Subtheme: History and conditions for success

Title: Defining the Entrepreneurial *Mindset of Life Science Academics*

Authors: Alicia Castillo Holley* and John Watson

The aim of this exploratory study was to provide an understanding of the diverse views held by life science academics (LSAs) concerning the commercialization of research discoveries, and to organize those views in a systematic way that would help our understanding of the process of academic entrepreneurship and be useful in designing, evaluating, and improving support mechanisms. A qualitative research methodology was used, based on in-depth interviews with six technology transfer officers and twenty seven LSAs who were selected using a purposeful, snowball-sampling approach. Based on their views and the actions they took with respect to commercializing academic research, they can be categorized as either: non-entrepreneurs, semi-entrepreneurs, pre-entrepreneurs, or entrepreneurs. Within these major categories, thirteen sub-categories of LSAs emerge, ranging from antipreneurs to traditional high growth entrepreneurs. LSA's views and roles are dynamic, being influenced by personality, project characteristics, and support systems. The responses also indicate that some metrics could be distorting the evaluation of outcomes from commercialising academic research. We conclude with clear directions for tailored support mechanisms applied to the specific categories and subcategories.

Keywords: academic entrepreneurship, entrepreneurial mindset, semipreneur, antipreneur, technology transfer, university spin-offs.

*corresponding author

Alicia Castillo Holley is a Doctoral student in entrepreneurship at The University of Western Australia. She has been a lecturer on entrepreneurship, innovation, and venture capital in several universities around the world. She has started nine companies and one non-profit, and was the founder of Chile's first Centre for Entrepreneurship at the Universidad Adolfo Ibañez, and later the country's first seed capital fund 'Capital Semilla'. Castillo Holley has an Engineering degree and a master in biotechnology from Universidad Central de Venezuela, as well as a master of business administration from Babson College. Email: aliciacastillo@wealthing.com

John Watson is a Winthrop Professor in Accounting & Finance at The University of Western Australia. He lectures in financial accounting and formerly worked as a chartered accountant. He was Head of Department from 1991-93. His primary research interest is in the performance of the small business sector. He has a PhD from the University of Western Australia. Email: John.watson@uwa.edu.au

Introduction

Knowledge creation and dissemination has been the raison d'être for universities, however, some changes in: academic management; higher education policies; discretionary funding; and knowledge appropriation are reshaping the role of universities worldwide. Slaughter and Leslie (1997) use the term 'Academic Capitalism' to describe the way public research universities are adapting to new neoliberal policies. Etzkowitz and Leytesdorff (1997) introduced the term 'Triple Helix' to describe the new relationship between university, industry, and government and defined an 'entrepreneurial university' as an organization that expands its knowledge creation and dissemination from the classroom to local economic development.

Of the many changes occurring within universities, commercialization of publicly funded research is one of the most controversial. The passing of the Bayh-Dole Act of 1980 in the U.S. gave universities control over the intellectual property they generated from public funding and has accelerated the trend towards academic engagement with commerce via the establishment of Technology Transfer Offices (TTOs) and/or University-Industry Technology Transfers (UITTs) (Mowery and Sampat 2001). However, three decades after the implementation of the Bayh-Dole Act, the University ownership model for intellectual property remains a contentious issue and has been questioned by several authors (Nelson 2004; Baldini 2009; Kenney and Patton 2009). Some authors favour public dissemination of research findings, primarily through publications and conference presentations (Nelson 2004), while others argue that providing benefits to individual organizations ensures the necessary support to take research results to market (Jensen and Thursby 2001).

Kenney and Patton (2009) note that one of the most successful cases of technology transfer, the Cohen-Boyer patent (C-B patent), generated over $255 million dollars in revenue for Stanford University and the University of California via a series of non-exclusive licensing deals. Interestingly,

the two scientists involved with that discovery adopted very different approaches to their subsequent careers; one remained in academia while the other started a new venture by licensing the technology provided in the C-B patent and developing further intellectual property.

The role of the academic scientist in commercializing research has been recognized as important and understudied. Jensen and Thursby (2001) report that 71 per cent of the managers of TTOs claim that successful commercialization requires the cooperation of the scientists in further development. For example, although Siegel et al. (2001) note that the success of technology transfer depends on the participation of faculty, this topic is not covered in any of the studies to which they refer. Similarly, Shane and Ulrich (2004) review of the work published in Management Science since its 1954 inception on the topics of technological innovation, product development and entrepreneurship showed that only five of the 250 articles considered the role of the individual researcher. More recently, Jain, George and Maltarich (2009, p.292) conclude that "missing from much of this conversation is a deeper understanding of the involvement of a key actor – the university scientist." A better understanding of "the enablers and barriers to entrepreneurship in a university setting" (Brennan, Wall, and McGowan 2005, p.319) is still required.

