Track Title: Innovation

Sustainable Entrepreneurial Activities through Innovation: The Key for Economic Prosperity

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Abstract

The purpose of this paper is to examine the sustainability of university research activities through the use of commercialisation of intellectual property generated from within these institutions. Government funding of universities and the provision of public monies for R&D have declined across the majority of countries that comprise the OECD group of advanced economies (OECD, 2010a). While government investment in higher education and publicly funded research has declined, the need for universities to engage more with industry to help deliver economic benefits via innovation has increased. Many governments seek to enhance their National Innovation Systems (NIS) (Lundvall, 2007; Sharif, 2006). There is an increasing need for enhanced engagement between universities and the business community to foster entrepreneurship and innovation via technology transfer, commercialisation and collaborative R&D (Lockett, Wright and Franklin, 2003; Feldman, Feller, Bercovitz and Burton, 2002). However, there remain only a handful of examples of best-practice in this commercialisation process, and few models that can be used across international contexts (Harman and Harman, 2004; Van Looy et al, 2011). This paper examines the use of entrepreneurial management to achieve sustainable funding models for research and innovation in universities.

Key Words: innovation, commercialisation, universities, national innovation systems

Introduction

Innovation is widely accepted as an essential prerequisite for societies to survive and grow. Innovation enables firms to gain positional advantage through cost leadership and/or differentiation (Porter, 1990), and thus has become an area of substantial interest for both academics and practitioners (Hailey, Farndale and Truss, 2005). Innovation is the generation, development, and implementation of new ideas or behaviours, new and value adding to the adopting firm (Damanpour, 1991). Innovation is not only used in laboratories but it also helps at all levels of social and economic development. It is a process for the development of our societies to recover from crisis both socially and economically. This requires an enabling environment and sufficient investment. The conditions that are required for innovation include the facilitation of applied creativity, access to appropriate technologies, the diffusion of knowledge, skills and abilities, plus social and political tolerance. Change is also needed in the way individuals, institutions or communities act to solve problems or to generate new opportunities. “Innovation is not an option, it is imperative,” Raupp, the minister of science, technology and innovation of Brazil declared, “The future of our country depends on this creative effort” (Casassus, 2012).

Universities can play a key role in the enhancement of a country’s National Innovation System (NIS) (Balzat and Hanusch, 2004). Since the late 1990s NIS models have included commercialisation and innovation strategies that involve universities engaging with industry partners (Groenewegen and Van der Steen, 2006). Any limitations relating to innovation and the diffusion of knowledge may be due to the lack of interaction between the actors in the system. In the search for improved interaction between universities and business, governments often provide the foundations for effective partnering among the elements in the system. For example, there are differences in the framework conditions of the NIS of the USA and the Netherlands (Leisyte, 2011). These differences include the dispersal of commercialisation funding schemes in the USA, versus their concentration in the Netherlands. Further, different actors in the two NISs have shaped the definition of the code of conduct of technology transfer.

Despite these differences, interesting similarities are also found in the framework conditions of these countries NIS models. These include policy convergence concerning promotion of commercial and societal relevance in research, structural similarity of certain funding schemes and the competitive nature of the overall process. The creation of vertical linkages between universities and industrial firms from the two studied universities has been institutionalized in both cases. Any differences have to do with the transfer of intellectual property (IP) within the universities, the level of institutionalization of the technology-transfer function, and the level of institutionalization for the country’s research institutes/centres. Organisational inertia is sometimes observable in these various structures (Leisyte, 2011).

This paper aims at the study of entrepreneurial management which achieves sustainable funding models for research, innovation and commercialisation in universities. It examines the process of commercialisation of nanotechnologies out of Australian universities. It explores the factors that have influenced the success of commercialisation within these institutions and the role played by entrepreneurial management in doing so. The study focused on addressing four research questions: i) how do universities undertaken the process of commercialisation of emerging technologies? ii) what are the conditions within the environment that lead to enhanced commercialisation of scientific research?, iii) what is the role of networking in the commercialisation process? and iv) what type of funding leads to enhanced commercialisation and industry collaboration?

Literature review

Innovation is at the heart of the development of society and has the capacity to solve problems facing humanity. It is also a key element in the enhancement of economic productivity (Chandra et al, 2009; Dodgson et al, 2011; Hu and Png, 2013). Societies that focus on innovation and technological advancement develop and support their populations. Understanding the nature of innovation, how it operates, what enables and delays its progress is therefore of great importance to meeting the challenges facing the society. It has long been recognised that the rate of technical change and of economic growth depends more on efficient diffusion of innovation than on being first in the world with radical innovations. Industrialized countries have pinned their hopes on research and development (R&D) to spur recovery from the financial and economic crisis, but these hopes remain mostly unfulfilled (OECD, 2012).

