ABSTRACT
This paper is based on initial description and exploration of an Australian technology transfer office of the role that technology transfer professionals play in commercialisation strategies. This paper emphasises the strategic actions of these professionals within the two institutions, academia and the market. The purpose of this paper is to familiarise the reader with the uncertainty in the technology transfer process as these professionals make sense of scientific ideas with entrepreneurial judgement. This paper concludes with a number of key research implications to guide further research in the field.

INTRODUCTION
Over the last 30 years universities have been undergoing sweeping change with the growth of the commercialisation of scientific research. The most famous examples of successful commercialisation are Stanford in Silicon Valley and MIT in the Boston area. The success of these prestigious universities has ushered in new ways of viewing and valuing scientific knowledge and has inspired higher education institutions around the world to replicate new ways of collaboration with industry. Changes to the interface between universities and society have been described as the ‘third academic revolution’ (Etzkowitz, Webster, Gebhardt, & Terra, 2000, p 313) and ‘academic capitalism’ (Slaughter & Leslie, 1997, p10). However, some university leaders are taking a simplistic view of this interface, seeing technology transfer as a recipe to new ventures and economic growth in the local region (Miner, Eesley, Devaughn, & Rura-Polley, 2001). There are no single or simple approaches to understanding how successful university-industry linkages are developed and each are context-specific (Tornatzky, Waugaman, & Gray, 1999). This paper aims to bring a renewed sensitivity to the institutional context of technology transfer and it considers how technology transfer professionals perceive the path to commercialisation.

LITERATURE REVIEW
The knowledge economy can be understood as the changing nature of innovation into more open forms of innovation (Chesbrough, 2003). Distributed forms of innovation challenge traditional boundaries of economic organisation and new forms of collaboration are occurring. Firm-level strategy includes knowledge management dimensions in which knowledge both inside and outside the traditional boundaries of the firm is incorporated into the strategy of the firm. Some literature describes a shift in the locus of innovation and how firms can come up with new ways of achieving strategic competitive advantage in their industry (Powell, Koput, & Smith-Doerr, 1996). The use of knowledge in strategic development and the subsequent recombination of the factors of production has been proven to lead to competitive advantage in a number of industries. Increasingly, university research is becoming a domain into which industries are exploring in their search phase of strategy. Firms are exploring upstream with the intent of finding technology or scientific knowledge that will assist in the strategy process (Bercovitz & Feldman, 2006; Laursen & Salter, 2004).

The changing role of universities in recent years is an exciting area of research as these new forms of collaboration between industry and universities challenge the traditional role of the university (Etzkowitz et al., 2000; Slaughter et al., 1997). Universities have been a bastion of knowledge, wisdom, and understanding with academics focussing on scientific inquiry. The university has for many centuries been a type of intellectual commons (Feldman, 1994). Universities are an institution
that has lasted many years with the clear purpose of producing scientific knowledge for the public good (Etzkowitz, 2003). Knowledge developed in academia and the market has been traditionally diffused through publications and informal contact with academic. Through the publication of research the limits of social networks are overcome to some degree and spill-over effects are possible (Sorenson & Fleming, 2004). These university/industry linkages can become a unique mechanism for cross-boundary learning as the university has different incentives, goals, routines, and decision-making structures from profit-oriented firms (Bercovitz et al., 2006). But collaboration between the university and the market can also be characterised by knowledge asymmetry due to institutional differences. The differing norms between academics and the market means that the commercialisation process can present a pervasive cultural and informational barrier (Siegel, Waldman, & Link, 2003).

This transfer of knowledge between science and business is characterised by a high degree of uncertainty as scientific paths of inquiry do not necessarily lead to commercial outcomes. The beauty of a scientific discovery can differ from the beauty of an invention, or something which provides some tangible advantage (Polanyi, 1962). Knowledge is also imperfectly shared (Hargadon & Sutton, 1997) as it involves tacit dimensions (Polanyi, 1967) where ‘know how’ cannot be codified in patents and publications. Knowledge can have latent dimensions (Agrawal, 2005) where it is the learning gained through many failures before a successful experiment that has potential benefits for firms. The interactions between the science and business involve a highly evolutionary process that is described in the literature as the Darwinian sea (Branscomb & Auerswald, 2001). It is at a proof of concept stage that the role of the technology transfer professional is pivotal as the technological and market risk behind a scientific idea are determined. Technology transfer professionals act as boundary spanners (Allen, Tushman, & Lee, 1979) who can understand science and business and face the strategic choices of which knowledge to commercialise.