State of the Art

There are two main research streams regarding categorization of academic entrepreneurship. One focuses on institutional activities and the other on academic researchers either participating or intending to participate in a research-related start-up. In the case of institutional activities, academic entrepreneurship can take many forms. For example, Louis et al. (1989) identify five academic entrepreneurial activities: securing large externally funded research projects; deriving supplemental income, mainly through consulting; soliciting research funding from industry; patenting the results of research; and forming companies based on the results of research. Brennan et al. (2005) establish six

areas of a 'third' stream of University funding: consultancy; public-sector contracts; private-sector contracts; joint ventures; spin-out firms; spin-in firms; and intellectual capital management. Wright et al. (2008) categorize tacit and codified knowledge transfer in the following five areas: spin-offs; licensing and patents; contract research; consultancy and reach-out; and graduate and researcher mobility. Finally, Philpott et al. (2011) provide a range of nine activities that span across the traditional academic paradigm to the entrepreneurial paradigm, namely: producing highly qualified graduates; publishing academic results; grantsmanship; consulting; industry-training courses; contract research; patenting and licensing; spin-off firm formation; and creation of technology parks.

The following table summarizes these studies.

Insert Table 1 about here

Studies regarding categorization of academic scientists focus on their participation on research related start-ups, or on their intention to do so in the future. In the particular case of a University Spinouts (USO), Nicolaou and Birley (2003) establish three business models defined by the researcher's relationship with the USO: an orthodox USO, where the researcher leaves academia to take up an entrepreneurial role; a hybrid USO, where the researcher takes a part-time or advisory position in the USO; and a technology USO, where the researcher is not involved in running or managing the USO. Some universities seem to favour the use of surrogate entrepreneurs, in which the researcher is not actively involved in running or managing the USO (Franklin, Wright, and Lockett 2001), however, other authors argue in favour of faculty learning to become better entrepreneurs (Vohora, Wright, and Lockett 2004; Sanz-Velasco and Saemundsson 2008). In the U.S., most researchers seem to adopt the 'hybrid' approach, navigating between their primary roles as academics and their secondary roles as commercializers (Jain et al. 2009). It should be noted that a researcher's relationship with a USO can be impacted by government policy. For example, the Small Business

Innovation Research (SBIR) program in the U.S. only funds USOs on the provision that the researcher participates in the day to day operations of the firm (Toole and Czarnitzki 2007).

Brennan et al. (2005) categorize nascent researchers, proposing four types of academic entrepreneurs: Hero, Maverick, Broker, and Prospector. Two key attributes distinguish the four types: the importance attached to the production of knowledge versus the exchange of knowledge; and the relationships of academics with their host University in comparison with their relationships with the commercial world. Hero characterizes an individual with a focus on both production and use of knowledge, and a balanced relationship between academia and business; Mavericks also have a focus on both production and use of knowledge, but their relationships are skewed towards business; Brokers are more interested in trading knowledge, and have a balanced relationship between academia and business; and Prospectors are more interested in trading knowledge and have relationships skewed towards business. Brennan et al. (2005, p.318) suggest that the increasing prevalence of entrepreneurial activities within Universities "will create significant challenges for both university policy makers and managers, and indeed for those who aspire to academic entrepreneurship."

Dickson, Coles, and Smith (1998) report three different types of scientist academics: the academic entrepreneur focuses on academic activities but is involved in commercial activities; the entrepreneurial scientist focuses on commercial activities but is involved in academic activities; and the scientific entrepreneur uses science as a business.

The study of academic entrepreneurship has traditionally focused on those academics directly participating in the process of commercializing knowledge, or on the reflections by others of the impact of the academic's involvement. A deeper understanding of the process can be obtained by also including the views of those academics not directly participating (and/or interested) in the commercialization of research discoveries for the following reasons:

1. It is generally accepted that entrepreneurial activity does not only involve the formation of a start-up, but might also include other activities (Schumpeter 1947; Shane and Venkatamaran 2000). Furthermore, several authors have included other forms of commercial exploitation, such as consulting and joint-venturing, in their descriptions of academic entrepreneurial activities (Brennan et al. 2005).

2. Individuals who have not yet started a new venture but are actively engaged in exploring the opportunities (referred to as 'nascent' entrepreneurs) are considered part of the entrepreneurial process (Liao and Welsch 2008). Studying this group has provided useful information about appropriate support mechanisms for individuals at this 'nascent' stage (Davidsson and Honig 2003).

3. Some academic researchers may have been engaged indirectly in academic entrepreneurial activities, for example, as consultants in the licensing process of a research discovery or as advisors to a USO (Markman, Gianiodis, and Phan 2008).

Methodology

We adopted a qualitative research methodology involving in-depth interviews with six TTO managers and 27 life science academics (LSAs) that were, or had been, working at an Australian University. In most cases a researcher had worked at more than one University within Australia or other parts of the world. A purposeful snowball-sampling approach was taken to ensure a diversity of views was obtained. With respect to the TTO managers, we were interested in obtaining input from TTO whose primary focus was on licensing, those focused on USOs, and those with no expressed commercialization focus. The TTO managers interviewed included two females and four males; with two having participated in a USO and all six having worked at some stage as full time employees of a life sciences technology-based company. One TTO manager had also worked for a seed-capital fund

and was semi-retired at the time of the interview. The interviews with the TTO managers were used as a source of background information and to provide the context for both our subsequent interviews with LSAs and the evaluation and categorization of their responses. TTO managers also suggested specific individuals for interviews but did not make an introduction.

In terms of the LSAs, we selected those who: were not participaing in the any form of commercialization; were participating at arms length; or had been involved in a USO.