The most fundamental resource in the modern economy is knowledge (Lundvall, 2007). Consequently, the most important process is learning, and the learning process is essentially an interactive one that must be understood in its institutional and cultural context. A significant difference between Lundvall approach and that of Freeman and Soete (2009) is the relative emphasis attached to the patterns of interaction between firms as part of a collective learning. Lundvall (2002) sees knowledge characteristics as the key underpinning of the innovation system. This flows from the belief that innovation is increasingly tied to a process of interactive learning and collective entrepreneurship. Underlying Lundvall's conception of the innovation system is an analysis of how knowledge evolves through the interactive process of learning:

> "A system of innovation is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and … a national system encompasses elements and relationships, either located within or rooted inside the borders of the nation state." (Lundvall, 1992: 2)

This conception of the innovation system is predicated on several key assumptions. One assumption concerns the fact that key elements of the knowledge base, which are critical for the innovative capacity of an economy, are highly localized. Another assumption is that interactive nature of the innovation process means that it is socially embedded in the framework of institutions that govern the operation of the economy. National innovation systems differ significantly in terms of their capacity for capitalizing on new sources of knowledge. Their productive capabilities depend on localized nature of the knowledge base and the socially embedded context of the interactive learning process (Lundvall, 2002). Balzat and Hanusch (2004) have also described the National Innovation System as:

> "A national innovation system can be perceived as a historically grown subsystem of the national economy in which various organisations and institutions interact with and influence one another in the carrying out of innovative activity." (Balzat and Hanusch, 2004: 1)

It is about a systemic approach to innovation in which the interaction between technology, institutions, and organisations is central. Since the late 1990s, NIS thinking emerged in a growing number of policy studies (Groenewegen, 2006). Limitation on innovation and the diffusion of knowledge may be due to the lack of interaction between the actors in the system. In search of improved interactions, governments can provide the foundations for effective partnering among the elements in the system. Policies for science and technology are intertwined with policies for trade and industry. The innovation process is one, which requires often rather extensive networks of information flows and rather free informal contacts over a fairly long period and often of a rather unpredictable kind. National competitive strategies, if they are to be relevant to the real problems, must take into account experimental results (Freeman and Soete, 2009).

The overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities) perform, but on how they interact with each other as elements of a collective system of knowledge creation and action, and on their interplay with social institutions (such as values, norms, and legal frameworks). They hold open the possibility of analysing the formal economic institutions and the historically, socially and culturally embedded understandings of what are legitimate and appropriate structures, strategies and practices.

A properly functioning NIS underpins the innovative capacities of firms, because the institutional structures provide collectively what firms cannot produce individually. These factors include "public good" research and the development of a broad range of expertise that is necessary for firms' innovation strategies but cannot be afforded by individual companies. This is especially true in small countries and for small firms that have too few resources to meet the cost of basic research. The effective national innovation systems continually change.

Continuous innovation is the key to the sustained advancements of nations, industries and firms. Innovation rarely occurs within the confines of individual organisations and patterns of innovation can be thought of as a system involving many contributors. The national characteristics of innovation systems strongly influence their performance. As many Asian nations are striving to perform at the technological forefront to build and sustain

their advancement, the relationships between the social and economic institutions and organisations that facilitate innovation and the businesses that deliver it are fruitful grounds for research.

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One of the impacts of the Global Financial Crisis (GFC) of 2008-2009 was a precipitous decline in innovation across most industries around the world. This was evidenced by a 4.5% downturn in spending on R&D throughout the 30 advanced economies that comprise the OECD. Although R&D expenditure has now recovered since that time it remains subdued in many countries (OECD, 2012). Across the OECD 34 member nations agreed to boost their collective R&D spending by 9% in 2009. This was partly offset by the drop in business outlays, but budgets soon came under pressure. By 2010 many countries cut back public R&D allocations by a total of 4%.

In the eastern and southern European countries such as Greece, where unemployment was already high and R&D spending low, the economic crisis has made things worse. By contrast, China, South Korea and other emerging Asian economies increased their R&D expenditure and innovation activity. Markers such as the number of patent filings have increased in these countries since 2007, and this can be expected to continue. China's share of global R&D spending jumped from 7% in 2004 to 13% in 2009, and innovation also rose in India and Brazil. Unless both the public and private sectors turn more attention to innovation and R&D, they are unlikely to meet their objectives in restoring economic growth and employment to acceptable levels (OECD, 2012).

However, there are factors that make innovation an expensive and risky undertaking (Christensen, 2007). Understanding of the job to be done is one of the most important ways to limit both risk and expense. Quite possibly, the root reason why innovation is so prone to failure is not that the outcomes are intrinsically unpredictable, but rather that some of the fundamental paradigms of marketing that we follow in segmenting markets, building brands and understanding customers do not apply to more radical or disruptive technologies (Costa, Fontes and Heitor, 2004). This is something that has been recognised in the commercialisation of new technology-based firms (Knockaert, Vandenbroucke and Huyghe, 2013), and has now become a feature of business model design for start-up technology entrepreneurs (Trimi and Berbegal-Mirrabent, 2012).

Adams, Bessant and Phelps (2006) suggest that the management of innovation within an organisation should consider at least seven interconnected elements: i) inputs; ii) knowledge management; iii) innovation strategy; iv) organisational culture and structure; v) portfolio management; vi) project management and vii) commercialisation. Of these, the process of commercialisation is one of the least understood within the academic literature particularly in relation to NIS (Kim et al, 2011; Hemert et al, 2013). Much of the extant research that has been published in this area has focused on large companies, with relatively little attention given to universities (Milton-Smith, 2001; Sharif and Baark, 2008).