The ability to identify opportunities when ideas are in the embryonic stage of basic science and scientific risk highlights the need for entrepreneurial judgement (Weitzman, 1998, p313). Kirzner (1997) makes an important distinction between the entrepreneur and the knowledge expert, arguing that it is the entrepreneur who can realise the full value from knowledge. In this way, we want to ascertain whether entrepreneurial judgement impacts the selection of projects. Conditions of uncertainty require the initial coordination of resources without which the resources required to exploit a market opportunity would not have happened (Alvarez & Barney, 2005). There is a role for institutional place holders until the most efficient form of organisation under risk can be discovered. It is the technology transfer professionals’ ability to act as boundary-spanners, and not just knowledge managers, that can bridge the gap between academia and the market (Katz & Tushman, 1983).

The strategic choice of the transfer professional can have a significant impact on the outcomes that are produced, including the way certain scientific and technological opportunities evolve. This is evidenced in the work on institutional entrepreneurship in Wisconsin where individuals are responsible for protecting, propagating, and influencing stem-cell research (Jain & George, 2007). Technology transfer professionals in this case exerted political power to achieve the traction necessary for a technology to become a commercial reality. In this way, scientific and technological opportunities evolve with the help of agents who select and prioritise a particular idea and believe that it should go further. The cognitive dimensions of how these professionals perceive technology transfer, their role and the transfer structures around them, have a significant effect on evolution of the relationship between the science and business.

The activity of individuals in technology transfer, in selection and coordination, remain unstudied and do not give the reader a processual understanding of technology transfer and the factors that help them decide and prioritise ideas. Case studies of successful technology transfer may provide policy makers a ‘strategic template’ to follow but may not provide a rich understanding of the institutional terrain in which technology transfer takes place. The tendency to follow best practices and strategic recipes overlooks Berger and Luckmann’s (1967, p78) point that institutionalisation does not gain an ‘ontological status apart from the human activity that produced it’. The level of analysis of much of the commercialisation research is at the meso-level such as universities and university technology transfer offices (Nikulainen, 2007). This research views the university as a unitary concept with clear and distinct boundaries and knowledge as an objective reality. The use of terms such as the ‘entrepreneurial
university’ (Slaughter et al., 1997) convey the university as a bounded and discrete entity which is far from reality. Universities instead consist of a plurality of interests (Hardy, 1991) and can be viewed as a loosely coupled system (Weick, 1976) where science is not diffused in linear fashion but does so through social networks and serendipity.

RESEARCH METHOD

This early, exploratory study was conducted in an Australian technology transfer office. The participants are technology transfer professionals. Our sample involved interviews with five technology transfer professionals whose role is to assess the novelty and commercialisability of scientific ideas generated from within the university. These subjects were chosen on their relevance to the research topic (Flick, 2006) as they are close to the grass-roots level of technology transfer. The interviews aimed to gain an appreciation of the context or terrain of commercializing within a university environment. Each interviewee came from a scientific background and had worked in the technology transfer field from six months to four years. The interviews presented an opportunity to capture relevant and rich data from professionals who had studied and/or worked in a traditional scientific roles but now were engaged in this new career of technology transfer. The decision to interview these professionals was to give the researchers a greater appreciation of the institutional terrain between universities and the market, and potentially give insight into the potential conflicts and synergies between science and business.

Five participants out of a possible fourteen employees at this level in the organisation were chosen using snowball sampling (Bernard, 2005). The snowball sampling method starts with identifying one participant, and then from that interview, other participants are recommended by the first interviewee. In our case, the first interviewee liaised with their manager who then contacted other analysts and associates and asked them to participate in the research. While this sampling method does not ensure the highest level of representativeness, after subsequent interviews with four technology transfer professionals, a high degree of overlap in their answers was identified, and some sense of saturation was reached.

In-depth open interviews were conducted to investigate how the technology transfer professional experienced technology transfer. The interviews took place in their place of work. The decision to interview at their workplace was part of our goal to discover and develop empirically grounded theories and to have these people ‘represented in their entirety in their everyday contexts’. Flick (2006:15). These interviews ranged from thirty to forty-five minutes in duration. Semi-standardized interviews were adopted as this approach tends to be theory-driven with hypotheses-directed questions (Flick, 2006:156).