The interviews were based on the following open-ended questions:

1. What is your view on the commercialization of academic research?

2. What is the role of the scientist in the process?

3. What factors external to the scientist impact the commercialization of research?

While the interviewees were assured their responses would remain confidential/anonymous, some interviewees expressed a preference for not having their responses recorded. There were also a number of cases where the interviewer felt that the LSA might be more open and forthcoming if the interview was not recorded. Where the interviews were not recorded the interviewer took detailed notes during the interview and, with the permission of the LSA, a number of direct quotes on issues of particular importance were taken verbatim. Interviewees' non-verbal communication, such as: body language, tone of the response; and any distractions/interruptions, were noted by the interviewer. Recorded interviews were transcribed by a third party and then checked for accuracy. The interviews lasted between 20 and 90 minutes with two interviews being conducted by phone, six held in public locations (such as a cafe) and the remainder conducted in the LSA's office.

Additionally, the LSAs interviewed were asked to provide the following profile data: age decade; job title; years spent in academia; number of publications; number of patents; and the number of USOs and licensing agreements in which the interviewee had participated. Table 1 provides a summary of the demographic information for our sample of 27 researchers. Interestingly, three of the LSAs that were approached declined to be interviewed because they were strongly opposed to commercializing University research discoveries and considered this study to be inadequate. From Table 2 it can be seen that four of the LSAs were female and 23 were male. There was a good spread across the various age groups and the LSA's years in academia ranged from seven to 44. The number of reported publications varied greatly, from 22 to 1800. Note, however, that in some cases the LSA identified publications in peer-reviewed journals, as well as white papers, cases, conference papers, books and book chapters. The number of registered patents in which the LSAs participated ranged from zero to 70. However, it should be noted that the individual involved with 70 patents was an outlier who had led a large research institute; the next highest number of patents reported was 20. Of the 27 LSAs interviewed, 14 had participated in at least one USO, one was involved in the formation of a USO, and six have been involved in more than one USO. Finally, eight of the LSAs had participated in negotiating a licensing agreement.

Insert Table 2 about here

An adaptation of Burnard's (1991) method for analyzing interview data was used to examine the views of the LSAs about the questions asked. Specifically, the interview records (including the notes about the interviewee) were coded with respect to the answers provided by the whole sample. Then, the coded data were grouped into higher-level categories. Note that an iterative process was used, in which the transcripts were read and re-read, the data coded and re-coded and then the coded data grouped and re-grouped until it was felt that a reasonably exhaustive categorization had been obtained. Table 3

illustrates the outcome of this process with respect to a sample of responses to the first question, namely, the views of the LSA's concerning the commercialization of research discoveries.

Insert Table 3 about here

Finding and Interpretations

Several conclusions emerge from the analysis of the responses. First and foremost, LSAs views on commercialization are dynamic, evolve with time, and are based a combination of factors derived from three areas: individual-driven, project-driven, and support-driven. Many respondents reflected upon the changes in their views in time. Although we did not specifically ask for a pathway to entrepreneurial process, the responses provided offer enough information to develop preliminary pathways to the process of academic entrepreneurship. These pathways will be explained after the definition of the specific subcategories developed by this analysis.

Individual driven considerations included the personal LSA views about research commercialization, their vision of their professional career and some personal and lifestyle considerations.

Researchers also reported that their views had to take into consideration project characteristics such as: perceived market value, capacity to reach customers, and capacity to generate a team strong enough to continue developing the intellectual property in commercial applications. These considerations were more important for those who had a propensity to accept and get involved in commercial exploitation of research. In some cases, scientists referred to their evaluation of the project's potential to make decisions regarding their potential participation in a start-up and, furthermore, their levels of involvement. This type of evaluation seemed intuitive rather than formal.

Finally, support systems play a large role in the decision to commercialize research. All of the interviewed scientists highlighted the need of appropriate funding as a critical factor to engage in

commercial activities and, more specifically, start-up formation. They specifically referred to the need for capital provided primarily through government funds.

A definition of typologies of academics' views with regard to the various forms of commercial exploitation of research is required to understand the process of academic entrepreneurship. It is important to note that some scientists could fall into more than one category depending on the project and the support system; therefore the definition of types must consider that dynamism.

Table 4 sets out the major categories that were derived from the data coding process illustrated in Table 3. As can be seen from Table 4, the LSAs views about commercialization ranged from being totally opposed to such activities to being actively engaged in the process. Based on our analysis of the views expressed by the LSAs interviewed we suggest that LSAs views can be appropriately categorized as either: non-entrepreneurial; semi-entrepreneurial; pre-entrepreneurial; or entrepreneurial. The definition of these categories is based on the LSA's involvement in entrepreneurial activities. The non-entrepreneurial category encompasses LSAs who are not participating directly in any activity related to any form of commercial exploitation of research. The semi-entrepreneurial category includes LSAs who could not readily be categorized as either for or against commercialization, but who appeared willing to participate in the process at arms-length without taking significant personal risks. The pre-entrepreneurial category involves LSAs who clearly expressed an interest in participating in a USO but had not yet started a company. Finally, the entrepreneurial category involves LSAs who are, or have been, actively involved in establishing and running a USO.

Insert Table 4 about here

A more detailed exploration of the interview data allowed us to expand the four major categories presented in Table 4 into 13 sub-categories, as described below and summarized in Table 5. Within

each category, different factors impacted different approaches to the involvement of the LSA in the various forms of entrepreneurial activities.