Commercialisation can mean taking an innovation to market, but may also include convincing production managers to adopt a series of new techniques available to them. Indeed, the successful introduction of new products and services into markets is important for the survival and growth of organisations (Gans, Hsu and Stern, 2002; 2003; Cooper, Edgett and Kleinschmidt, 2004abc; Lee et al, 2010). Commercialisation is concerned with making the innovative process or product a commercial success; it includes issues such as marketing, sales, distribution and joint ventures (Chakravorti, 2004). Within universities the process of commercialisation remains complex due to the need for industry partners with various options such as spin-outs, joint ventures, technology transfer and licensing (Martin, 2012; Plewa et al, 2013; Boehm and Hogan, 2013). However, there remain significant gaps in the knowledge base over how such processes are best managed.

It is also important to understand the concept of technological change, “at the level of invention, of innovation, and of imitation” (Brozen, 1951). For a country to maintain a competitive position in global trade and to seek growth in its levels of productivity and living standards it needs to invest in innovation. This requires the development of a first-class education system (Agency, 2007). There must be investment at all levels from schools, through vocational training and education, and onto higher education to teach and foster the skills and capabilities that will allow innovation and commercialisation to flourish (Curtin et al, 2011). Government policy can play a key role in this process (OECD, 2010b; OECD, 2013; DIISR, 2010; DOI, 2013).

Education (including higher education) is predominantly publicly funded in most countries. This gives the educational system in each country its distinctive features. Even if high-level scientists and doctoral students work and study abroad, the international flows will not materially affect the large bulk of students at home (Carlsson, 2006). Also, most funding of basic research comes from public sources (some military) and tends to reinforce existing areas of strength in each country; international funding of transnational research projects is not likely to materially change the research profiles of nations. The process of European integration affects national systems of innovation. European integration will not do away with national systems of innovation in Europe and that only a very partial European system of innovation in a narrow sense of the term is likely to emerge. So, what can governments do to unleash innovation? Some examples: i) educate people in science and technology from a young age; ii) train people to become entrepreneurs; iii) provide incentives to business R&D; iv) lower barriers to entrepreneurship; and v) reconsider the tax treatment on returns from innovation.

Systems and policies, strategic networks and geographical clusters, successful models for creating innovation including role of universities are very important for consideration. Universities should have a clear mandate to engage in the commercialisation of research and this should be acknowledged as a legitimate third role for universities alongside teaching and research. Universities need to be producing excellent research, as it is excellent research that is most likely to generate the most significant commercialisation opportunities, and need to publicize their research capabilities (Cutler, 2008). However, universities also need to be undertaking research in areas that fit with the interests of business community (Collier, 2007).

Policies for science and technology are intertwined with policies for trade and industry. The innovation process is one, which requires often rather extensive networks of information flows and rather free informal contacts over a fairly long period and often of a rather unpredictable kind. National competitive strategies, if they are to be relevant to the real problems, must take into account experimental results (Freeman, 2009). For small and medium firms (SMEs), cooperative behaviour in the commercialisation confirm the influence of complementary assets and transaction costs, but surprisingly do not support any influence of IP rights protection on cooperative behaviour. For large firms the results show a negative relationship for both IP rights protection and ownership of complementary resources with cooperative behaviour. Overall, collaboration-based commercialisation in nanotechnology for both small/medium as well as large firms seems to follow antecedents previously identified. In addition, current stage of the nanotechnology commercialisation environment, intellectual property rights protection for small/medium-sized enterprises is associated with the acquisition of other firms for science and technology (Fiedler, 2010).

Sets of important national policies constitute another element of the common innovation infrastructure. It is well understood that the incentive to innovate disappears when firms cannot reap returns on their investments. As a consequence, policies that protect intellectual property are essential for creating a pro-innovation environment (Porter, 1999). The continued success of the German chemical industry, for example, has been underpinned in large part by a highly developed university system that encourages innovative research partnerships with industry.

A study of SMEs based on a web-scraping and content analysis of current and archived nanotechnology enterprise websites showed transitions vary by SME characteristics, technology and market sectors. The findings suggest that although the idealised linear innovation model is present, important instances of divergence exist. Cluster analysis uncovered sectoral differences but even more distinctions based on the age, funding source, and research intensity (Youtiea, 2012).

For managers or entrepreneurs operating within small innovator firms, the entrepreneur needs to understand the needs of the customer and end users within any target markets. The willingness of a customer to adopt a new product or service is likely to be contingent on their perception of the opportunities this innovation offers them and their ability to see that the risks and costs associated with its adoption are outweighed by the opportunities. Knowing that the innovation can be readily integrated into the customer's existing systems is likely to alleviate concerns over risks and costs. In addition to knowing their customer, the small firm entrepreneur should also be willing to open their mind to the potential of strategic partnering with complementary actors should such alliances be necessary. The stronger the firm's control over its IP rights, and the more it understands its customers, the more power it is likely to enjoy within any future alliance (Mazzarol and Reboud, 2008).

A study of the commercialisation outcomes for 3,162 Australian inventions provides new insights into the role that patents play in aiding inventors in their efforts to appropriate returns from their innovative investments. Unlike previous studies that potentially confound the effectiveness of patents with the limited coverage of the patent system, they provide a counterfactual that includes only inventions that are patentable subject matter. In doing so, they are able to deepen their understanding of the role that patents play in commercialisation. Their results can be summarized as follows. First, patents play a positive but modest role in the decision to manufacture inventions. They find that being refused a patent reduces the likelihood of commercialisation by about 13 percentage points. However, they cannot rule out the fact that unobserved differences in the underlying value of the invention may partly explain this result. If these are positively correlated with a patent grant, then the true effect will be less than the estimates. Second, invention owners get some spill over protection from complementary patents embodied in the final product or process (Webster and Jensen, 2011).

