



**QUEEN'S
UNIVERSITY
BELFAST**

Additionality of incubator support on networks of university spin-out firms

Hewitt-Dundas, N., Burns, C., & Chapman, G. (2016). Additionality of incubator support on networks of university spin-out firms. In P. Ahrweiler, N. Gilbert, & A. Pyka (Eds.), *Joining complexity science and social simulation for innovation policy: agent-based modelling using the SKIN platform* (pp. 289-325). Cambridge Scholars.

Published in:

Joining complexity science and social simulation for innovation policy: agent-based modelling using the SKIN platform

Document Version:

Peer reviewed version

Queen's University Belfast - Research Portal:

[Link to publication record in Queen's University Belfast Research Portal](#)

Publisher rights

Copyright 2016 Cambridge Scholars.

This work is made available online in accordance with the publisher's policies. Please refer to any applicable terms of use of the publisher.

General rights

Copyright for the publications made accessible via the Queen's University Belfast Research Portal is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The Research Portal is Queen's institutional repository that provides access to Queen's research output. Every effort has been made to ensure that content in the Research Portal does not infringe any person's rights, or applicable UK laws. If you discover content in the Research Portal that you believe breaches copyright or violates any law, please contact openaccess@qub.ac.uk.

Open Access

This research has been made openly available by Queen's academics and its Open Research team. We would love to hear how access to this research benefits you. – Share your feedback with us: <http://go.qub.ac.uk/oa-feedback>

CHAPTER X

ADDITIONALITY OF INCUBATOR SUPPORT ON NETWORKS OF UNIVERSITY SPIN-OUT FIRMS

Introduction

Government policy to promote a knowledge-based economy (Kitagawa and Robertson, 2012) has led to a growing emphasis on promoting research excellence in the university sector in conjunction with efforts to translate this into economic and social benefit. Government policy has been instrumental in this specifically through encouraging the commercialization of research. In the US, the Bayh-Dole Patent and Trademark Amendments Act (1980) made two significant changes: first, it authorized US universities to retain rights to—and license inventions resulting from—federally-funded research; second, it assigned ownership of patents or IP created within a university to that university, as opposed to the inventor (Hoppe and Ozdenoren, 2001). While most European countries subsequently adopted similar legislation to the USA, variations exist. For example, Italian policy makers, have sought to encourage commercialisation of university research by shifting IP ownership to inventors (Geuna and Rossi, 2011). In other countries, including Ireland, ambiguity in IP policy means that ownership of intellectual property rights (IPRs) and patents by the inventor or by their employers remains unclear and inconsistent across the sector (Patents Act, 1992).

Beyond policies to stimulate directly the commercialization of research through IP, in some countries such as the UK, cuts in public funding for universities combined with a meritocratic system whereby universities compete for funds have left universities less well-resourced than previously (Hewitt-Dundas, 2012; Harrison and Leitch, 2010; Siegel *et al.*, 2003; Etzkowitz *et al.*, 2000). Indeed suggestions that future public funding of university research may be contingent on the potential industry benefits or university-industry links stemming from research (Florida, 1999), is likely to encourage universities to forge an even stronger commercial focus.

Universities in general, have responded to these legislative and policy changes by placing a greater emphasis on the protection of University-based intellectual property and pursuit of commercially-oriented activity, metrics and outcomes (Grimaldi and Grandi, 2005; O’Shea *et al.*, 2005, Owen-Smith, 2003). This has extended beyond private ownership of IP and a more proactive IP development and exploitation strategy (Siegel *et al.* 2003; Lockett and Wright, 2005) to also include greater business-engagement (OECD 1999, Chatterton and Goddard 2000, Holland 2001). This engagement occurs through various channels including collaborative and contract research, consultancy, the use of facilities and equipment as well as professional education and training (Hewitt-Dundas 2012). Ultimately, universities have sought to generate wider economic and social benefit through the education of students, through knowledge and technology transfer activities involving cooperation with external organisations and through the protection and subsequent exploitation of IPRs. However, it is perhaps the protection of IPRs and exploitation of this through university spin-out firms (USOs) that has received most attention by academics, technology transfer professionals and policy makers.

University Spin-outs

University Spin-outs (USOs) are defined as ‘new ventures that are dependent upon licensing or assignment of [an] institution’s intellectual property for initiation’ (Lockett and Wright, 2005: 1044-1045). Siegel *et al.* (2003) point to the relatively recent shift in emphasis from exploitation of university IP through licensing models to a focus on spin-out activity. However, the perception remains that research commercialization through spin-outs will tend to occur, only when other routes such as licensing have been exhausted (Wright *et al.*, 2008). Indeed, in the early 2000s only 21 per cent of US university technology transfer offices explicitly mentioned new firm creation in their mission statements (Markman *et al.*, 2005) and only 52 per cent of UK universities spun out *any* firms in 2005 (UNICO, 2006). More recently, increasing rates of USO formation have been reported (Fini *et al.*, 2011; Mustar *et al.*, 2008; Clarysse *et al.*, 2005; Markman *et al.*, 2005) with a growth rate in the UK of 46 percent between 2008 and 2011, or an average annual increase of 15.3 percent (HESA, 2012). This growth has been attributed to a number of factors (Fini *et al.*, 2011; Mustar *et al.*, 2008; Clarysse *et al.*, 2005; Markman *et al.*, 2005) reflecting the changing policy environment discussed above.

First, increasing recognition of the central role of knowledge in economic development and of its monetary value has created an impetus for producers of research, to reap its financial reward (Harrison and Leitch, 2010; Van Geenhuizen and Soetanto, 2009; EU, 2003). In this regard, USOs represent a means of transferring and profiting from

university knowledge (Ndonzuau *et al.*, 2002). A recent example of this is the 2011 initiative in New York City to incentivise universities to develop their science and engineering infrastructure with a view to stimulating 400 USOs within 30 years (Bloomberg, 2011).

Second, some authors link increased rates of spin-out to researchers' and universities' decreasing reliance on patenting as their primary means of commercialising university research (Geuna and Rossi, 2011; Siegel *et al.*, 2007). In other words, universities have expanded the channels through which they attempt to exploit their IP. Third, and perhaps most significantly, in recent years there has been an 'explosion of policy' (O'Shea *et al.*, 2008:654) in the US and in many EU countries, prompting universities to demonstrate their contribution to national and regional economies (Huggins and Johnston, 2010; Wright *et al.*, 2008; Grimaldi and Grandi, 2005; Lockett and Wright, 2005; O'Shea *et al.*, 2005; Siegel *et al.*, 2003; Mian, 1997), with spin-out activity being an important channel for this¹.

While there is agreement that spin-out activity as a whole has increased, its distribution remains highly skewed: in the UK and US, the majority of USOs originate from a small number of universities (O'Shea *et al.*, 2005; Lockett and Wright, 2005). In addition a key aspiration underpinning public policy around university commercialisation is to emulate archetypes of USO creation like MIT and Stanford, but these success stories are likely embedded in and dependent on the environment from which they emerged and it is unlikely that their structure and success can simply be replicated in different contexts (Harrison and Leitch, 2010; Huggins and Johnston, 2010; Clarysse *et al.*, 2005). Gilsing *et al.* (2010: 12) support this perspective, arguing that public policy to promote spin-out activity has been based on 'policy fashions rather than empirical evidence'. A 2003 UK Treasury report also raised doubts about the proliferation of USOs, suggesting that too many USOs were being created in circumstances where *other* avenues for technology transfer would be more appropriate (Lambert, 2003) with Wright *et al.* (2008) suggesting that a shift in policy emphasis away from USO and towards start-ups may be needed.

Alongside debates on the appropriateness for universities of alternative commercialization channels, concerns have also been raised about the high failure rates of USOs – estimated at around 30 per cent - (Targeting Innovation, 2008; Rothaermel and Thursby, 2005b) and no-to-low growth among those which survive compared to other new technology based firms (Harrison and Leitch, 2010; Van Geenhuizen and Soetanto, 2009; Lockett and Wright, 2005; Degroof and Roberts, 2004; Rice, 2002; Dahlstrand, 1997). These concerns are compounded further by lower than anticipated financial returns to universities and regions from USOs (Colombo and Piva, 2012; Leitch and Harrison, 2005). As a result, questions have been raised about policy makers and universities sustained commitment and investment in USOs (Gilsing *et al.*, 2010; Schwartz and Hornyk, 2010; Mustar *et al.*, 2008; Geuna and Nesta, 2006; Florida, 1999). For this reason we consider briefly the rationale for intervention – whether by government, private sector investment or by universities – in supporting the formation and growth of USOs.

Case for Intervention

Intervention is most commonly discussed in terms of government's role in the market where its justification is based on market imperfections which will remain uncorrected in the absence of intervention. In the same way, other actors may also intervene to overcome sub-optimal market conditions. In the case of USOs, this intervention might take various forms including direct fiscal incentives to support the development of USOs, legislative and regulatory changes e.g. rules on disclosures and IP requirements to knowledge brokering activities which seek to overcome information asymmetries in the market. Ultimately where market and/or system failures exist, this will result in an under-investment in and underproduction of R&D and innovation relative to the socially desirable level (Martin and Scott, 2000). Both of these failures are now considered in more detail.