Insert Table 5 about here

The Non-Entrepreneurial Category

LSAs categorized as non-entrepreneurial were not participating in any form of research commercialization. A more detailed analysis of their responses suggests that the reasons given for their lack of participation could provide for a further sub-categorization as unaware, uninvolved and antipreneurs.

Unaware: LSAs in this group were focused purely on their research and teaching activities and appeared to be unaware of any potential to commercialize their research findings.

> *"I'm not against it but I'm ill informed. I don't mind that. We have a responsibility as scientists to help our communities... but I would consider it more in the form of publishing…"*

Uninvolved: LSAs in this group were aware of possibilities to commercialize their research findings but did not want to participate. They were not interested.

> *"Many people never give it a thought, either because it is not applicable to the research we do, or maybe because we are not interested."*

Antipreneur: Because of strong personal values/beliefs, the LSAs in this group were opposed to any form of commercial exploitation of their research.

> *"... I also have a problem because my work is funded by government or charities, so unless the money goes back to the public pool, I think it's*

kind of unethical… to make some profits for myself? I think it's almost illegal."

Many of the non entrepreneurial LSAs were conducting basic rather than applied research. However, we do not know if the nature of their research was the cause, or consequence, of their predisposition to not participate in the commercialization of their research.

The Semi-Entrepreneurial Category

LSAs categorized as semi-entrepreneurial, have some form of involvement in an entrepreneurial activity as defined by Brennan et al. (2005) and Philpott et al. (2011), yet cannot be clearly defined as having an interest on a start-up formation. A more detailed analysis of their interview responses, and in particular their preferred approach to participating in commercialization, suggests they can reasonably be allocated to three sub-categories, as follows:

Advisor/consultant: LSAs in this group typically were involved in the individual exploitation of their personal knowledge (at minimal risk) through commercial connections. They typically considered this activity as a complement to their academic income. This sub-category was derived largely from the feedback provided by the TTO managers and the literature, rather than the responses provided by the LSAs. One LSAs referred to the relationship to industry without expanding into the type of relationship. It is likely that this activity is not viewed as the commercialization of research by the LSAs but as a commercialization of knowledge and it rather, falls under the umbrella of a traditional academic activity as reported by Philpott et al. (2011).

Research-funds seeker: LSAs in this group appeared to be involved in exploiting their personal knowledge and commercial connections for the benefit of their research team and to create new knowledge. They typically did not want to benefit personally (financially) and were highly motivated

by altruistic purposes such as "*the advancement of science and developing the next generation of scientists*." They value the relationship they have with industry.

> *"Building up a trustful relationship and not ripping them off is important. Industry has been burnt and has stopped funding."*

Delegator: LSAs in this group were involved in exploiting their personal knowledge but worked jointly with TTO managers to participate at arms-length in the commercialization process. Delegators are not interested in participating in USOs and could be involved at arms length in conversations with companies about licensing agreements. They appear to take little initiative or risk but do expect to benefit personally. They also wish to remain engaged with producing knowledge.

> *"It is not something I want to do full-time, I mean getting into only commercial things…because you become very constrained in what you do."*

The Pre-Entrepreneurial Category

Prior to engaging in a USO, individuals gather information and resources, define a business model, evaluate possible team members, and mentally incubate their idea(s). According to Brennan et al. (2005) nascent research entrepreneurs can be categorized according to their relationship between knowledge creation/production and interest in academic/commercial world. We did not find such differences. All of our interviewees in this category included active researchers in academia who were very focused on creating knowledge, and showed a balanced relationship between academia and the commercial world. Nevertheless, we did find that some researchers showed an interest in learning business skills and appreciated the support of their TTO managers, whereas others showed a different approach: reducing the importance of learning business skills

and expressing an interest in their technology more than in market needs. In our sample, nascent research entrepreneurs could be categorized according to their commitment with respect to learning about the business world and converting this learning into action. This commitment to learning also impacts the relationship between the TTO manager and the LSA:

> *"It depends on the dynamics between the scientist and the TTO manager, so you might have a situation where a scientist has a wonderful idea but doesn't understand why nobody is buying into the idea. The other extreme is the TTO not recognizing the value of an idea." (from a Dual, referring to the pre-entrepreneurial phase)*

Based on the above, the LSAs categorized as pre-entrepreneurial can reasonably be allocated to two sub-categories, as follows:

Nascent: LSAs in this group want to participate directly in the commercialization process and actively seek the required knowledge about the process, the market and business requirements. These LSAs are very appreciative of the involvement and support of TTO managers.

> *"One needs help. People you meet along the way are invaluable."*

> *"We are doing everything and learning, our disclosures, our business plan, our analysis, "S" [a TTO manager] has been very helpful."*

Dreamer: LSAs in this group want to participate in the process but are unwilling to seek the knowledge they require to make it happen. These LSA are not appreciative of the work done by the TTO managers.

"There is a perception that 'this' [commercialisation] is beneath the researcher." (from a TTO manager)

"… then we have the TTO manager telling us what to do when they don't have a clue about the technology."

The Entrepreneurial Category

The entrepreneurial category involves LSAs who are or have been involved in establishing a USO. They are not only shareholders but are also involved in the strategic planning process and participate in the operations of the company as advisors, part-time executives, or full time employees. The level of involvement marks clear differences for entrepreneurial LSAs.