In terms of university commercialisation practices there is a distinction that should be made between two different entrepreneurial models. The first is based on university spin offs (USOs) that are championed by university employees who seek to commercialise their own inventions. The second is associated with the transfer of IP rights to external entrepreneurs who are not the original inventors, but who acquire the IP rights to develop and commercialize technology originating from university research. Past studies suggest that external entrepreneurs have a different mind-set that makes them better equipped to deal with opportunities and obstacles related to financing and developing USOs (Politis, 2012). However, the development paths of USOs are embedded in a more complex web of path-dependent interactions, where the championship of the USO becomes interwoven with existing and emerging social relationships and opportunities, and challenges related to the technology that is commercialized (Politis, 2012).

These issues can provide policy-makers with fruitful information about where external entrepreneurs can be a value-adding mechanism in efforts to support the commercialisation of technology originating from university research. Moreover, empirical studies of existing support initiatives that already use external entrepreneurs are also warranted. There is a range of questions that remain to be answered about the external entrepreneur phenomenon. Further studies of this emerging research area offer the potential to provide both practitioners and policy-makers with actionable knowledge about how to increase the commercialisation of technology developed at universities are essential (Politis, 2012). Economic prosperity depends on the level of collaboration between the new sciences and practice. University is the best forum for this.

In a review of government intervention in innovation, Laredo and Mustar (1996) described a conceptual framework relating to the pathway through which the commercialisation moves. They described this as the Techno-Economic Network (TEN), which is illustrated with the following model:

S + (ST) + T + (TM) + M

Where:
S = Scientific activity (e.g. research fundamental & applied)
T = Technological outcome (e.g. patents, prototypes, software, models)
M = Market diffusion of products and,
(**ST**)&(**TM**) = transfer points

According to Laredo and Mustar (1996) the TEN framework is an interconnected chain of heterogeneous

actors that includes the researchers and laboratories in which the fundamental research science is performed. Once this research has identified commercially useful innovations it is developed into patents and prototypes or other transferrable IP. This can be used to create commercially valuable outcomes that financial institutions and industry can invest money and time into for eventual diffusion into markets. Of importance is the need for all these actors to effectively interact with each other, and to collaborate in order to bring this science to market.

The three primary poles (S + T + M) comprise the core of the TEN framework. The weakest links are typically the two transfer points (ST) and (TM). The first is related to the mechanisms, structures and systems that can identify commercially valuable intellectual property within scientific research (S) and move it towards the (T) pole to create commercialisation opportunities. The second transfer point relates to the commercialisation pathways through which the technology moves towards the market (M). This can involve the interplay between a range of actors (e.g. universities, private companies and venture capital investors).

This process appears simple but is a challenging and often difficulty pathway for universities to move their research. Academics are generally not commercially focused and their orientation is towards publishing in peer reviewed journals for the public good and the target market for their findings is other scientists. This focus ensures that any IP rights can only have weak levels of appropriation. For example, it is common for their findings to be published in journals where the publisher is granted the copyright by the authors. By contrast the commercialisation process requires that IP rights be captured and secured so that they can be appropriated by investors and sold via their incorporation into product and process innovations, or through licencing agreements (Laredo and Mustar, 1996).

A major problem in the successful commercialisation of university generated research is the different focus that academic and industry communities have. Berman (2008) examined the interaction between Australian universities and industry partners engaged in “Linkage Grants”, which are special research grants provided by the Australian Research Council for applied collaborative research that benefits industry. What emerged from this analysis was the gap that existed between the orientation of the academics and that of their industry partners. For example, as one academic researcher explained:

> “Industry isn’t concerned with the science – only with the practical solution to the specific industry problem. They need persuading that the scientific work is essential.” (Berman, 2008: 167).

This contrasted with their industry partners who saw the project as an investment in research leading to commercially valuable outcomes. Major issues that arose from the interaction between the two groups involved determining who owned IP rights, and the complex and time consuming legal and administrative negotiations that took place between the university and its industry partners who were co-investing in the research. Also of concern to the industry partners was the ability of the academics to effectively manage the projects in a manner that was timely and efficient. The universities were accused of taking too long to complete the research and not viewing the achievement of commercially important deadlines as a priority. As one industry partner commented:

> “Academics are notorious for taking a long time to do research, whether it’s due to teaching commitments or because the work is linked to the requirements of a PhD…two months of work with a professional agency is closer to two years for academics…this is a big issue.” (Berman, 2008: 170)

Plewa et al (2013) suggest that the key to success in the commercialisation of university-based research is for academics and their industry partners to be able to establish open and honest, two-way communication that enhances mutual understanding and trust. Interpersonal relationships between the partners and a well-defined set of project goals, timelines and outcomes are essential. Both the industry partners and the university need to appreciate the needs, strengths and limitations of each other. Without these conditions in place the project is unlikely to succeed. There has also been a call for universities to change their missions and policies in relation to commercialisation to support and encourage such activity (Collier, 2007).

Methodology

In keeping with the recommendations for case study research outlined by Eisenhardt (1989), the research questions and a priori constructs were developed following a review of the literature. The TEN framework was used as a macro model to help guide the study. Our process of selecting cases was undertaken using a theoretical rather than a random sampling approach and we commenced with an examination of the level of research activity within the nanotechnology field being undertaken by Australian universities. A final group of seven institutions were examined. Each institution had an active nanotechnology research program, and all had evidence of commercialisation activities relating to this research.