For USOs market failure arises mainly due to leakages from imperfect patent protection and knowledge spillovers that prevent firm's undertaking R&D and innovation, from fully appropriating the benefits arising from these activities (Knockaert *et al.*, 2014). In addition, market failure may also be evident in investor short-termism, information asymmetries and excessive risk associated with new technologies (Bleda and Rio, 2013). As a result USOs often struggle to access finance to fund their activities (Mustar *et al.*, 2008) with this impeding USO development, by preventing them from fully appropriating their intellectual property, and depriving them of the finance needed to fund core activities (Martin and Scott, 2000; Dodgson *et al.*, 2011).

Beyond market failures, USO development may also be inhibited by system failures. The systems perspective recognises that innovation is increasingly an interactive process, with firm's innovative success dependent on collaborating with numerous other actors and institutions (Woolthuis *et al.*, 2005). Through collaboration, firms acquire

¹ It is interesting to note that developing nations and less favoured regions have seen similar prioritisation of commercial university activity, mainly with the goal of combatting poverty and high unemployment (Etzkowitz *et al.*, 2005).

new ideas and access new resources and expertise, integrating this external knowledge with their internal knowledge to enhance the knowledge base from which they innovate (Lichtenthaler, 2011). These exchanges are facilitated by institutions and the USOs networks and capabilities, with system failure occurring when imperfections that inhibit collaboration exist (Woolthuis *et al.*, 2005). System failure may be evident at a macro-level in terms of institutional and infrastructural failure, while at the micro- (firm-) level it may take the form of capability and network failure (Weber and Rohracher, 2012).

Infrastructural failure relates to a lack of physical and knowledge infrastructure to facilitate collaboration and knowledge generation (e.g. information technology). Institutional failure falls into two sub-categories; hard and soft. Hard institutional failures relate to the absence of or shortcomings with current laws and regulations for innovation and R&D activities. Whereas, soft institutional failures, relate to issues and problems with the culture and values of society toward innovative activities (e.g. risk averse). These failures inhibit innovation generally, however, particularly within USOs due to the often radicalness of their technology and their reliance on intellectual property for value creation (Wright *et al.*, 2004). More detrimental to USOs however, is network and capability failure, given deficiencies in social capital and inadequate internal capabilities are key inhibitors of USO development (Vohora *et al.*, 2004).

Capability failure occurs when USOs lack the necessary capabilities to learn and absorb new knowledge for innovation, inhibiting their efforts to adapt to new and changing environments (Weber and Rohracher, 2012). Given the importance of knowledge acquisition and integration throughout the USO development process (Vohora *et al.*, 2004), capability failure may be particularly detrimental. New knowledge is identified and complementary resources, ideas and expertise acquired through the USOs network (Lichtenthaler, 2011) with network failures occurring in two ways: *strong failures*, were the closeness of ties results in lock-in, and *weak failures*, were the USOs lack linkages with other actors (Woolthuis *et al.*, 2005), preventing them from accessing external knowledge. For USOs, as for market failures, system failures, particularly network failure, significantly impede USO development.

Interventions to overcome market failures and specifically access to finance have been studied elsewhere (Mustar *et al.*, 2008), yet much less well understood are the effectiveness of interventions to overcome system failures. When 'treated' USOs are more successful and sustainable post intervention then intervention is deemed to have been effective. This may be assessed in terms of USOs overcoming financing constraints and leveraging additional support (input additionality), increasing their revenue generation and speed to market (output additionality) or improving their networks via leveraging their social capital (behavioural additionality).

An important way in which intervention has occurred to support the formation and development of USOs has been through the establishment of incubators. With estimated average capital investment costs for an incubator of around €3.7m and annual operating costs of €0.48m (see Dee *et al.*, 2011, 48) it is critically important to understand the additionality that UIs generate for USOs (Bruneel *et al.*, 2012). While evidence supports the positive influence of R&D and innovation subsidies (Falk, 2007; Breschi and Lissoni, 2009) and technology intermediaries (Knockaert *et al.*, 2014) on firm networking and cooperation, few studies have examined the influence of incubator support on USO networks, from an additionality perspective. Evaluation is necessary to understand if incubators achieve this, generate value for money or induce other unintended or unanticipated benefits (Woolthuis *et al.*, 2005; Georghiou, 1998).

University incubators

Incubators are commonly defined as 'a property-based organization focused on accelerating the growth and success of entrepreneurial companies through the provision of business support, resources, and services' (Markman *et al.*, 2008: 1406). University incubators (UIs) are incubators located on university campuses, specialising in the commercialisation of university technology (Allen and McCluskey, 1990) and typically hosting high-tech USOs. Beyond offering tenant firms suitably equipped business premises at attractive rates, they also offer services such as 'coaching, mentoring, consulting, general advice, motivation, business introductions, technical appraisal and business network access' (Ahmad and Ingle, 2011:629).

In contrast to property-based UIs (Markman *et al.*, 2008: 1406, Durão *et al.*, 2005) a 'non-incubator' approach to the commercialisation of USOs exists. Here, 'universities without a central incubator building supply incubation support to spin-offs located at distributed places on-campus and off-campus' (Van Geenhuizen and Soetanto, 2009: 671). Evidence from the Netherlands and Italy suggests that UIs with 'no building space and physical facilities' are common (Colombo and Delmastro, 2002: 1107; see also Van Geenhuizen and Soetanto, 2009), yet this model of university commercialisation support is discussed much less frequently. The validity of the non-incubator approach to supporting USOs is further evidenced by references to 'virtual' incubators (Carayannis and von Zedtwitz, 2005; Durão *et al.*, 2005; Hackett and Dilts, 2004). For example, OuluTech, the commercialisation support unit at the University of Oulu, epitomises this 'non-UI' model, spinning out 10-20 firms per year and being a main contributor to the 'Oulu

phenomenon' (an exemplar of regional development in Finland), but without a physical incubator (Rasmussen *et al*, 2006).

Table 1 presents a synthesis of the main characteristics of the University Incubator (UI) model to USO support and the Non-University Incubator (Non-UI) model.

Table 1: Characteristics of UI and Non-UI USO support models

USO Characteristics	University Incubator (UI) model	Non-University Incubator (Non-UI) model
Location of USO	USOs located on-campus in university-administered premises	USOs located in off-campus premises not administered by university or on-campus in academic offices/labs
USO facilities and equipment	Shared start-up infrastructure and services (phone, heating, reception, meeting rooms, etc.) included	USOs source, install and pay full rate for equipment, internet access, overheads, etc.
Links to University	USOs can use university address	USOs can use university address
Business Support Services	Business support services offered to USOs (e.g. mentoring, advice, business network access)	Business support services offered to USOs (e.g. mentoring, advice, business network access)
Development Period	USOs have limited time period before 'graduation' (i.e. leaving UI) is required: typically 2-5 years	No formal 'graduation' policy for USOs

Source: Hewitt-Dundas and Burns (2015)

To date empirical evidence generally points to a net positive effect of incubators on job growth, innovation, and inter-organisational links of new firms (Colombo and Delmastro, 2002). However, other research (Tamásy, 2007) suggests that the probability of survival, business growth or innovative activity among incubated and non-incubated firms is not significantly different. Further, although a number of studies have examined the effect of incubators on the growth of USOs, a key limitation of many of these studies has been that they have looked only at tenants in the absence of a counterfactual scenario where USOs are formed and grow in the absence of an incubator: the non-UI model. For universities seeking to support USOs these findings create uncertainty as to the anticipated benefits to be derived from establishing an incubator facility with its associated costs.

Incubators and USOs

While various studies have examined how incubators enhance the internal resources and capabilities of USOs, more limited evidence exists on the configuration of networks for USOs located in UIs and their subsequent access to external resources. Similar to the perceived role of TTOs, incubators act as 'intermediary – or mediating – organisation(s), helping newly founded and young ventures to establish cooperative relationships with a broad range of economic actors' (Schwartz and Hornych, 2010: 485). Through these cooperative relationships, start-up firms acquire access to resources and capabilities essential to survival and growth (Aernoudt, 2004; Hansen et al, 2000). Ahuja (2000, 319) suggests that these external resources that firms access may 'not be available for purchase in factor markets and require time to build up' yet be very important in creating value for the business. For example other empirical research finds that 'network structure differentially influences the flow of financial resources, capabilities and opportunities' to businesses (Ayra and Lin 2007, 698). Therefore, network structure and the position of a business within this network will influence its behaviour and performance (Mizruchi and Marquis, 2006). This suggests that understanding the potential effect of UIs on network structure of USOs may be central to appreciating the resource and capabilities that USOs access by being based in a UI and consequently how this contributes to USO growth.

Where UIs facilitate network ties, these - anticipated positive - externalities may be important not only in supporting USO growth, but much earlier in the USO process by (i) bridging the gap between the conception of a business idea and its actual "instantiation" (Hackett and Dilts, 2004: 69) and (ii) helping start-ups (and specifically USOs) to survive the 'valley of death' between public funding of basic research and private equity funding for a viable business (Barr et al, 2009: 371; Mustar et al, 2008). This suggests the need for a process view of USOs as opposed to the cross-sectional analysis that typifies most empirical studies in adopting a "snapshot approach" and overlooks the dynamic process

inherent in the creation and evolution of a spin-out firm (Mustar et al, 2006: 295). Rasmussen (2011: 457) therefore concludes that examining USOs through stage models is appropriate for identifying “the challenges and problems to be dealt with at different times in the [spin-out] process”. In addition, consideration of the way in which UIs contribute to the formation of USO networks overcomes the criticism that incubators have been studied as a ‘black box’ (see Clarysse et al, 2005; Mian, 1997) with a lack of insight into what this process might comprise (Scillitoe and Chakrabarti, 2010; Hackett and Dilts, 2004).