The transcripts were analysed by the lead researcher for a preliminary attempt at highlighting significant phrases in relation to how technology transfer professionals understand their work. The transcripts were read several times to become familiar with the data. Then, the transcripts were read again one by one and relevant sections to the propositions were highlighted on each page. The similarities in what participants said provided an initial framework of understanding as well as the identification of some general themes.

FINDINGS

Science and Business

The narratives showed that there was a variety of interpretations these technology transfer professionals had about their role and the benefits of this role. These interpretations included a benefit for society, a benefit for further research, and a benefit for the university.

Technology transfer professionals studied understood technology transfer to be one of a vital linking role between universities and the community. For example, one respondent I160 said:

“you get to see really great technology and you get to do something good with it and so you get the satisfaction from both, and having a foot in each camp”
There was an overriding sense of the duty of technology transfer to the wider community, and the promotion of scientific outcomes as a public good. These particular interviews revealed a distinction between commercialisation value and community benefit and the understanding these technology transfer professionals have of achieving both. Two interviewees (I1:25 and I16:2) respectively said:

“it’s got to have a certain amount of value for us to take it out of the academic environment...so basically there are the 2 main things: community benefit and are we going to make a profit on it”

and

“Other things if we can see that it can be put out in society then it really should functionalise the research and obviously there is a whole host of arguments as to why it is good, the economy, people’s health if it is a drug, and all that kind of stuff, but certainly I think you just get a warm fuzzy”

A great deal of research in the field of technology transfer has focussed on the concept of the academic entrepreneur and the devolution of the traditional scientist. Yet some technology transfer professionals view their role as a permanent and sustained career in its own right. In fact, there was a sense that the role of the technology transfer professional involved winning research work for the university through successful university-industry collaborations. This is a far cry from a clash of institutions argument where the role of academia and scientific research is extended rather than diminished. Two interviewees (I2:34 &I1:50) remarked respectively:

“If we can create it here locally we can do the research and that is good for the university of course”

and

“It’s not just dollar value in terms of profit but it’s dollar value in terms of the value they bring back into the university, to the researchers, to society”

These comments seem to indicate that the role of technology transfer is mediated through an understanding of the research function of the university and the benefit of technology transfer for research. These narratives suggest that technology transfer is a vital institutionalised role and a role that academics and researchers cannot readily assume. These professionals in this way are custodians of the technology transfer process, allowing the academic to continue in their role. Implicit in these comments is a clear division of labour and responsibility between science and business with the technology transfer professional bridging the two worlds. One interviewee (I4:17) said:

“To assess a technology in a non-biased position is time consuming... I think they require a tech transfer company because I don’t think they have the time to put into commercialising their technology”

The last interpretation was that the role of technology transfer is largely mediated by the view of the ‘host’ university. The professional had a clearer sense of the authority the university had in the process of technology transfer. One interview (I3:51) remarked:

“It’s not a commercial world. It’s artificial. We are sort of protected by the university. Essentially we’ve got this big gorilla behind us. Personally I see it as part of the university, almost like a gatekeeper to the university, we are understanding commercial returns and the way to deal with commercial companies”.

The gatekeeper role played by the technology transfer policy reflects the university policy to own the intellectual property and derive commercial benefits from it. The university backs the technology transfer professionals in their efforts to bring in revenue for the university. This lends to a resource dependency view where the university aims to reduce dependency on uncertain revenue streams such as government funding (Powers, 2000; Salancik & Pfeffer, 1974).
Technology transfer professionals can encounter some apprehension between academics and the technology transfer office. Speaking about the seminars that the technology office gives in faculties to generate awareness of the aims of technology transfer office, one interviewee said:

“We are the commercial arm of the university, we are not a monster...all the researchers view technology transfer companies as money hungry monsters but basically without tech transfer companies, you can’t get technologies out into the community” (I5:4)

This exploratory work has revealed a variety of interpretations that technology transfer professionals have about their role which can be aggregated into a proposition to guide further research. The interpretations, which included normative dimensions about the public good, the role of further research, and the financial aspects behind technology transfer can be summarized into the following proposition.