A case study protocol was developed for guiding each case. In this we followed the prescriptions suggested by Yin (2003). Also, in keeping with this case study methodology we undertook a pilot case to explore issues and determine whether we had the appropriate units of analysis. Data was collected via website searches and in-depth interviews and with over 40 directors of research, managers, academics, students, commercial units' directors and managers at the universities and their industry partners. The decision to examine nanotech projects was due to the fact that the lead author has a background in nanotechnology and had worked at universities in this area including commercialisation work. It has also been an area of some priority within the Australian university and research arena.

All interviews were transcribed and subsequently coded using NVivo software for qualitative data analysis according to the categories of the framework (see Table 1). The emerging themes and statements are transcribed in this table according to the general research questions. The data collection involved both macro and micro level analysis of interviews and direct observation. Interview data was coded and analysed using NVIVO software. The process of 'coding' involved the gathering all the references to a specific key word (topic), theme and person. All sources were coded and through the NVIVO software brought together in a single 'node'. The patterns were then identified and analysed.

Based on the interviews and supported by documents, a model was developed that sought to define the commercialisation processes at each of the seven universities. These models were then compared. Along these categories, a cross-case search for within-group similarities and inter-group differences between successful and unsuccessful cases followed (Eisenhardt 1989). Using pattern-matching, the emerging empirical patterns were compared with initial theoretical categories and a pilot case (Yin 2003).

Table 1: Actors in the commercial process of the university research

Research Questions	Emerging Themes	Statements
How do you choose the research area? Why Nanotechnology research?	Nanotechnology is an emerging important research area	"Australia is capable of entering into the nanotechnology sector and focus on precision and nano-manufacturing". "There are some hot discoveries in the area of nanocarbon tubes and graphite, water purification and to be successful we need more engagement with the researchers." "The Research Institute is increasing the affiliation with the industry and the platform is nanotechnology." "General awareness in the community about Nanotechnology is poor. Raising awareness will help to promote industry development and regulations."
What are the procedures for commercialisation at your University?	Commercialisation Process at University are based on different models	"There are many obstacles in commercialisation and there is no need for this". "Usually 1 out of 20 patents are successful and attract venture capital and US investors take the risk. "All of our success came through the CRC because of the resources that are available at the CRC the process of the patent to prototype goes ahead very quickly." "Licensing the patent very quickly means that it was protected without going through the complexities of the system and time." "To take the product to market should be for those who want it." "The universities should be engaged in the production of knowledge." "The procedures for commercialisation at our university are too costly and we usually do not go that path." "The University commercial unit has not been very helpful." "The cost is also an issue to maintain a patent for some time." "IP policies are blocking the commercialisation." "The process of getting patents is only for the first 18 months and then for full patent more funding is required."

		"It costs a lot of money to maintain the patent." "Normally we feel is waste of time and not practical to spend so much time and money to go for patent and prototype and not be able to find the interested industry to support it." "None of our patents have ever been commercialised." "Commercial company uses the open decentralized model."
What type of Funding leads more to commercialisation and industry collaboration?	Funding that leads to commercialisation are mostly from ARC grants	"The ARC linkage grant program is a good scheme." "The problem is the long process of negotiation of IPs." "To work constantly for commercial contracts and IP the university needs a good cash flow." "The standard discovery grant is very good. It is very helpful for the early stages of the research. " "For venture capital it is not good to start early because of time." "Time is important for the Venture Capitalist who wants to make money as soon as possible." "CRCs have not been very successful in producing a lot of Marketing Goods because of too much administration and the focus of how to get the next funding." "Often high active researchers like to be free from the red tapes and bureaucracy." "Special seeds funding and some capital funding which is offered for spin-off companies and then spin-off companies help enhance the IP with research contracts." "New spin-off is a service company. It has set up a very good collaboration with the industry." "Fundamental research is important, to be at the edge of science and apply for ARC discovery funding is very important for getting new science and to be at the top of new research. " "To receive linkage grants is great, because these funds are $1 for $1 with industry which creates good industry connection and collaboration. These funds create environment for more funding and more collaboration with the industry." "ARC discovery grants are the best for research." "All of our funding is from ARC discovery grants working in modelling nanocarbon tubes and very successful."

		“Research funding to the University is around $250 million per year.” “The Licence fees that come to the University vary between $1-$5 million per year.” “The Top 10 Universities in the US generate large licensing revenues coming back to the University.” “In terms of which types of funding that produce more innovations, in general the more free thinking type research such as ARC Discovery Grants create more worthwhile discoveries.” “The established companies fund specific type projects can restrict research.” “To fund 'early stage' projects or concepts that have clear commercial potential into 'investor-ready' or 'pre-seed fund ready' opportunities.” “Commercial outcomes are from all kinds of research teams and funding.” “From the following four areas of funding mostly.” “ARC discovery grant.” “Linkage grant.” “University Consulting.” ‘Collaboration research funding.“
What are your benefits if you commercialise your research outcomes?	Benefits to academics is not clear	“The reward for the academics is that they have made a difference in the community by their invention.” “Transformational research has always had the benefit for the society and is relevant.” “The academics are not in it for the financial rewards.” “The benefit for the academics is satisfaction of their work and the commercial return financially is always 1/3 of the profit.” “The motivation of the researchers are usually the breakthroughs.” “The benefit for the University is at every level. They attract good people and then good graduates, publications and the reputation of the university advances.” “Benefit of working in a large group with good funding is use of networking of ideas as well as good use of equipment at the University.”