While various spin-out process models have been proposed (see Clarysse et al, 2005; Vohora et al, 2004; Ndonzuau et al, 2002), there has been a lack of process-oriented empirical research (Rasmussen, 2011; Mustar et al, 2006; Grandi and Grimaldi, 2005; Lockett and Wright, 2005; Wright et al, 2004)². Despite these different conceptualisations of the spin-out process, significant commonality exists with most highlighting distinct stages where the commercial opportunity arising from research is identified and framed, IP assessment/protection is undertaken, the USO is chosen over alternative commercial channels and there is the acquisition of resources/investment.

One of the most comprehensive conceptualisations and widely cited models of the USO process is Vohora et al.’s (2004) ‘critical junctures’ model. In this model, five distinct stages are identified in the development of USOs with four critical junctures between these stages being: (i) opportunity recognition, (ii) entrepreneurial commitment, (iii) threshold of credibility and (iv) threshold of sustainability. This model offers several distinct benefits over other models. First, it provides clear thresholds between one phase and the next. For example, it is only when management is committed to exploiting commercial opportunity through a USO that ‘pre-organisation’ activities such as strategy formulation and resource acquisition can begin. Second, each phase of the model involves revisiting preceding phases in light of newly acquired social capital, resources or capabilities. The implication is that each spin-out phase is distinct but not detached from preceding phases: there is built-in scope for ‘feedback’ to decisions and actions taken during earlier phases, addressing criticisms that stage models tend to be too rigid and linear³ (Rasmussen, 2011; Neergaard, 2003). Third, to progress beyond each juncture, USOs need to overcome their ‘deficiency in social capital, resource weaknesses and inadequate internal capabilities’ (Vohora et al, 2004: 168). As such, a process perspective to USO development precludes a ‘blinker’ process orientation – where no variables are incorporated into the model – while also reflecting the high fluidity inherent in USO development.

Networks in USO development

Although support to USOs either through the UI or the Non-UI model (Table 1) may take various forms, here our primary interest is in network ties that USOs form in these different university environments and the effect of these ties on USOs, especially at the early stages of the business development process (Vohora et al. 2004). As outlined above, the role of UIs in supporting USOs may be particularly important in (i) bridging the gap between the conception of a business idea and its actual “instantiation” (Hackett and Dilts, 2004: 69) and (ii) helping start-ups (and specifically USOs) to survive the ‘valley of death’ between public funding of basic research and private equity funding for a viable business (Barr et al, 2009: 371; Mustar et al, 2008).

Opportunity recognition and entrepreneurial commitment

An entrepreneurial opportunity is defined as a ‘feasible, profit-seeking, potential venture that provides an innovative new product or service to the market, improves on an existing product/service, or imitates a profitable product/service in a less-than-saturated market’ (Singh, 2001: 11). Drawing on the organisational knowledge literature, Nonaka (1994) emphasises the centrality of social interaction between individuals in sharing and developing new knowledge. Indeed, more recent work on the role of social networks in entrepreneurship also argues that entrepreneurial success depends on ‘the ability of the entrepreneur to exploit social networks’ and that the establishment by universities of technology transfer offices has been in response to concerns over inadequacies in academic’s commercial awareness. In other words, while many of the antecedents of opportunity identification have been studied at the individual level, these may be moderated by the environment. As such, the UI may also enhance (or constrain) the identification of entrepreneurial opportunities by USOs.

Evidence on how UIs might affect USOs opportunity identification and entrepreneurial commitment activities is mixed. On one hand, the campus incubator environment (UI) may encourage informal or formal inward-looking organisational links between USOs ‘remain[ing] too much oriented on the academic world’, to the neglect of commercial

² Exceptions to this include Rasmussen (2011) and Van Geenhuizen and Soetanto (2009).

³ Other work shares this notion of spin-out as a process of resource acquisition and reconfiguration (McAdam and McAdam, 2008; Lockett and Wright, 2005; Druilhe and Garnsey, 2004).

efforts (Gilsing *et al.*, 2010, 16; see also Bekkers *et al.*, 2006). Indeed, where links to external organisations outside the UI are lacking, the inter-organisational network of the USO will be characterised by a homogenous group of similar firms that may constrain USOs' development activities. Specifically, such lack of diversity may reduce 'the chance of unforeseen novel combinations of knowledge which can lead to discovery' (Pittaway *et al.*, 2004: 44).

In contrast to this, social networks formed between early-stage academic entrepreneurs may be particularly important in terms of avoiding isolation and gaining reassurance through a 'sense of common struggle' (Cooper *et al.*, 2012; McAdam and Marlow, 2007: 363) and having role models which encourages them to commit to their business (Vohora *et al.*, 2004). Further, where informal or social ties develop in a UI between USOs (Cooper *et al.*, 2012; Schwartz and Hornych, 2010), the development of relational capital may lead to *formal* relationships (Bøllingtoft, 2012; Debackere and Veugelers, 2005). This may be particularly important for academic entrepreneurs, where time constraints make formal networking difficult (McAdam and Marlow, 2008). However, Lindelöf and Löfsten (2004) argue that informal ties to co-tenants rarely lead to formal transactions or collaborations, instead constituting opportunities which are rarely taken.

Despite physical proximity, there is considerable evidence that UI tenants are unwilling to share information with one another (Schwartz and Hornych, 2010; McAdam and Marlow, 2008; McAdam and Marlow, 2007) for fear that it may be misappropriated evoking more general findings about firms' reluctance to share 'core' knowledge (Amesse and Cohendet, 2001; Hamel *et al.*, 1989). Even where informal relationships develop, the initial benefit of these may be eroded over time. For example, Bloodgood *et al.* (1995) identify three possible problems: expected preferential treatment (where friends become customers but, because of relational capital, expect to be given more favourable terms); poor advice (where friendship distorts the entrepreneurs' perception of whether they are receiving impartial and useful business advice) and lack of professionalism (where friends become suppliers and take advantage of the relationship by delivering lower quality goods in a less timely fashion than if they were delivering to other customers). Bøllingtoft suggests that this creates an environment whereby incubator tenants may behave and make decisions in the interests of their co-tenants to their own detriment, 'because you have to think of the other entrepreneurs' businesses also' (2012: 312).

Mixed evidence therefore exists on the perceived advantages and disadvantages for USOs of being located in a UI. However, studies on the effect of UIs on USOs have predominantly been one-dimensional in examining those USOs located within an incubator and their interaction with other tenants and wider partners. Where the evidence is less well developed is in determining if the network of relationships for USOs in a UI are different to those for USOs with no incubator support. In other words, do UIs significantly affect the profile of networks for USOs? This is important because if one of the main advantages of a UI facility is in terms of the information, resources and capabilities that it's USOs (tenants) can access, and in turn these affect the behaviour and development of the USOs, then this clearly strengthens the argument for universities making substantial investments in such organisational supports. However, if the profile of network relationships for USOs from universities without a UI facility are similar (or better) to those with a UI—and the benefits derived from these network relationships are similar (or better)—then this raises questions about the feasibility of investing in expensive UI facilities in a period when efficiencies are being sought in the commercialization of research. Indeed, some argue that with advances in ICT and globalisation of markets, the traditional advantages of incubators have eroded the necessity for physical proximity between businesses and that the benefit of clustering (as in UIs) has therefore diminished (Onsager *et al.*, 2007; Durao *et al.*, 2005).

In the remainder of this chapter we explore the network configuration of USOs in two comparative contexts: a research intensive university *with* a UI on campus and a research intensive university *without* a UI (either on-campus or off-campus), both located on the island of Ireland. The aim of the investigation is two-fold: (i) to determine if there is a structural difference in the network additionality of an incubator facility on USOs and (ii) to explore the effect of an incubator on the early stages of USO development, particularly in terms of opportunity identification and entrepreneurial commitment.

Data and Methods

Our investigation is based on case analysis of two universities. In University A, a wholly-owned incubator was established on the University campus in 2003. This incubator's (hereafter referred to as UI) premises comprised business units, desk space and bio-incubation units, as well as a reception service, equipped meeting rooms and a café. Generally, no investment is made in tenants in this UI but University A does take equity of fifteen percent in each USO in exchange for University-owned IP being assigned to the firm. At the start of 2013, UI had 34 tenants (Table 2).

The second case, University B has a much longer history than University A in providing formal support for the commercialisation of university research. University B formed a commercialization unit but without an incubator (hereafter referred to as Non-UI) in 1984 as a limited company with the objective of commercialising university research

by supporting spin-out activity. University B/Non-UI invests in each USO and, upon receiving equity in the firm, IP is assigned from the University to the USO. USOs can also access, through the Non-UI, professional services, IP advice and venture capital networks but, crucially, not university-owned physical incubation facilities. To 2014, University B had supported 59 firms – 25 of these were still active and have not been acquired during the period of study (Table 2).