Novice: LSAs in this group have recently started a company and are going through a steep learning curve. They are usually holding their full time academic job or have taken a time limit leave. They are typically excited about the business potential, and reflect upon the differences found in the business world and the academic world.

"The commercial world sees me different if I am a commercial person (I have the CSO[1] hat on) than if I am an academic. Industry has to worry about confidentiality. Academics talk too much and don't keep things confidential."

Dual: LSAs in this group balance their academic and entrepreneurial responsibilities. Company growth is typically slow and stable. In some cases, further paid research is performed by the scientist in the same laboratory and with the same team as that existing before the creation of the company.

[1] CSO= Chief Scientific Officer

Researchers in dual roles exhibit an appreciation for business skills and are very clear about the need for role separation. They also exhibit less appreciation for the role of the TTO manager than those at the novice and nascent subcategories, and feel accountable for the success of the business.

> *"...half of the administration is useless; the other half cannot control what we are doing now. They mess you around... Basically say, it's your job to make this work."*

Oscillator: LSAs in this group have participated in a USO yet they exhibit no enthusiasm nor apparent commitment to work on those ventures. In some cases, they report that the decision to establish a USO was driven by a specific funding mechanism. Support mechanisms have been reported by Audretsch and Weigand (2002) as having a positive impact in commercialization of academic research. However, in the sample we evaluated, some firms were created only as a vehicle to channel funds into business implementation or further development and not into generating sales revenues or developing steps to create a sustainable firm. We specifically identified oscillators as individuals who had not taken clear actions to support the USO in which they had participated but were also not taking actions to close those businesses. Oscillators could reflect upon what they perceived as actions needed to be taken but did not provide an indication that these actions were being taken by any person. On the contrary, LSAs in any other subcategory spoke in first person and expressed a sense of personal accountability.

> *"You need to be focused in a different way. A lot of the work is not experimental, there is a lot of market analysis needed and understanding other people, this is done alongside the lab work."*

"…we tried to get some funding, there was a grant and there was a constraint that a company needed to be formed… The university hasn't got a serious commercialization team."

Serial: LSAs in this group are recurrently starting, growing, and exiting USOs. These individuals have a sense of practicality that is unique -- they balance business and academic life and relate well to others. Serial LSAs see their commitment to a company as a temporary but intense. They do not wish to grow a company but prefer to exit after finding a suitable management team or selling the start up. Compared to the oscillator, the serial LSA feels in control and accountable for the outcomes of the process. They also understand the interdependencies between the many stakeholders in the process and seem to be comfortable with changing their roles: from being intensively committing to a USO for a short period of time, then delegating to a CEO, and finally leaving the USO completely. Serials and duals can state their views about the main constraints on research commercialization with no emotional attachment. On the contrary, oscillators imply that they are not in control or capable of overcoming difficulties. Serial academic entrepreneurs also appreciate the role of TTO managers.

"To make this happen one has to think about what is good enough and not try to gain all of it. I had a good mentor that taught me that. For academics it is complicated [to focus on commercialization] because we don't get raises or research funding unless we publish. Nobody cares about IP or starting a company or doing any other form of commercialization, so you do it because you want to do it."

"… the system doesn't promote activities on commercialization, that is why universities have TTO, and it is best to work with them…

"…but for me, I get bored and I like to move to the next opportunity."

Harvester: LSAs in this group are typically managing a large public corporation in which they were involved as a startup. Unlike oscillators and serials, harvesters focus on continuous improvement and growth for the company they have created. They take accountability to an extreme and have a systematic way of evaluating data for continuous improvement.

> *"It's the journey, and it never stops. It is the whole process not the milestones."*

> *"You have got to love it, be real, wake up in the morning when all is going bad and still feel passionate about it."*

Academic Entrepreneurship as a Process

The analysis of our sample indicates that academics engage into entrepreneurial activities when three conditions are met: the scientist is not opposed to it; the project is promising to the LSA; and there are support mechanisms, specially funding, available.

The majority of LSAs interviewed expressed that did not pursue scientific careers thinking that they would become entrepreneurs; therefore, efforts to commercialize their research were often viewed as distractions from other professional activities such as publishing, researching, and teaching. Our interviews with LSAs also indicated that all of them had been, at some time, in the non-entrepreneurial –unaware- subcategory. An entrepreneurial opportunity was usually provided by a conversation with another person, such as a TTO manager, an industry partner, or even an acquaintance. This sense of awareness in our interviewees triggered three possible outcomes: "I'm against it"; "I'm not against it but I don't want to get involved"; or "I might get involved in the future". These decisions seem to be based on personal beliefs. Some researchers that were in favour of commercialization mentioned the impact of previous experience in commercial activities, either as a child working in a family business; a young adult having part-time work; or a professional contract in a small or large business.

…"then I took a sabbatical and went to work in Japan, in Tokyo, and run B [a company] R & D program, then I never went back." (from a harvester)

Those who did not approve or wanted to participate in commercialization of academic research did not mention any previous direct contact with the business environment and some expressed negative views about it.