How do you create the appropriate environment for scientific research to achieve innovative outcomes, which may lead to commercialisation?	Appropriate environment for innovation is healthy networking	"Engaging directly with the industry." "Research Institute has a very good industrial affiliate program." "Setting up Institute has been very successful." "As a commercial manager we do this with organizing seminars and workshops regularly with the academics as well as with the industry and we bring the two communities together creating a culture that is needed to commercialize." "This does not just give a financial benefit which is at most 3-5% of the total fund spent in scientific research, it creates a culture of innovation which the university is encouraging." "The leader of research groups are very keen to promote spin-off companies and therefore meeting interests is essential." "This is easy in the US. There is a culture there. It is very hard to create it in Australia." "Research Institute has around $30 M from government and some very good people involved. It has 18 Australian innovators as program leaders."
What is the role of networking in commercialisation?	Networking for Commercialisation	"Clustering is good and it creates critical interaction and joint appointments." "Clustering is good for various groups to work together and have joint projects." "Clustering is good for Australia to get it emerging in the multidisciplinary areas such as nanotechnology." "To get into market is mostly done through those you know." "There are some good models around. If the companies are happy with the service they get from the " "Universities they then put funds and support back to the university." "Good university students who become great in the market and become CEOs of the companies always come back to university and support it." "The centre needs more networking to get the commercial benefits from its research." "Networking is critical. It has to be local, national and international. The global network is very important."

		“Networking is very important because geography can become a barrier. It is nice to be close.” “Chatting over the coffee line especially when the research is multidisciplinary close proximity is important.” “It is hard for the researchers to do research, teaching and also to make the connection and enter networking with the industry.” “Networking is critical to commercialisation.” “We need to get people out there to meet new people.” “Researchers need go to conferences, talks, workshops.” “We have retreat to brainstorm and plan.” “It is KPI (knowledge Product International) working in collaboration.”
What are some of the successful examples at the university that have already been through the process?	Successful Examples	“Commercial company uses decentralized open model.” “The unique capabilities of the Institute come from merging the skills of the engineer, chemist, biologist and computational scientist to conduct a world-class research program in nano-scale science, technology and engineering, technology transfer and commercialisation. “

Results & Discussion

The analysis generated a series of conceptual models of university-industry engagement in the process of commercialisation. Across the seven cases three "generic" models emerged. The first model (see Figure 1) is what we describe as a "Simple and Centralised" one. It involves a commercial lawyer, and several managers who work at the central administration of the university monitoring and supporting the commercial process through a commercialisation unit or office. In this model, the commercial unit is located at the central administration of the university and is directed by an appointed director/manager who works for the university and for the central administration. This model is simple and straightforward and many universities in Australia have now adopted this model for their technology transfer.

The second model (see Figure 2), is a little more complicated and we have termed it the "Complex Commercial Company". It involves the university setting up a company to direct the commercialisation process for the university. In this model, the commercialisation mangers have more autonomy and resources. Therefore, the support and expertise increases with this model because more ownership is given to the project management and the company has more funding to support commercialisation. This model was found to be associated with a greater number of success stories. Two major universities out of the seven cases that were studied were using this model. In both cases some successful spin out companies initiated by the academics and supported by the commercial company were reported.

The third model (see Figure 3) which we can describe as "Entrepreneurial", involves a professional private company that is set up by the university as an independent entity conducting the work in close collaboration with the university. This model has proved very promising because of the independent and professional commercial company that is conducting the commercialisation process for the university. This company has managers that work for the company but are located in the research centres or faculties. This physical daily contact proves very beneficial to the researchers as well as the commercial company. The accumulated human and financial resources in this set up are also very significant and prove essential for the support of commercial process.

Entrepreneurial management approaches (e.g. Model III) were found to be the most successful, although also less easily incorporated into the university's more conservative and risk-averse organisational cultures. This also translated into issues associated with the way in which academics were recognised and rewarded within their institutions, with many institutions and national research performance measures not aligned with entrepreneurial behaviour. It is obvious that the success of university technology transfer relies on two important concepts. The first relates to the quality of the support that is given to the researchers. The second relates to the innovation environment that is created at the institutions for them to engage actively in this type of commercialisation work.