USOs in University B (Non-UI) were typically older than clients of the UI – this was unsurprising given the considerable difference in the units' ages and the absence of 'graduation' (short of acquisition/liquidation) in the Non-UI. Despite this, the average (median) number of employees in the USOs was similar for both universities. Further, the pattern of USOs by sector grouping was broadly similar in the two contexts, although UI had a significantly higher proportion of pharmaceutical manufacturing firms while, in Non-UI, equipment manufacturing was more prevalent. Exploring such a limited number of cases in detail is warranted by the absence of extant research comparing these two models (Dul and Hak, 2007) and by the complexity of collecting, mapping, analysing and comparing network data.

Our approach recognises that despite the wealth of research on incubator networks (see Bøllingtoft, 2012; Soetanto and Jack, 2011; Scillitoe and Chakrabarti, 2010; Bøllingtoft and Ulhøi, 2005; Hansen *et al.*, 2000), studies applying SNA in this context are rare – the exception being Cooper *et al.* (2012) and Tötterman and Sten (2005). This is despite the widely-cited importance of networks for start-up firms generally (Meyer, 2003), for new technology-based firms (NTBF) more specifically (Lindelof and Lofsten, 2004; Yli-Renko and Autio, 1998) and for high-tech USO in particular (Debackere and Veugelers, 2005; Gübeli and Doloreux, 2005).

Our data collection involved two stages: research at the level of the overarching network, complemented with semi-structured interviews with the founders of each USO. This approach is in response to Wellman *et al.* (1997) who emphasise that research on networks conducted with the actors (USOs) as the level of analysis is meaningless without some consideration of the broader network structure in which individual relations exist. Network analysis encompasses the entire network structure and provides a detailed overview, description and analysis of the entire social system (Provan *et al.* 2007). SNA was used, the principle goal of which is 'to examine relational systems in which actors dwell and to determine how the nature of relationship structures impacts behaviors' (Rowley, 1997: 893-894). Nodes (individual actors within the network, e.g. USOs) and ties (relationships between nodes, e.g. social and contractual agreements) along with attributes of these (e.g. direction, strength) were therefore mapped.

Data collected on the network structure for both the UI and Non-UI included measures of both informal and formal network ties: all firms were asked to identify all (i) other USOs and (ii) host university schools with which they had formal or informal ties¹. Respondents were given a list of *all* current and former USOs from their university and a list of all academic departments within their host university. Network analysis was carried out using UCINET. After documenting and gauging the strength of all UI and non-UI firms' formal and informal ties, this data was inputted to UCINET by creating and importing DL language text files. Having imported each reported node and tie to UCINET, as well as the attributes of nodes (firm type, age, host university) and ties (direction, frequency of interaction), a range of network statistics were then calculated of which we report density in this chapter⁴.

In addition to collecting network data, we attempted to interview the population of active USOs in both universities to explore emergent differences or similarities in network characteristics between the UI and Non-UI contexts. Interviews were conducted with the firm's founders exploring their perceived obstacles and enablers to network formation, details of cooperative partnerships, benefits accruing to firms from network ties, and the impact of being located (or not) in a university incubator on these various factors. Data collection occurred between November 2012 and February 2013, with interviews occurring at the firm's premises or a similarly suitable location and lasting for between 45 and 90 minutes.

Interviews were recorded, transcribed and analysed with MaxQDA (qualitative analysis software). The data was 'open coded': each transcript was systematically studied and relevant words and phrases were categorised under themed headings and sub-headings, created and restructured dynamically during analysis. The resulting code system (cross-referenced by respondent and group) allowed identification of recurrent themes and comparison of the experiences and opinions of UI and Non-UI founders, and of sub-groups within each context. Finally, network data was revisited in light of the interview data. Insights into reported network obstacles, enablers, capabilities, benefits, etc. allowed us to intuitively understand and explain structural characteristics and differences across the two contexts.

⁴ It should be noted that network analysis was conducted on a cross-sectional basis at the same time in both University contexts. Spin-out firms were of different ages, focused on different sectors and were at different stages of the development process. It is possible that this had some effect on the structural composition of the network, however this is most likely to have related to the formation of formal as opposed to informal ties.

Table 2: Characteristics of USOs in University A (UI) and University B (Non-UI)

	University A - UI				University B - Non-UI		
	Tenant USO	On-campus USO	Spin-In	Total	USO	Shareholding	Total
N	9	6	25	40	22	3	25
% surveyed	67.0	83.0	64.0	68.0	82.0	100.0	84.0
Age and size							
Age (years): Mean (median)	7.0 (7.3)	2.5 (2.1)	5.2 (5.2)	5.1 (4.7)	10.5 (9.2)	15.8 (14.3)	11.3 (9.9)
USO size (no. FTEs): Mean (median)	8.7 (4.0)	4.4 (0.0)	4.9 (2.5)	5.7 (2.0)	46.1 (2.3)	9.7 (6.0)	40.9 (3.0)
Sector (% of USOs)							
Human health & social work	16.7	0.0	0.0	4.2	5.6	0.0	4.8
Information and communication	33.3	0.0	56.3	41.7	27.8	33.3	28.6
Manufacturing	33.3	60.0	18.8	29.2	38.9	33.3	38.1
Professional, scientific and technical activities	16.7	40.0	25.0	25.0	27.8	33.3	28.6

Note: Data relates to February 2013

Findings

Structural networks among USOs

By analysing the presence of informal and formal ties that USOs reported with (i) other USOs from the same University (excluding spin-ins and shareholdings), (ii) all other firms (including spin-ins located in the UI and shareholdings of Non-UI) and (iii) academic schools or centres within the host university, density measures were calculated (Table 3).

Overall, the density of informal ties between USOs was significantly greater in the UI context (41.67 per cent) compared to the Non-UI context where there was no incubator (18.18 per cent)ⁱⁱ. Further, informal network density between USOs and university schools was also significantly (albeit weak) higher in the UI (12.57 per cent compared to 8.86 per cent).

A somewhat different profile was obtained however for formal networks. Here, although the density of these was very low in both the UI and Non-UI contexts (Table 3) this was significantly higher in the Non-UI context. For example, formal ties between USOs in University B were 6.06 per cent while no formal ties were found in UI. This was also accompanied by denser formal ties between USOs and university schools in University B (Non-UI) (12.50 per cent as compared to 5.81 per cent). Again, the correlation between informal (social) ties and formal (relational) ties was weak.

Table 3: Density of UI and Non-UI informal and formal networks

	UI	Non-UI	Pearson Chi square	p-value
Informal network				
USO-USO network	41.67	18.18	20.461	0.000**
USO-school network	12.37	8.86	5.453	0.020*
Formal network				
USO-USO network	0.00	6.06	4.605	0.032**
USO-school network	5.81	12.50	22.066	0.000***

Note: (i) Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$ (ii) Full Network includes spin-in firms in the case of UI and firms for which Non-UI have a shareholding.

These findings suggest that USOs located in a university incubator have denser informal network ties both to other USOs and to schools in their host university than USOs without a university incubator. In contrast, we also find that USOs from a university without a UI (University B) have denser formal network ties both to other USOs and to host university schools with no apparent relationship between the presence of informal and formal network ties. This finding contrasts with that of Bøllingtoft (2012) and Debackere and Veugelers (2005) where it was suggested that informal ties would translate into formal business relationships. In contrast, in the case of Non-UI, informal ties were less common but where links between USOs did exist, these were more likely to be based on formal contractual arrangements.

USO external network ties

The extent of external ties beyond the immediate University environment was also gauged. External network ties to external private clients, suppliers, collaborators, universities and publically funded research centers/labs were examined⁵ (Table 4).

Table 4: Frequency of external network ties

	UI tenants	UI	Non-UI
	(incl. spin-ins)	USOs only	USOs only
Customers/clients	25.20	17.60	18.93**
Suppliers	8.40	7.20	5.40
Private collaborators	0.00	0.00	0.73
Total Private	33.60	24.80	25.07
Other universities	3.00	2.00	2.07
Publicly funded research centres/labs	0.40	0.30	1.07
Total Public	3.40	2.30	3.13
All	37.00	27.10	28.20

Note: Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

USO tenants (including spin-out and spin-in firms) in UI reported, on average, more external network ties than USO clients of Non-UI with mean counts of 37.00 and 28.20 respectively (Table 4). Excluding spin-in firms from the analysis and comparing only spin-out firms in UI and Non-UI we see no significant difference in the extent of external network ties (average of 27.1 ties per USO in UI compared to 28.2 ties in Non-UI). This suggests that the context of being located in an incubator, or not, has little effect on the scale and scope of external partnerships formed. However, the findings also highlight that spin-in firms are more developed commercially than university spin-outs. While it might have been anticipated that proximity of USOs to spin-in firms would assist – through a learning effect - in developing the external network ties of USOs, this is not found.

Opportunity recognition and entrepreneurial commitment

Previous research highlights the importance to early-stage academic entrepreneurs of receiving advice on protecting IP, securing investment, maintaining accounts, etc. (Clarysse et al, 2011; Vohora et al, 2004; Cooper et al, 2012; Soetanto and Jack, 2011). These business basics are fundamental in enabling the academic entrepreneur to evaluate the feasibility of a business opportunity. If this information can be provided on an informal, pro bono basis, through the USO network – drawing on the prior experience of other academic entrepreneurs – then this is likely to be a significant advantage in overcoming the USO process junctures of identifying the opportunity and committing to the business.