**Proposition 1:** Technology transfer professionals mediate the institutional boundaries between science and business

**Uncertainty and Entrepreneurship**

The nature of the technological process means that it is difficult to assign a value on the particular technology. It is highly uncertain, imprecise, and invariably dependent on the intuition of the technology transfer professional. The analyst or the associate must ‘make a call’ on whether to push this knowledge forward in the commercialisation process. In this way, the concept of value is contingent on the technological process and the technology transfer professionals understanding of that. One interviewee (I3:26) said:

“when you read about a technology its something that goes on inside of you which is ‘yeah, this is promising’ and that sort of skill is not something you can learn how to do, it’s something you have to keep...you get a gut feel after a while”

This sentiment was further crystallised when an interviewee (I2:54) explained:

‘there is an unknown market out there and your job is to drive the project forward. You need to ensure that the that the information you give is something that the managers can act on... it needs to be dealt with ethically’

Market analysis is one way to determine the potential value of a particular technology. The technology transfer position is characterised by searches in the market for a guide of what value the technology might have. This can be likened to a manager’s activities to reduce the amount of uncertainty when making a decision (Alvarez et al., 2005). If value is identified in a particular idea, the market value must be high enough to warrant further work on it. Another factor in the market analysis on a particular technology are the dimensions of the target market. We found that it was important for the technology transfer professional to match the technology with the requirements of the industry and what the market actually needs.

Another way to determine value is through intellectual property analysis. If the technology does not have a strong intellectual property position then the idea put forward will rarely be advanced as the commercialisation value might not be realised. The idea therefore must be patentable (or have copyright/trademark potential if a patent is not suitable) for an idea to be followed up on. The emphasis in the minds of these interviewees is to ensure that the ideas generated by the university have adequate intellectual property value. The interviewees (I3:33 and I4:9) respectively commented:

“I think the first thing is to make sure the creativity is filtered through people who might be able to have an intuitive understanding of what is novel, what could be a valuable patent”
“that is why we assess these technologies first, we’ve got to make sure that they are technologically sound and have commercial value otherwise the money we are coughing up for the provisional and PCT’s we aren’t going to recuperate”

With these two approaches to determine commercialisation value, a major part of this role is ‘killing’ a project that does not have commercialisation value. This is to ensure that energies and focus can be spent on other projects that present a better prospect for a return on investment. One interviewee (I3:28) said:

“if a technology is a bit weak, you can cull it because you sort of say the value proposition is not going to be enough if we do a deal to pay for patent costs and people’s time and the inventors time and things like that, you can reduce your workload”

This conception shows technology transfer professionals who navigate a course of scientific and market risk towards a ‘commercial event’. When they do find a technology that overcomes this risk and they realise its commercial value, it is an exciting moment for the technology transfer professional. One interviewee (I2:50) concluded that:

“it is exciting seeing something happening, something coming out of course and most of it is getting killed but every now and again, you see a project moving a step forward”

These narratives provide a rich understanding of the process that technology transfer professionals take towards scientific ideas. This process can be summarized into the following proposition.

Proposition 2: Technology transfer professionals face uncertainty in the proof of concept phase and make sense of, and select, projects

Knowledge Transfer

Technology transfer is a fluid, dynamic environment with technology transfer professionals processing a number of different scientific ideas. These scientific ideas can be at a variety of stages in development and proximity to a commercialisation event which means that the technology transfer may be involved in a number of different projects. Each interviewee felt that it was through project-based and team learning that the work of technology transfer was performed. The project-based structure of their work is considered by those interviewed as the best aspect of the job, particularly as they could learn from others on that particular team. One interviewee (I5:40) said:

‘It’s very much on the job training, so until an opportunity comes up and you can be involved in, that’s where you really know something. And that’s basically where you want to get into multiple projects so that you can get that experience’

In another interview, another interviewee (I5:72) said:

“I suppose because I am only new in this role to some extent you don’t get as much...you only learn as much as you get put on so if you aren’t put on something you are kind of cornered as to what roles you can and can’t do”

It may be that the type of projects that they are assigned to mediates the performance of the technology transfer professional. Other research that has been done on organisational structure concluded that the most critical organisational factors are faculty reward systems, TTO staffing/compensation practices, and cultural barriers between universities and firms (Siegel et al., 2003). The way that technology transfer professionals are compensated according to this view determines the effectiveness of the technology transfer office. Yet, this preliminary data suggests that an environment of ongoing learning and access to
knowledge facilitates greater levels of knowledge transfer. The knowledge base of the technology transfer professional seems to be the starting point from which technology transfer effectiveness comes.