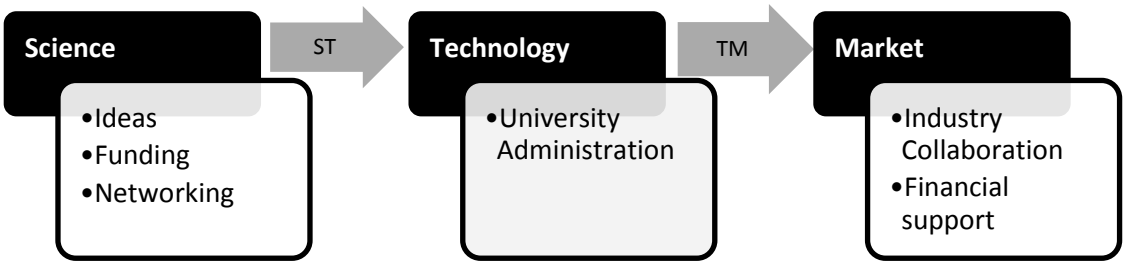

Figure 1: Model I – Simple and Centralised

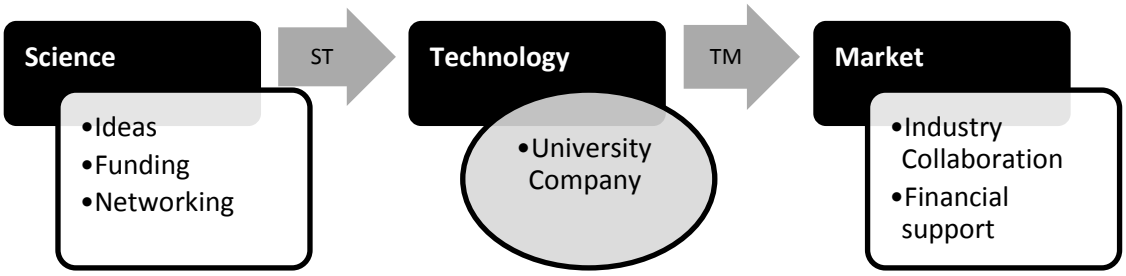

Figure 2: Model II – Complex Commercial Company

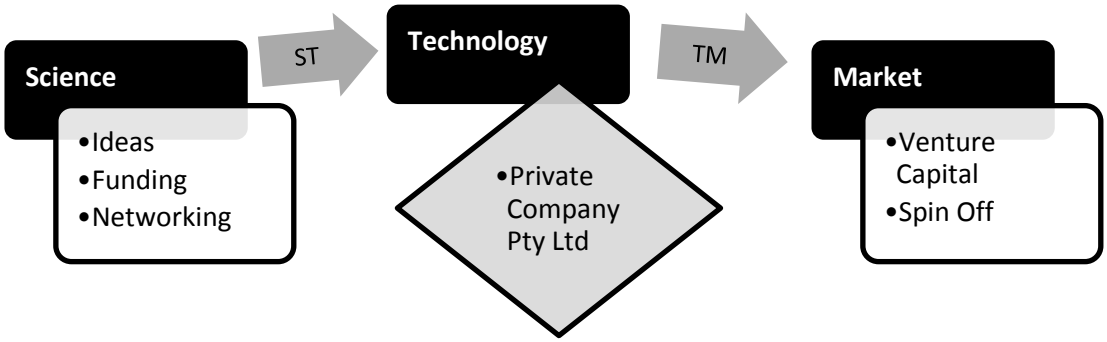

Figure 3: Model III – Entrepreneurial

The boundaries of these interactions are set by the innovation strategies, good management, organisational culture and behaviour, and, no doubt connected directly with the National Innovation System. The facilitation of commercial activities within the university is of course not just a concern for university administrators, it is essential that debate about such facilitation and the issues raised be as broad as possible and informed from a number of perspectives including students, academics, government, and industry.

Business will understandably want the lead in any university-business partnership; and will want to define the university's role in this partnership. Researchers are reminded of their responsibility to disclose all intellectual property to their technology transfer offices. The ideal scenario for university-business collaboration is for the university researcher to identify and engage a qualified corporate partner prior to initiating research activities, and at the earliest possible time in the corporate product planning cycle. IP rights for likely research outcomes should be negotiated between the researcher and their university prior to entering into collaboration. The researcher should pursue external funding to gain negotiation leverage with both the university and potential business partners. Internal champions facilitate negotiations between the researcher and business. Willingness on the researcher's part to broaden the notion of "university research" will uncover many novel opportunities for collaboration.

Once collaboration is established, the university research team should learn its role project and adopt a "business culture." The university research team should avoid competing with or antagonizing any member of the business team at all costs. Conducting research; seeking patent protection; identifying potential licensees; and securing a license agreement that leads to a commercial product is the most common but much less effective path to market (Bauer 2006). To achieve a successful collaboration, university researchers may bridge the gap between academic and corporate culture; and work closely with their university technology transfer office.

It would be less of a problem for the university if a clear IP ownership policy were in place, but even where such a policy exists there will often still be room to argue about the application of its terms. Many academic managers may be unprepared to deal with situations of conflicting interests where there are assets of significant commercial value at stake. It also shows one of the consequences of increased commercialisation of the work of universities; they will have to be prepared to act commercially where this valuable property is in jeopardy. The interest of individual actors then becomes important too. In most cases, the commercial managers who work for the university central administration, and are not from an independent source, are seen to be working more in favour of the university as an institution rather than the individual actor, namely an academic. This calls for sound policies.

Australia spends proportionally more on university R&D, particularly when compared with business expenditure on R&D, than almost any other advanced economy, which suggests that creating the right environment to encourage the commercialisation of Australian university research results is vital if Australia is to obtain the best economic results from its investment (Collier, 2007). For the economic health of the country, and to maintain Australia's position as an innovative economy, it is essential that the results of this university research are deployed effectively. This means that structures and mechanisms should exist to promote and encourage the diffusion of research results in such a way that they can be used, whether through collaboration with business and industry, or through other mechanisms such as university spinoff companies.