In this sense, UI network ties placed tenant USOs at an advantage relative to USOs in the Non-UI context among whom such open sharing of information—and its associated benefits—appeared to be lacking. For example, in the UI, although USOs differed markedly in their sector and stage of development they had all experienced similar problems at

⁵ None of the counts were normally distributed and usable data was returned from 25 incubator respondents and eighteen Non-UI respondents (i.e. $N < 30$). As a result, the non-parametric Mann-Whitney test was applied to determine if significant differences existed between the external network ties of spin-outs located in an incubator (UI) and those with no incubator (Non-UI).

the start-up phase and so the idea of drawing on the diverse experiences of co-tenants as a resource for overcoming common challenges was raised repeatedly:

“You’re surrounded by sources of knowledge and experience on all the common factors companies like us have to deal with. And everybody is good at something different [but] everyone is facing the same challenges” (UI: ISI9).

Similar informal sharing of information and associated knowledge-based benefits were discussed much less frequently by Non-UI USOs, but founders were conscious of—and aspired to—these information benefits:

“It would be fantastic to have a whole group of different people that you could dip in and out of when you needed to” (Non UI: LF).

“Knowledge of what other [Non-UI] companies do would be helpful for each of the [Non-UI] companies to know who can be a partner. And how they can work together. I know there are 27 [Non-UI] companies, but I don’t know what these companies do” (Non UI: ANDT).

“Essentially if the university has an incubation space, you could do all that learning while you’re working – you could learn much quicker” (Non-UI: CT 1).

In addition, a number of Non-UI USOs commented not only on the potential learning that could occur from other USOs, but that in the absence of an Incubator facility the opportunity to learn from others was lacking (and slowing down USO development) and that existing efforts of the TTO to act as an intermediary in facilitating ties between USOs were inadequate:

“[Non-UI] should actually be playing [the] role of linking people within [University], and outside [University]. That doesn’t happen. (Non-UI: ANDT).

“I haven’t had the opportunity to see what could have happened if [TTO] made more of an effort to facilitate links to other [Non-UI] companies. I think there is a lot of value in talking informally to a range of different people and learning by word of mouth from other client firms” (Non-UI: LF).

Our findings suggest that all USOs are aware of the potential learning benefits from informal ties with other USOs and that where inter-USO network ties occur, this learning is predominantly concerned with business-related issues such as IP protection, investment requirements etc. The presence of a UI appears to significantly increase the likelihood of realising these benefits and indeed supports our earlier findings on the density of informal USO-USO ties in the two university contexts. Our main new finding from the interviews is that among Non-UI USOs there is a willingness to engage to a much greater extent with other USOs for the purposes of learning and an attitude that this could be achieved through more pro-active intermediation by the TTO.

Perhaps more important in the opportunity identification stage are network ties to university departments and external actors. Significant commonality was found for both Universities in the manner business opportunities were identified with limited influence of the UI (or lack of UI) in this. In general opportunities were recognised through academics’ proximity to university science matched with their industry knowledge from informal ties, collaboration, contract research, etc. As such, neither a technology-push or market-pull model dominated however in almost all cases, informal ties were significant in conceiving the initial business idea:

“I’d been doing contract research for [a major pharma] for maybe three years, doing exactly this type of work, so that’s where we said ‘Right, we can do this faster and more efficiently than doing it through the university system” (UI: BN).

“I knew it, yeah. From my own research. I’ve been researching biodegradable plastics, biodegradable polymers because we know that from a research point of view as well, as you know, science wants to answer these questions because we know how important these plastics and polymers can be”. (UI: BT).

“[The research] was presented at a number of conferences and, given the level of interest from individuals saying that this would be something that they would be interested in getting access to and potentially acquiring, we realised we should use the intellectual property and the know-how to establish some commercial outlet for it” (Non-UI: PXL).

“[Name] who was an ex-physics guy who was now president of [company X] in the US was visiting and he saw the stuff and he asked was anyone interested in doing that commercially... and we said ‘Yes’ and within months they had given us £36,000 and said develop a commercial version” (Non-UI: A).

Therefore, while the incubator (or absence of an incubator) appeared to play very little role in opportunity identification, it became more important in the subsequent refinement and development of the business idea. For USOs that were based in the UI this provided proximity to academic research which was significant in subsequent development of the technology: “Because we are based in [UI] it’s a very big advantage being based in the heart of research where things are happening and we have access to that development work that is going on - research work. And we have access to brains in the university and if you have any issues to be discussed with scientists we can discuss. Any issues we are not an expert in that areas, we can find somebody” (UI: ET). Similarly, “If we weren’t here with the proximity to the college... we wouldn’t even be working the space area. We’d properly still be trying to bang our heads on the medical area and failing as a company” (UI: EB).

The significantly higher density of USO-University School informal ties in the UI context was manifest in access to university equipment and lab space on a pro bono basis (i.e. involving no contract or payment), which represented a significant benefit and in some cases was central to their business. The founder of a biotech USO explained that without access to highly specialised university-owned lab equipment, “it actually would probably be easier to move out of the country” (UI: BN), given the financial and regulatory challenges of setting up a comparable lab.

Founders largely accredited this open access to university resources to their USO’s on-campus (i.e. UI-based) location, and to “being based in the heart of the research where things are happening and we have access to that development work that is going on” (UI: Enz).

In contrast, Non-UI USOs used university-owned equipment, and several also provided equipment to the university. However, these interactions were typically on a contractual, paid basis, and the type of ‘open access’ to school lab and equipment so apparent in the UI was much less common in the Non-UI setting (see Table 3). Further, where USOs lacked the physical proximity of the UI as in University B, the location of business premises, often at a distance from the university proved to be detrimental in their development activities: “[Being based] in a remote place outside of the city, you do your best – I do what I can in terms of finding out what’s going on – but the best place to find what’s going on is at the centre of things because that’s where it’s happening” (Non-UI: HM). Therefore, perceived isolation and neglect from the university seemed to have left some USOs disengaged from the university science hub, impeding the refinement and development of technology applications.

The main contribution of the UI in the opportunity identification stage appears to be in terms of agglomeration and proximity effects. Agglomeration of USOs in a UI is conducive to greater levels of informal network ties (as evident in the density scores) and sharing of experiential knowledge i.e. how to protect IP, how and where to access finance etc. Our findings suggest however that in the absence of an incubator, there is the potential for this information sharing to occur – given the willingness and perceived benefit as noted by the interviewees – however this needs to be facilitated by an intermediary and unfortunately in our case University, was not happening. Proximity of the UI to the University research base was also noted as being important in the subsequent development of technology and for those USOs without a UI, being based often at a significant distance from the university was perceived as being detrimental to these developments. There was limited evidence that the presence, or otherwise, of a UI had any influence on the initial opportunity identification. This typically arose from academic’s existing informal and formal ties with individuals external to the University environment. The Universities appeared to play little role in these ties with the exception of a contractual role where contract research was being undertaken. This suggests that a UI facility has limited (if any) effect on opportunity identification with the main benefit at this initial stage of USO development being through agglomeration of USOs and the subsequent sharing of information and proximity to university research in facilitating technological development.

Threshold of credibility

Discussion of the credibility benefits of being linked with the host university was common in interviews, with certain USO founders in both contexts stating that “the affiliation gives us some gravitas” (UI: O) or “it adds weight and credibility” (Non-UI: TF). More specifically, there was a feeling that, through their university ties, USOs had access to otherwise unattainable “top talent and cutting edge research” (Non-UI: H), and that this was something which external parties valued and aspired to. As such, advocates of this perspective were inclined to openly cite and promote their university ties, even in purely commercial circles.

However, others (and indeed the majority of USOs) saw their USO’s association with its host university as a threat to credibility. Many founders had noted, among industry partners, a tendency to be “quite dismissive” (UI: BN) of USOs, making it difficult for them to be viewed as a “proper company” (Non-UI: A). In some cases, this had manifested as reluctance from larger companies to partner with USOs for fear that, as “not fully established companies” (UI: W), USOs would not survive in the long term: “That would just set alarm bells off: ‘We’re going to make a key product for

us dependent on a small company which could be gone in two years' time..?' Those are the questions they're asking". (Non-UI: A)

Similarly, others felt that prospective partners had avoided them on the basis that campus companies are not 'real businesses':

"Because we're located within a university you're seen as a sort of second string. You're not really at the coalface, you're play acting" (UI: BN) or

"If you bring in the university, [people from industry] know it is a university and they then see us as researchers" (Non-UI: W).

The findings are therefore mixed on how university affiliation effects the threshold of credibility. Reflecting on the interviews this effect appears to vary by USO sector with founders in life science related industries (pharmaceutical manufacturing, diagnostics) tending to value and publicize their university links more. While USOs engaged in manufacturing and ICT industries were more likely to see the university affiliation as detrimental to the commercial credibility of their USO.

The effect of a UI on the threshold of credibility was found to differ somewhat to the wider University effect. In general the UI was frequently referred to as an "impressive facility" and a significant selling point for USOs, allowing firms to present themselves as legitimate and stable "going concern[s]". Several UI respondents referred to the specific value of this in establishing credibility and overcoming USO stigma: "We would have site visits here. You can bring [prospective clients] to [UI] and they go 'Ok, there's four walls—that's a start'. Then you bring them to the labs and they go 'Yes, this is real', and they're convinced that this is not some cowboy operation" (UI: ISO3).