In explaining their role, it was important for technology transfer professionals to be confident and leverage off their existing knowledge and bring experience from the outside to the role in technology transfer. The work of technology transfer requires broad knowledge, not just in science, but also in business and legal knowledge. This approach can be likened to ‘analogous thinking’ where individuals draw upon their own experiences to make analogies when solving a novel problem (Hargadon, 1998). One interviewee stated:

‘But if you have got a little flair then, and you are already have some understanding of a particular area of commercialisation, then you kind of get in... that’s your foothold and you start working your way out and learning those other areas that you don’t know’ (I5:14)

As part of this process, a broad scientific knowledge base was seen to be the ‘entry ticket’ into a technology transfer role. We found that each technology transfer professional recognised that a PhD was necessary for this role as the in-depth knowledge that a PhD provides improves the overall ability of the technology transfer professional to grasp the scientific and technological issues of a project. In one case (I1), the interviewee had never directly used their PhD specialisation on a project but instead expressed it was their ability to understand the basic challenges that a technological process can produce that was considered to be important to their job. Having done a PhD also helped relate to researchers and academics about their inventions and their science in general.

These narratives indicate that the role of the technology transfer professional is based on their knowledge base and that technology transfer success comes from access to other projects that supplement this knowledge base. This leads us to propose that:

**Proposition 3:** Technology transfer professionals’ knowledge base mediates knowledge transfer

**IMPLICATIONS**

This early, exploratory paper presents a number of propositions which have implications for further research. Before making some general conclusions, and outlining the implications of this exploratory work, some limitations should be described. The narratives produced in this research were derived from a small sample of five interviewees so this paper does not aim to make any generalisations. This exploratory study aimed to obtain an initial but rich sense of what is involved in technology transfer at the grassroots level. In addition, a follow up study should include technology transfer professionals from a variety of levels within the organisation to elicit a broader view of the technology transfer process. This study was limited to the entry-level position.

The first proposition is that technology transfer professionals mediate the institutional boundaries between science and business. Renowned case studies of MIT and Stanford and meso-level analysis of commercialisation can take attention away from the role of individuals, particularly institutional entrepreneurs who use resources to shape and legitimate new institutional realities. This is a process where conversations between institutional actors can become legitimate organisational templates (Hardy & Phillips, 2004). In this preliminary study, there were a number of institutional logics to support and justify the emergence of technology transfer. Further study might consider how these logics were initiated, transmitted, and ultimately carried by technology transfer professionals.

The second proposition is that transfer professionals face uncertainty in the proof of concept phase and make sense of, and select, projects. This brings to our attention the importance of intuition and the filtering process used to evaluate the trajectory of certain ideas. Future research may track the commercialisation of ideas to establish whether there is a feedback loop between the academic and the technology transfer professional and how much of this feedback is shaped by the findings of intellectual property or market searches and how much rests on entrepreneurial judgment. Additionally, given the risk/uncertainty ratio of individual projects, future research might consider the nature of collaboration...
chosen by the technology transfer professional and whether uncertainty leads to certain economic models. For instance, in an uncertain project, are start-up firms preferred or are licensing deals more appropriate for certain outcomes?

The last proposition advanced was that technology transfer professionals’ knowledge bases mediate knowledge transfer. Further research may consider the emerging profession of technology transfer and those that are best suited for this type of role, and whether this has any impact on effectiveness. The perceived necessity of a science background, especially a PhD, as well as broad legal and business knowledge, may mean that educational background and specific scientific experience may be correlated to superior transfer performance. Further research might test for statistical significance in this regard.

**CONCLUSION**

This early exploratory investigation brings attention to the role of technology transfer professional where most studies in the field focus on universities and technology transfer offices. The preliminary data indicate that there is some variance in the way technology transfer is conceptualised, the way certain scientific ideas are promulgated, and the structural elements that contribute to technology transfer. Making the technology transfer professional the unit of analysis adds a new level of richness to existing literature in the field, particularly in the way individuals shape the development of technology transfer as a field. Further research needs to be conducted to substantiate these initial findings and map the institutional terrain between science and business.
LIST OF REFERENCES