"What I dislike is that biotech companies are driving their price of share market, [and therefore] a lot of science, is driven by [these companies'] inner profits." (from an antipreneur)

Personal beliefs are not the only trigger for entrepreneurial activities. LSAs also expressed the need to estimate the potential of a specific project in which they were involved. Our interviewees divagated between two conflicting thoughts: the perception that further development of research of market potential would contradict the curiosity needed to develop further research and their excitement about the possibility of making a change for a large number of people. All of the interviewees expressed the need to create useful science, to "make an impact, to leave a legacy." Although we specifically did not ask for drivers or goals, benefits such as economic development, job creation, investment returns were not mentioned. Furthermore, those involved in entrepreneurial activities did not express an interest in financial rewards but in creating companies or supporting companies that "would be useful to humankind." The only mention of financial rewards was provided by a harvester who had grown the company to a large multimillion dollar public firm that have moved to the USA, after explaining extensively their process of research "… and after you do all this work, it has to pay the rent."

There have been conflicting findings reported in the literature concerning the benefits of support mechanisms established to encourage academic entrepreneurship. For example, Louis et al. (1989) concluded that university policies and structures had little effect on entrepreneurship. Kenney and Patton (2009) suggested that the existing mechanisms disempowered scientists. However, Markman, Gianiodis, and Phan (2008) demonstrated that stronger support mechanisms reduced the chances that scientists would bypass the TTO manager (to the detriment of the university) in their attempts to commercialize their research discoveries. Similarly, Ho and Wilson (2007) concluded that a combination of researcher, research project and the environment (particularly the support mechanisms) were important in the development of USOs. A possible explanation of these differences might be offered by understanding the differences in views as we intended. As evidenced in our study, some researchers value the TTO's work more than others. We believe a better understanding of the drivers for scientists' lack of past participation in the commercialization of research discoveries is critical to the development of more efficient programs and policies. Except for the "research funds seeker" subcategory, all of the interviewees mentioned the need to secure further public funding to help commercialization efforts.

Finally, the exploration of this categorization would not be complete without a timeline evaluation of the path taken by some researchers: the academic entrepreneurship process. Early into our research we realized that such categorization could change with time. Researchers who strongly opposed commercialization would mention that in some cases, they would accept it although they would not be actively involved in it, moving to the 'delegator' subcategory.

A further analysis of some results provided enough information to create entrepreneurial path. In one case, a researcher moved through these subcategories: unaware-nascent-novice-dual-oscillator-antipreneur. This researcher had failed and returned to academia, and, at the time of this study,

expressed strong views opposed to any participation of the researcher in any form of commercialization. Another researcher moved through these subcategories: unaware-advisor-nascent (shifting to work as a TTO manager)-novice-harvester. Table 6 provides a visual representation of these two paths. Understanding categorization as a series of stages could also help provide better support mechanisms. Furthermore, shifts in categories and subcategories could provide a more comprehensive evaluation of policies.

Insert Table 6 about here

A post-evaluation realization of these findings suggests that if there is a category of pre-entrepreneurial activities, there must be a category of post-entrepreneurial activities that needs to be explored.

Conclusions, Implications, Limitations and Further Research

The aim of this study was to provide an understanding of the diverse views held by LSAs concerning the commercialization of research discoveries, and to organize those views in a systematic way that will help our understanding of the process of academic entrepreneurship and be useful in designing, evaluating, and improving support mechanisms to encourage academics interested in commercialization. We adopted a qualitative research methodology based on in-depth interviews with six technology transfer officers and twenty seven LSAs selected using a purposeful, snowball-sampling approach to ensure a diversity of views were obtained. Our analysis of the interview data suggests that, based on their views, LSAs can be categorized as either: non-entrepreneurs, semi-entrepreneurs, pre-entrepreneurs or entrepreneurs. Within these major categories, thirteen sub-categories emerge. In general, the views expressed by the LSAs concerning commercialization appear to be based on a combination of three factors: their personal views about and desired to be involved with

commercialization; the research project's characteristics; and the support mechanisms available. Given this, it is possible that LSAs might form different views about commercialization from one project to the next and based on changes to the available support mechanisms. Furthermore, some of the LSAs interviewed recognized that their views had changed over time.

By establishing a clear typology, institutions and policy makers are able to better understand the academic entrepreneurship process, and evaluate tailored programs. The preliminary information provided by this research supports the notion of entrepreneurship as a process, furthermore, we have identified few categories where the function of the TTO is welcomed and valued and some finer differences between categorizations that could support they work of the TTO. Additionally, some of the objective measurements of commercialization need to be revised considering each specific subcategorization. A classical example would be the number of USO formed. In our work, USOs supported by the different subcategories of academics within the entrepreneurial category are very different. Further exploration on the differences between nascent and dreamers, as well as novices and oscillators is required. Other measurements of success must be re-evaluated considering each subcategory and not the overall commercialization effort, for example, research funds seekers that work with firms that protect their intellectual property via industry secrets will have no interest in patenting and will report zero patents, whilst showing revenues, publications and close relationship with industry. Finally, interaction with commercial activities seems to have an impact in the way LSAs perceive the commercial world. In some cases, early working experience in a non-academic field, were reported as having an impact in the LSA's capacity to interact with industry.