This "professional façade" and its role in attracting and reassuring clients was an inherent benefit of being a UI tenant, but was obviously lacking for Non-UI client USOs. In the absence of UI facilities, some were premised in "shabby" facilities (Non-UI: CSO) or had been forced to move "out here to the *** sticks" (Non-UI: CSO6), damaging their reputation in clients' eyes. Other Non-UI firms had not secured office premises for their business, with a significant minority (28 percent) running their USOs from their academic offices and, in one case operating an early-stage USO from home: "I sold the first machine off my kitchen table. [University B] didn't have an incubation space and they wouldn't give me a desk in the department, so I had no desk to work at and I had to make commercially sensitive calls to customers" (Non-UI: CSO5).

Assuring credibility was therefore more difficult for Non-UI USOs who frequently identified problems of assuring clients that being a USO did not preclude them from being a "proper company" (Non-UI: CSO4). Although physical location was seen to have some effect in assuring clients and other external partners of credibility, of greater importance was the financial investment by the universities in the USOs. The willingness by the university to invest directly or take an equity stake in the business was seen as a powerful and positive signal to potential investors: "There's an endorsement there. When other people look at it they're thinking 'Well, these other guys saw fit to invest in this company' so there's definitely a worth in having a look at it" (Non-UI: CSO1).

Conclusions

Rates of USO activity are reported to have increased markedly since the late 1990s (Fini et al, 2011; Mustar et al, 2008; Clarysse et al, 2005; Markman et al, 2005) and recent data for UK universities suggests that this trend is being sustained, growing by 46 percent, or an average annual increase of 15.3 percent, between 2008 and 2011 (HESA, 2012). Despite growing recognition of the potential contribution of USOs to economic development, concerns relating to high failure rates of USOs and difficulties experienced by them in achieving sustainable growth have led university management and policy makers to (re)assess how they can best support these new (typically high-tech) ventures.

There has been limited focus on the case for intervention with a lack of studies providing robust evaluations of the additionality arising from support for USOs. In part, a major reason for a lack of such studies is the difficulty in identifying appropriate counter-factual contexts. This has led to an abundance of studies examining institutional environment and infrastructural supports on USO development, but typically limited by an inability to determine the counter-factual and therefore the full additionality of an intervention.

In this chapter our focus has been on examining one form of intervention – university incubators (UI) – to support the development of USOs. UIs have the potential to overcome a number of market and systemic failures that USOs experience and here our focus has been on system failures and in particular the potential of UIs to strengthen informal and formal network ties between USOs and University Schools as the basis for social capital. By focusing on USO

networks it is suggested that these ‘indirect and social aspects’ are a better gauge of the true value of UIs than more traditional metrics of performance, such as average incubation period (Bøllingtoft and Ulhøi, 2005:267) or purely economic measures (Jack, 2010). As such, in analysing network characteristics, capabilities and benefits in this research, we operationalise a series of alternative UI performance metrics.

Examining two case Universities we have sought to identify a counter-factual scenario where in a research intensive university environment one University has sought to support the development of USOs through a UI while in the other professional support is provided in the absence of a UI. There are obviously limitations to our case comparison and the methods employed, however through SNA we have sought to determine if differences are evident in the informal and formal network structure of USOs and through interviews we also consider the role of these networks and the UI (or lack of UI) at the early stages of the USO process i.e. in terms of opportunity recognition and building entrepreneurial commitment and the effect of an incubator on this.

USOs located in a university incubator (UI) had denser *informal (social) network ties* to one another and to University Schools than USOs without a university incubator (Non-UI) where instead *formal ties* were significantly more common – both to other USOs and to University schools. This suggests a weak relationship substitute relationship between informal and formal ties.

In the UI context, many previous findings around incubator network benefits were supported: tenant USOs willingly shared their technology and knowledge with one another (Soetanto and Jack, 2013; Cantù, 2010) and were able to avail of open access to equipment and expertise within their host university (Gübeli and Doloreux, 2005; Rice, 2002). In the Non-UI environment, USOs were isolated from one another and often from the university—reducing the potential to share proprietary resources and benefit from the associated network advantages. As such, the implication is that resources accessed through UI networks placed UI USOs at an advantage in overcoming early junctures, for example in building into the USO the initial value required to assure entrepreneurial commitment.

At the same time, it could be argued that in a Non-UI environment the extent to which USOs are disadvantaged is debateable. Here, network ties are more likely to be formal (contractual) to both other USOs and the host University. While, based on informal tie density, there appears to be a lower awareness among the USOs in the Non-UI context of the activities of other USOs, given appropriate network facilitation through an intermediary (which was clearly lacking in the case studied) it is possible that informal network ties could be at least strengthened, and at best, equal that of USOs in the UI. Further, based on the lack of significant difference in the number of network ties to external organisations, including suppliers, clients, customers etc. of UI and Non-UI USOs this further questions the contribution of the UI or indeed the detrimental effect of having no UI on USO development.

Our findings highlight that opportunity identification was largely the outcome of academic and industrial ties of the academic entrepreneur with virtually no initial effect of the UI. The UI was important in supporting the post-opportunity identification stage in terms of subsequent technological/market development. This was achieved in two main ways: first through a proximity effect in being located close to university schools and thereby facilitating ad hoc informal support, advice and access to specialist equipment and facilities; and second, by providing physical premises that enhanced the credibility of the USO to industrial partners. What emerged as perhaps more significant however to USOs in achieving credibility was where the University had made a direct financial investment in it as this acted as a positive signal to other potential investors.

Drawing on the somewhat limited analysis of our two case universities, our findings contribute to the emerging debate on the effectiveness of intervention to support USOs, specifically in terms of UIs and the substantial capital and recurrent investment associated with their operation. Although some authors point to the fact that UIs may or may not comprise physical premises and infrastructure (Aerts *et al*, 2007; Durão *et al*, 2005; Carayannis and Von Zedwitz, 2005; Meyer, 2003; Etzkowitz *et al*, 2000), there is no definitive indication of the optimal property-based context for successful UI. This research makes a tentative step in contributing to this debate.

ⁱ A formal network tie was considered to exist where a contractual agreement had been entered into or money had changed hands between the firm and the partner in question (Bøllingtoft and Ulhøi, 2005). An informal tie was defined as any interaction which involved neither a contract nor a financial transaction.

ⁱⁱ This difference was latent in the full network analysis due to the inclusion of university schools as nodes: the higher number of schools (44 compared with 20 for the Non-UI) ‘diluted’ the UI informal network and gave a misleadingly low density figure.

References

Aernoudt, R. (2004) ‘Incubators: Tool for Entrepreneurship?’ *Small Business Economics*, 23 (2), 127-135.

-
- Aerts, K., Matthyssens, P. and Vandembemt, K. (2007) 'Critical Role and Screening Practices of European Business Incubators.' *Technovation*, 27 (5), 254-267.
- Ahmad, A. J. and Ingle, S. (2011) 'Relationships Matter: Case Study of a University Campus Incubator.' *International Journal of Entrepreneurial Behaviour and Research*, 17 (6), 626-644.
- Ahuja, G. (2000) 'The Duality of Collaboration: Inducements and Opportunities in the Formation of Interfirm Linkages.' *Strategic Management Journal*, 21 (3), 317-343.
- Allen, D. N. and McCluskey, R. (1990) 'Structure, Policy, Services and Performance in the Business Incubator Industry.' *Entrepreneurship: Theory & Practice*, 15 (2), 61-77.
- Amesse, F. and Cohendet, P. (2001) 'Technology Transfer Revisited from the Perspective of the Knowledge-based Economy.' *Research Policy*, 30 (9), 1459-1478.
- Bekkers, R., Gilsing, V. A. and van der Steen, M. (2006) 'Determining Factors of the Effectiveness of IP-based Spin-offs: Comparing the Netherlands and the US.' *Journal of Technology Transfer*, 31 (5), 545-546.
- Arya, B. and Lin, Z. (2007) 'Understanding Collaboration Outcomes from an Extended Resource-Based View Perspective: The Roles of Organizational Characteristics, Partner Attributes, and Network Structures.' *Journal of Management*, 33 (5), 697-723.
- Barr, S. H., Baker, T. E. D., Markham, S. K., and Kingon, A. I. (2009) 'Bridging the Valley of Death: Lessons Learned from 14 years of Commercialization of Technology Education.' *Academy of Management Learning & Education*, 8 (3), 370-388.
- Bleda, M., and del Río, P. (2013) 'The Market Failure and the Systemic Failure Rationales in Technological Innovation Systems.' *Research Policy*, 42 (5), 1039-1052.
- Bloodgood, J. M., Sapienza, H. J. and Carsrud, A. L. (1995) 'The Dynamics of New Business Start-ups: Person, Context and Process.' In: *Advances in Entrepreneurship, Firm Emergence and Growth*. ed. By Katz, J.A. and Brockhaus, R.H. Greenwich, CN: JAI Press: 123-144.
- Bloomberg, M.R. (2011) 'Future of New York City.' Keynote speech on 19 July 2011 at: *Crain's New York Business Conference*. Available online at: <http://www1.nyc.gov/>
- Bøllingtoft, A. (2012) 'The Bottom-up Business Incubator: Leverage to Networking and Cooperation Practices in a Self-Generated, Entrepreneurial-Enabled Environment.' *Technovation*, 32 (5), 304-315.
- Bøllingtoft, A. and Ulhøi, J. P. (2005) 'The Networked Business Incubator - Leveraging Entrepreneurial Agency?' *Journal of Business Venturing*, 20 (2), 265-290.
- Breschi, S., and Lissoni, F. (2009) 'Mobility of Skilled Workers and Co-invention Networks: An Anatomy of Localized Knowledge Flows.' *Journal of Economic Geography*, lbp008, 1-30.
- Bruneel, J., Ratinho, T., Clarysse, B. and Groen, A. (2012) 'The Evolution of Business Incubators: Comparing Demand and Supply of Business Incubation Services Across Different Incubator Generations.' *Technovation*, 32 (2), 110-121.
- Cantù, C. (2010) 'Exploring the Role of Spatial Relationships to Transform Knowledge in a Business Idea – Beyond Geographic Proximity.' *Industrial Marketing Management*, 39 (6), 887-897.
- Carayannis, E. G. and von Zedtwitz, M. (2005) 'Architecting gloCal (global-local), Real-virtual Incubator Networks (G-RVNs) as Catalysts and Accelerators of Entrepreneurship in Transitioning and Developing Economies: Lessons Learned and Best Practices from Current Development and Business Incubation Practices.' *Technovation*, 25 (2), 95-110.
- Chatterton, P., and Goddard, J. (2000) 'The Response of Higher Education Institutions to Regional Needs.' *European Journal of Education*, 35 (4), 475-496.