Generally speaking, business and industry undertake research in order to develop innovations of economic value, but this has not been the historical role of university research. Australia therefore faces a greater task than most economies, certainly when compared with the United States or other European countries, in developing a system and culture that encourages and promotes something valuable, the diffusion of university research of economic value, from a system and culture in which this object has not, until recently, been a significant factor (Dodgson et al, 2011). Changing the values and orientation of universities (and businesses, for that matter) to exploit the potential economic value that universities are creating requires a co-ordinated and long-term effort on the part of government, business and individuals.

Government and some business institutions in Australia have begun to establish the systems which may permit the potential economic value created through university research to be released. Because the process of innovation and economic growth is, itself, constantly changing, the task for all parties in this environment will never be static and requires constant review, analysis and re-orientation. For this reason and the sustainability of the research funding for universities, a perfect system, is not yet set in motion.

Australian federal and state/territory governments, in conjunction with university and industry, need to develop policy responses that encourage a more effective use of Australian university research for commercial use. While it is essential to undertake high quality scientific research, more is required in how research activity is recognised and rewarded within universities to foster commercialisation. Collier (2007) has suggested that a review be undertaken of universities technology transfer and commercialisation offices in order to examine their structure and effectiveness. We would endorse this and our own findings suggest that a more entrepreneurial model is likely to be the best solution.

However, this model may not sit comfortably within the current culture and organisational structure of many of the most research intensive institutions. These institutions, which in Australia are defined as the "Group of Eight" leading universities, generally have fairly conservative organisational cultures. They are also more committed to the publication of peer reviewed papers than the engagement with industry in commercialisation projects. Collier (2007) also recommended that university missions and policies might need to change so as to make them more supportive of commercialisation. In particular this relates to systems of appointment and promotion of academic faculty. The current state of play sees publication in peer reviewed articles as the most important criteria for such decisions. In this we also agree and our own data highlighted a cultural division between academics and industry in the motivation and priorities that they placed on commercial activity.

Australia still remains behind comparable economies in encouraging and promoting the successful exploitation of university research for the betterment of the Australian community (Collier, 2007; Dodgson et al, 2011; Dutta, 2012; Schwab, 2014). It is vital that university and other stakeholders are very clear on the

university's objectives on knowledge transfer, motivations and benefits, and hence, a clear model (structure and approach) for commercialisation at the university is needed.

The public sector should promote collaboration between firms and existing regional institutions such as colleges and universities. Central government, together with public sectors in the regions, may aid the transformation by means of a wide range of initiatives related to the development of knowledge-based structures and the acceleration of learning in action. By creating and developing physical infrastructures, such as telecommunications and transport systems which firms rate as highly important, the public sector can reduce some of the drawbacks of being located in a less-advantaged region, and enhance the advantages of the location. Thus, integration of regional infrastructures with national infrastructures must be an important part of a policy that stimulates sustainable economic growth in the region. The education system must develop a flexible system that makes it possible to combine vocational and higher education to attract new students. More specifically, policies should address the current problems associated with attracting and retaining skilled labour.

Even as the field of nanotechnology experiences rapid growth, the movement from discovery to innovation cannot be taken for granted. Too often, innovative technology is assumed to automatically translate into successful commercialisation and societal benefit. It is rarely so straightforward. This is argued (Youtiea, 2012) that more attention is required to the end stages of the innovation process, in particular to better comprehend the wide range of innovation models that companies in emerging industries adopt and the dynamic evolution of their approaches.

Conclusions

The university research community can play an important role in industry research and development activities leading to new products. Business is the gateway through which all new products enter the marketplace. University researchers are advised to engage business partners prior to the inception of their own research activities, and early in the corporate product development cycle. A sustainable and well-designed commercial structure will benefit both university and the industry involved. Successful university-business partnership requires that university researchers and other stakeholders recognize business' lead in product development and commercialisation; and understand and practice business culture. University contributions may include: technical research and development; identification of customer and technology needs; product definition; prototype testing; product validation; clinical trials and external funding through grant activities.

When nations improve innovative capacity, they enjoy more rapid growth in productivity and with it an improved standard of living. Improving innovativeness in one country can also benefit other countries through the diffusion of knowledge and products. According to Porter (199) the degree of openness to international trade and investment is a necessary element in the national innovation infrastructure, who suggests that; "prosperity depends on whether we can remain a moving target".

Universities are an important institution that has long played an important role in generating economic growth and prosperity. However, the means to these ends have evolved considerably over the past two decades as the traditional mechanisms of creating and disseminating knowledge through research and teaching have been joined by countless new initiatives. Many countries around the world are experimenting with new initiatives to promote technology transfer from universities, with varying results. The effectiveness of these initiatives and the degree to which these economies adapt is determined by the specific local context. Examining new ways, breaking new grounds and making new rules would open the doors to victory. Learning through action is an important determinant of the relative share of resources allocated to inventive versus innovative activities.

It is important for national and (more specifically) regional governments to be familiar with the particular needs of firms in the areas for which they are responsible. Regional policies should take into account the evidence concerning firms' innovation needs, and the inadequacies or perceived unimportance of the existing technological infrastructure in the region. Public support may be directed to those aspects of the innovation process in which firms are actually involved. Collaboration with university researchers provides many benefits

to industry. University research can include: basic and applied research; prototype development and testing; market research; and clinical trials. The collaboration provides the industry partner with access to research infrastructure; technical, business and clinical expertise; skilled labour, financial resources through grants, and human subject populations. Unfortunately, a number of factors interfere with such collaborations. If the goal of research is commercialisation, which is within the domain of industry, then industry is a key customer of university research.

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