Because of the exploratory nature of this study we chose a sample from one country and one field (life sciences). Future research could usefully expand on our preliminary work by examining the views of academic scientists in other countries and fields. Also, further studies are needed to better

understand the process of academic entrepreneurship and to incorporate into that understanding the relationship between various categories and sub-categories of LSAs.

The role of the entrepreneur has long been recognized as a driving force in the design, establishment and further development of start-ups (Gartner 1988). Yet, within the academic entrepreneurship setting, commercial success can be accomplished without the scientist's participation (Feldman, Colaianni, and Liu 2007). It seems that in academic entrepreneurship it makes more sense to consider the 'changing' role of the LSA in the diverse commercialization options available.

We hope the findings we have presented will be helpful to both policy setters and university administrators in designing systems tailored to the specific needs of the various sub-categories of academic entrepreneurs identified in this study so as to better support researchers interested in commercializing their discoveries.

Bibliography

Audretsch, D. B., J. Weigand, et al. (2002). "The Impact of the SBIR on Creating Entrepreneurial Behaviour." *Economic Development Quaterly,* 16(1): 32-38.

Baldini, N. (2009). "Implementing Bayh & Dole-Like Laws: Faculty Problems and their Impact on University Patenting Activity," *Research Policy,* 38(8), 1217-1224.

Brennan, M., A. P. Wall, and P. McGowan (2005). "Academic Entrepreneurship: Assessing Preferences in Nascent Entrepreneurs," *Journal of Small Business and Enterprise Development,* 12(3), 307-322.

Burnard, P. (1991). "A method of analysing interview transcripts in qualitative research," *Nurse Education Today,* 11(6), 461-466.

Davidsson, P. and B. Honig (2003). "The role of social and human capital among nascent entrepreneurs," *Journal of Business Venturing,* 18(3), 301-331.

Dickson, K., Coles, A. and Smith, H. (1998). "Science in the Market Place: the Role of the Scientific Entrepreneur." in During, W. and Oakey, R (eds), *New Technology-based Firms in the 1990s,* Paul Chapman, London, pp. 27-37.

Etzkowitz, H. and L. Leytesdorff (1997), *Universities in the Global Economy: A Triple Helix of Academic-industry-government Relation*, Croom Helm: London.

Feldman, M., A. Colaianni, and C. K. Liu (2007). "Lessons from the Commercialization of the Cohen-Boyer Patents: The Stanford University Licensing Program" in *In Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices* Ed. R. M. A Krattiger, L Nelsen, et al., MIHR: Oxford, U.K., and PIPRA: Davis, U.S.A.

Franklin, S. J., M. Wright, and A. Lockett (2001). "Academic and Surrogate Entrepreneurs in University Spin-Out Companies," *Journal of Technology Transfer,* 26(1), 127-141.

Gartner, W. B. (1988). "Who is the Entrepreneur? is the Wrong Question," *American Journal of Small Business,* 12(1), 11-32.

Ho, M. W. Y. and M. G. Wilson (2007). "Knowldege Resources for University Spinoffs: The Role of the Academic Entrepreneur," *Academy of Management Proceedings*, 1-6.

Jain, S., G. George, and M. Maltarich (2009). "Academics or Entrepreneurs? Investigating Role Identity Modification of University Scientists Involved in Commercialization Activity," *Research Policy,* 38(6), 922-935.

Jensen, R. and M. Thursby (2001). "Proofs and Prototypes for Sale: The Licensing of University Inventions " *The American Economic Review,* 91(1), 240-259.

Kenney, M. and D. Patton (2009). "Reconsidering the Bayh-Dole Act and the Current University Invention Ownership Model," *Research Policy,* 38(9), 1407-1422

Liao, J. and H. Welsch (2008). "Patterns of venture gestation process: Exploring the differences between tech and non-tech nascent entrepreneurs," *The Journal of High Technology Management Research,* 19(2), 103-113.

Louis, K. S., D. Blumenthal, M. E. Gluck, and M. A. Stoto (1989). "Entrepreneurs in Academe: An Exploration of Behaviors Among Life Scientists," *Administrative Science Quarterly,* 34(1), 110-131.

Markman, G. D., P. T. Gianiodis, and P. H. Phan (2008). "Full-Time Faculty or Part-Time Entrepreneurs," *IEEE Transactions on Engineering Management,* 55(1), 29-36.

Mowery, D. C. and B. N. Sampat (2001). "The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Model of other OECD Governments?," *Journal of Technology Transfer,* 30(1/2), 115-127.

Nelson, R. R. (2004). "The Market Economy, and the Scientific Commons," *Research Policy,* 33(3), 455-471.

Nicolaou, N. and S. Birley (2003). "Academic Networks in a Trichotomous Categorisation of University Spinouts," *Journal of Business Venturing,* 18(3), 333-359.

Philpott, K., L. Dooley, C. O'Reilly, and G. Lupton (2011). "The Entrepreneurial University: Examining the Underlaying Academic Tensions," *Technovation,* 31(1), 161-170.

Sanz-Velasco, S. A. and R. Saemundsson (2008). "Entrepreneurial Learning in Academic Spin-Offs: a Business Model Perspective," *International Journal of Entrepreneurship and Innovation Management,* 8(1), 15-35.

Schumpeter, J. A. (1947). "The Creative Response in Economic History," *The Journal of Economic History,* 7(2), 149-159.