- Clarysse, B., Wright, M., Lockett, A., Van de Velde, E. and Vohora, A. (2005) 'Spinning out New Ventures: A Typology of Incubation Strategies from European Research Institutions.' *Journal of Business Venturing*, 20 (2), 183-216.
- Clarysse, B., Tartari, V. and Salter, A. (2011) 'The Impact of Entrepreneurial Capacity, Experience and Organizational Support on Academic Entrepreneurship.' *Research Policy*, 40 (8), 1084-1093.
- Colombo, M. G. and Delmastro, M. (2002) 'How Effective are Technology Incubators?: Evidence from Italy.' *Research Policy*, 31 (7), 1103-1122.
- Colombo, M. G. and Piva, E. (2012) 'Firms' Genetic Characteristics and Competence-Enlarging Strategies: A Comparison Between Academic and Non-Academic High-Tech Start-ups.' *Research Policy*, 41 (1), 79-92.
- Cooper, C., Hamel, S. and Connaughton, S. (2012) 'Motivations and Obstacles to Networking in a University Business Incubator.' *Journal of Technology Transfer*, 37 (4), 433-453.
- Dahlstrand, Å. L. (1997) 'Growth and Inventiveness in Technology-based Spin-off Firms.' *Research Policy*, 26 (3), 331-344.
- Debackere, K. and Veugelers, R. (2005) 'The Role of Academic Technology Transfer Organizations in Improving Industry Science Links.' *Research Policy*, 34 (3), 321-342.
- Dee, N. J., Livesey, F., Gill, D. and Minshall, T. (2011) 'Incubation for Growth: A review of the impact of business incubation on new ventures with high growth potential', Research summary, NESTA, September 2011, London.
- Degroof, J. J., and Roberts, E. B. (2004) 'Overcoming Weak Entrepreneurial Infrastructures for Academic Spin-off Ventures.' *Journal of Technology Transfer*, 29 (3-4), 327-352.
- Dodgson, M., Hughes, A., Foster, J., and Metcalfe, S. (2011) 'Systems Thinking, Market Failure, and the Development of Innovation Policy: The Case of Australia.' *Research Policy*, 40 (9), 1145-1156.
- Druilhe, C., and Garnsey, E. (2004) 'Do Academic Spin-outs Differ and Does it Matter?' *Journal of Technology Transfer*, 29 (3-4), 269-285.
- Dul, J. and Hak, T. (2007) *Case Study Methodology in Business Research* 4th Edn., Butterworth-Heinemann/Elsevier, Boston, MA., ISBN: 10-0750681969.
- Durão, D., Sarmiento, M., Varela, V. and Maltez, L. (2005) 'Virtual and Real-estate Science and Technology Parks: A Case Study of Taguspark.' *Technovation*, 25 (3), 237-244.
- Etzkowitz, H., de Mello, J. M. C., and Almeida, M. (2005) 'Towards "Meta-Innovation" in Brazil: The Evolution of the Incubator and the Emergence of a Triple Helix.' *Research Policy*, 34 (4), 411-424.
- European Union-Commission of the European Communities (2003) *Summary Report: The Public Debate Following the Green Paper 'Entrepreneurship in Europe'*, Brussels: EU-Commission of the European Communities.
- Falk, R. (2007) 'Measuring the Effects of Public Support Schemes on Firms' Innovation Activities: Survey Evidence from Austria.' *Research Policy*, 36 (5), 665-679.
- Fini, R., Grimaldi, R., Santoni, S. and Sobrero, M. (2011) 'Complements or Substitutes? The Role of Universities and Local Context in Supporting the Creation of Academic Spin-offs.' *Research Policy*, 40 (8), 1113-1127.
- Florida, R. (1999) 'The Role of the University: Leveraging Talent, not Technology.' *Issues in Science And Technology*, Available online at: <http://www.nap.edu/issues/15.4/florida.htm>
- Georghiou, L. (1998) 'Global Cooperation in Research.' *Research Policy*, 27 (6), 611-626.

-
- Geuna, A. and Nesta, L.J.J. (2006) 'University Patenting and its Effects on Academic Research: The Emerging European Evidence.' *Research Policy*, 35 (6), 790-807.
- Geuna, A. and Rossi, F. (2011) 'Changes to University IPR Regulations in Europe and the Impact on Academic Patenting.' *Research Policy*, 40 (8), 1068-1076.
- Gilsing, V. A., van Burg, E. and Romme, A. G. L. (2010) 'Policy Principles for the Creation and Success of Corporate and Academic Spin-offs.' *Technovation*, 30 (1), 12-23.
- Grimaldi, R. and Grandi, A. (2005) 'Business Incubators and New Venture Creation: An Assessment of Incubating Models.' *Technovation*, 25 (2), 111-121.
- Grandi, A. and Grimaldi, R. (2005) Academics' Organizational Characteristics and the Generation of Successful Business Ideas.' *Journal of Business Venturing*, 20 (6), 821-845.
- Gübeli, M. H. and Doloreux, D. (2005) 'An Empirical Study of University Spin-off Development,' *European Journal of Innovation Management*, 8 (3), 269-282.
- Hackett, S. M. and Dilts, D. M. (2004) 'A Systematic Review of Business Incubation Research.' *Journal of Technology Transfer*, 29 (1), 55-82.
- Hamel, G., Doz, Y. L., and Prahalad, C. K. (1989) 'Collaborate with your Competitors and Win.' *Harvard Business Review*, 67 (1), 133-139.
- Hansen, M. T., Chesbrough, H. W., Nohria, N. and Sull, D. N. (2000) 'Networked Incubators: Hothouses of the New Economy.' *Harvard Business Review*, 78 (5), 74-84.
- Harrison, R. T. and Leitch, C. (2010) 'Voodoo Institution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK.' *Regional Studies*, 44 (9), 1241-1262.
- Hewitt-Dundas, N. (2012) 'Research Intensity and Knowledge Transfer Activity in UK Universities.' *Research Policy*, 41 (2), 262-275.
- Hewitt-Dundas, N. and Burns, C. (2015) 'Exploring the Moderating Effect of Incubators on the Network Structure of University Spin-outs.' In: *University Evolution, Entrepreneurial Activity and Regional Competitiveness* (eds. Audretsch, D.B, Lehmann, E.E, Meoli, M. and Vismara, S), New York: Springer.
- Higher Education Statistics Agency (2012) '*Higher education - Business and community interaction survey 2010/11*' Unpublished dataset.
- Holland, B.A. (2001) 'Toward a Definition and Characterization of the Engaged University.' *Metropolitan Universities*, 2 (3), 20-29.
- Hoppe, H.C. and Ozdenoren, E. (2001) 'Intermediation in Innovation: The Role of Technology Transfer Offices.' Mimeo, *Northwestern University*.
- Huggins, R. and Johnston, A. (2010) 'Knowledge Flows and Inter-firm Networks: The Influence of Network Resources, Spatial Proximity and Firm Size.' *Entrepreneurship and Regional Development: An International Journal*, 22 (5), 457-484.
- Jack, S. L. (2010) 'Approaches to Studying Networks: Implications and Outcomes.' *Journal of Business Venturing*, 25 (1), 120-37.
- Kitagawa, F. and Robertson, S. (2012) 'High-Tech Entrepreneurial Firms in a University-Based Business Incubator: Spaces of Knowledge, Resource Heterogeneity and Capital Formation.' *International Journal of Entrepreneurship and Innovation*, 13 (4), 249-259.
- Knockaert, M., Spithoven, A. and Clarysse, B. (2014) 'The Impact of Technology Intermediaries on Firm Cognitive Capacity Additionality.' *Technological Forecasting and Social Change*, 81, 376-387.

