the development of entrepreneurial capabilities within Irish universities. Noel also works as a global strategic account manager in the biopharmaceutical industry.

**Dr. Peter Robbins** is one of Ireland's foremost experts in innovation and new product and service development. His area of research is how firms organize for innovation. He is head of the Department of Design Innovation in Maynooth University. He has published in *R&D Management*, the *Irish Journal of Management*, *International Journal of Innovation Management*, *London Strategy Review* and regularly speaks at international conferences on the subject of managing creativity and innovation.

### ORCID

Noel M. O'Reilly  <http://orcid.org/0000-0002-7070-544X>

Peter Robbins  <http://orcid.org/0000-0002-5223-7718>

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