-
- Lambert, R. (2003) *Lambert Review of Business-University Collaboration*. London: HMSO.
- Leitch, C. M. and Harrison, R. T. (2005) 'Maximising the Potential of University Spin-outs: The Development of Second-Order Commercialisation Activities.' *R&D Management*, 35 (3), 257-272.
- Lichtenthaler, U. (2011) 'Open Innovation: Past Research, Current Debates, and Future Directions.' *The Academy of Management Perspectives*, 25 (1), 75-93.
- Lindelöf, P. and Löfsten, H. (2004) 'Proximity as a Resource Base for Competitive Advantage: University-Industry Links for Technology Transfer.' *Journal of Technology Transfer*, 29 (3-4), 311-326.
- Lockett, A. and Wright, M. (2005) 'Resources, Capabilities, Risk Capital and the Creation of University Spin-out Companies.' *Research Policy*, 34 (7), 1043-1057.
- Markman, G. D., Phan, P. H., Balkin, D. B. and Gianiodis, P. T. (2005) 'Entrepreneurship and University-based Technology Transfer.' *Journal of Business Venturing*, 20 (2), 241-263.
- Markman, G. D., Siegel, D. S. and Wright, M. (2008) 'Research and Technology Commercialization.' *Journal of Management Studies*, 45 (8), 1401-1423.
- Martin, S., and Scott, J. T. (2000) 'The nature of Innovation Market Failure and the Design of Public Support for Private Innovation.' *Research Policy*, 29 (4), 437-447.
- McAdam, M. and Marlow, S. (2007) 'Building Futures or Stealing Secrets?' *International Small Business Journal*, 25 (4), 361-382.
- McAdam, M. and Marlow, S. (2008) 'A Preliminary Investigation into Networking Activities within the University Incubator.' *International Journal of Entrepreneurial Behaviour & Research*, 14 (4), 219-241.
- McAdam, M. and McAdam, R. (2008) 'High Tech Start-ups in University Science Park Incubators: The Relationship between the Start-up's Lifecycle Progression and Use of the Incubator's Resources.' *Technovation*, 28 (5), 277-290.
- Meyer, M. (2003) 'Academic Entrepreneurs or Entrepreneurial Academics? Research-based Ventures and Public Support Mechanisms.' *R&D Management*, 33 (2), 107-115.
- Mian, S.A. (1997) 'Assessing and Managing the University Technology Business Incubator: An Integrative Framework,' *Journal of Business Venturing*, 12 (4), 251-285.
- Mizruchi, M. S. and Marquis, C. (2006) 'Egocentric, Sociocentric, or Dyadic?: Identifying the Appropriate Level of Analysis in the Study of Organizational Networks.' *Social Networks*, 28(3), 187-208.
- Mustar, P., Renault, M., Colombo, M., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B. and Moray, N. (2006) Conceptualising the Heterogeneity of Research-based Spin-offs: A Multi-dimensional Taxonomy.' *Research Policy*, 35 (2), 289-308.
- Mustar, P., Wright, M. and Clarysse, B. (2008) 'University Spin-off firms: Lessons from Ten Years of Experience in Europe.' *Science and Public Policy*, 35 (2), 67-80.
- Ndonzuau, F. N., Pirnay, F. and Surlemont, B. (2002) 'A Stage Model of Academic Spin-off Creation.' *Technovation*, 22 (5), 281-289.
- Neergaard, H. (2003) 'The Process of Entrepreneurship: A Managerial and Organizational Journey.' In: *New Movements in Entrepreneurship* (eds. Steyaert, C. and Hjorth, D.), Cheltenham: Edward Elgar, 160-176.
- Nonaka, I. (1994) 'A Dynamic Theory of Organizational Knowledge Creation.' *Organization Science*, 5 (1), 14-37.

-
- OECD - Organisation for Economic Cooperation and Development (1999) *The Response of Higher Education Institutions to Regional Needs*, Centre for Educational Research and Innovation, Paris: OECD.
- Onsager, K., Isaksen, A., Fraas, M. and Johnstad, T. (2007) 'Technology Cities in Norway: Innovating in Glocal Networks.' *European Planning Studies*, 15 (4), 549-566.
- O'Shea, R. P., Allen, T. J., Chevalier, A. and Roche, F. (2005) 'Entrepreneurial Orientation, Technology Transfer and Spinoff Performance of U.S. Universities.' *Research Policy*, 34 (7), 994-1009.
- O'Shea, R. P., Chugh, H. and Allen, T. J. (2008) 'Determinants and Consequences University Spinoff Activity: A Conceptual Framework.' *Journal of Technology Transfer*, 33 (6), 653-666.
- Owen-Smith, J. (2003) 'From Separate Systems to a Hybrid Order: Accumulative Advantage across Public and Private Science at Research One Universities.' *Research Policy*, 32 (6), 1081-1104.
- Pittaway, L., Robertson, M., Munir, K., Denyer, D. and Neely, A. (2004) 'Networking and Innovation: A Systematic Review of the Evidence.' *International Journal of Management Reviews*, 5 (3-4), 137-168.
- Provan, K. G., Fish, A. and Sydow, J. (2007) Interorganizational Networks at the Network Level: A Review of the Empirical Literature on Whole Networks.' *Journal of Management*, 33 (3), 479-516.
- Rasmussen, E., Moen, Ø. and Gulbrandsen, M. (2006) 'Initiatives to Promote Commercialization of University Knowledge.' *Technovation*, 26 (4), 518-533.
- Rasmussen, E. (2011) 'Understanding Academic Entrepreneurship: Exploring the Emergence of University Spin-off Ventures Using Process Theories.' *International Small Business Journal*, 29 (5), 448-471.
- Rice, M.P., (2002) 'Co-production of Business Assistance in Business Incubators: An Exploratory Study,' *Journal of Business Venturing*, 17 (2), 163-187.
- Rothaermel, F. T. and Thursby, M. (2005) 'Incubator Firm Failure or Graduation?: The Role of University Linkages.' *Research Policy*, 34 (7), 1076-1090.
- Rowley, T. J. (1997) 'Moving beyond Dyadic Ties: A Network Theory of Stakeholder Influences.' *Academy of Management Review*, 22 (4), 887-910.
- Schwartz, M. and Hornych, C. (2010) 'Cooperation Patterns of Incubator Firms and the Impact of Incubator Specialization: Empirical Evidence from Germany.' *Technovation*, 30 (9-10), 485-495.
- Scillitoe, J. L. and Chakrabarti, A. K. (2010) 'The Role of Incubator Interactions in Assisting New Ventures.' *Technovation*, 30 (3), 155-167.
- Siegel, D.S., Waldman, D. and Link, A. (2003) 'Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study.' *Research Policy*, 32 (1), 13-27.
- Siegel, D. S., Veugelers, R., and Wright, M. (2007) 'Technology Transfer Offices and Commercialization of University Intellectual Property: Performance and Policy Implications.' *Oxford Review of Economic Policy*, 23 (4), 640-660.
- Singh, R. (2001) 'A Comment on Developing the Field of Entrepreneurship through the Study of Opportunity Recognition and Exploitation.' *Academy of Management Review*, 26 (1), 10-12.
- Soetanto, D. and Jack, S. (2011) 'Business Incubators and the Networks of Technology-based Firms.' *Journal of Technology Transfer*, 36, 1-22.
- Tamásy, C. (2007) Rethinking Technology-Oriented Business Incubators: Developing a Robust Policy Instrument for Entrepreneurship, Innovation and Regional Development?' *Growth and Change*, 38 (3), 460-473.
- Targeting Innovation. (2008) '*Scottish University Spin-out Study*.' Glasgow: Targeting Innovation.

- Tötterman, H., & Sten, J. (2005) 'Start-ups, Business Incubation and Social Capital.' *International Small Business Journal*, 23 (5), 487-511.
- UNICO (2006) *UNICO UK University Commercialisation Survey: Financial Year 2005*, Cambridge, UK: UNICO.
- Van Geenhuizen, M. and Soetanto, D. (2009) 'Academic Spin-offs at Different Ages: A Case Study in Search of Key Obstacles to Growth.' *Technovation*, 29 (10), 671-681.
- Vohora, A., Wright, M. and Lockett, A. (2004) 'Critical Junctures in the Development of University High-tech Spinout Companies.' *Research Policy*, 33 (1), 147-175.
- Weber, K. M., and Rohracher, H. (2012) 'Legitimizing Research, Technology and Innovation Policies for Transformative Change: Combining Insights from Innovation Systems and Multi-level Perspective in a Comprehensive 'Failures' Framework.' *Research Policy*, 41 (6), 1037-1047.
- Wellman, B., Wong, R. Y. L., Tindall, D. and Nazer, N. (1997) 'A Decade of Network Change: Turnover, Persistence and Stability in Personal Communities.' *Social Networks*, 19 (1), 27-50.
- Woolthuis, R. K., Hillebrand, B. and Nooteboom, B. (2005) 'Trust, Contract and Relationship Development.' *Organization Studies*, 26 (6), 813-840.
- Wright, M., Birley, S. and Mosey, S. (2004) 'Entrepreneurship and University Technology Transfer.' *Journal of Technology Transfer*, 29 (3-4), 235-246.
- Wright, M., Clarysse, B., Lockett, A. and Knockaert, M. (2008) 'Mid-range Universities' Linkages with Industry: Knowledge Types and the Role of Intermediaries.' *Research Policy*, 37 (8), 1205-1223.
- Yli-Renko, H., Autio, E. and Sapienza, H. J. (2001) 'Social Capital, Knowledge Acquisition and Knowledge Exploitation in Young Technology-based Firms.' *Strategic Management Journal*, 22 (6-7), 587-613.