Shane, S. and S. Venkatamaran (2000). "The Promise of Entrepreneurship as a Field of Research," *Academy of Management Review,* 25(1), 217-226.

Shane, S. A. and K. T. Ulrich (2004). "Technological Innovation, Product Development, and Entrepreneurship in Management Science," *Management Science,* 50(2), 133-144.

Siegel, D. S., J. C. Thursby, M. G. Thursby, and A. A. Ziedonis (2001). "Organizational Issues in University-Industry Technology Transfer: An Overview of the Symposium Issue " *The Journal of Technology Transfer,* 26(1/2), 5-11.

Slaughter, S. and L. Leslie (1997), *Academic Capitalism: Politics, Policies, and the Entrepreneurial University*, The Johns Hopkins University Press: Baltimore.

Toole, A. A. and D. Czarnitzki (2007). "Biomedical Academic Entrepreneurship Through the SBIR Program," *Journal of Economic Behavior & Organization,* 63(4), 716-738.

Vohora, A., M. Wright, and A. Lockett (2004). "Critical Junctures in the Development of University High-Tech Spinout Companies," *Research Policy,* 33(1), 147-175.

Wright, M., B. Clarysse, A. Lockett, and M. Knockaert (2008). "Mid-range Universities' Linkages with Industry: Knowledge Types and the Role of Intermediaries," *Research Policy,* 37(8), 1205-1223.

Table 1

Entrepreneurial Activities within Universities

	Louis '89	Brennan '05	Wright '08	Philpott '11
Public Research	√	√		√
Consulting	√	√	√	√
Private Research	√	√	√	√
IP Management	√	√	√	√
Spinouts	√	√	√	√
Spinnin		√		
Grad Mobility			√	
Publishing				√
Cert Education				√
Industry Training				√
Tech Parks				√

Table 2

Sample Demographics

Gender	Age	Years in academia	Publications	Patents	USOs	Licenses
male	30	7	25	6	1	12
male	30	10	22	0	0	0
male	40	14	49	0	0	0
male	40	20	40	9	1	0
male	40	20	80	0	0	1
male	40	20	60	10	1	0
male	40	20	90	4	0	0
male	40	23	80	2	1	0
male	50	32	150	1	0	0
male	50	15	150	20	2	0
male	50	31	500	11	1	0
female	50	30	30	0	0	0
female	50	27	60	5	5	2
female	50	30	100	4	2	30
male	50	25	100	0	0	0
male	50	19	100	2	1*	0
male	50	26	200	5	2	1
male	50	28	100	0	2	4
male	60	35	600	12	1	1
male	60	40	110	0	0	0
male	60	12	130	2	1	0
male	60	25	300	70	2	5
male	60	33	70	0	0	0
female	60	30	150	0	0	0
male	60	18	150	12	1	0
male	60	44	150	0	0	0
male	70	38	1800	0	0	0

* USO in formation.

Table 3

Example of Coding and Categorizing Interview Responses

Excerpt from interview	Notes about the interviewee	Coding	Categorization
I have a problem with it [commercialization] because my work is funded by government, or charities, so unless the money goes back to the public pool I think it's kind of unethical … to make profits for myself? I think it's almost illegal.	Highly emotional, passionate, value driven.	Benefits from commercialization are unclear. No intent to profit for self or others.	Non-entrepreneurial, anti-entrepreneurial.
In most cases [commercialization], it's got to be a positive. So I certainly think that people working in universities should be endeavoring to make whatever they discover available to other people. Now that doesn't necessarily mean commercializing it.	Non-emotional, neutral.	Changing views about commercialization, accepting it as a means to an end, not an end in itself.	Semi-entrepreneurial.
Well I think it's inevitable, perhaps not for people of my generation. I never thought about it until 10-20 years ago, probably because of the nature of my research.	Disempowered, accepting with sadness.	I accept it for others, but I'm not interested. We are being pushed into commercialization.	Semi-entrepreneurial.
It [commercialization] is going to bring a lot of money to supplement your research funds. The TTO manager is helping us immensely. Then we are going to spin out a company at the university and license part of our IP and then we will be bought out.	Positive, passionate, enthusiastic.	Means to an end. We need more funding. I am interested, I am participating and I welcome and approve the help of the TTO manager.	An academic entrepreneur but with a need for justification.
The system itself doesn't promote it. You the scientist do it all at your own risk. It is a distraction and nobody helps you. You are an academic if you publish, there are no rewards for licensing IP, only for publications.	Calm, reflective, mature.	There is no support system or encouragement. I can do it by myself. I have learnt to play both roles.	An academic entrepreneur with a sense of independence.

[Commercialization] It's a good idea. At university there has to be a balance between basic fundamental research that can be applied to something that is useful to the community. Commercialization is a way to make that happen. There is no other way to do it because it is so expensive.	Calm, reflective, wise.	I approve of commercialization, I participate in it.	An academic entrepreneur with a practical approach.
I think that whenever research results are clearly applicable to advancing human kind in some way they should be commercialized. Without commercialization, research results remain an academic curiosity in the lab.	Calm, focused, contented.	I approve of commercialization.	An academic entrepreneur with a practical approach.

Table 4

Categorization of LSAs Based on the Views they Expressed in the Interviews

Non-entrepreneurial	Semi-entrepreneurial	Pre-entrepreneurial	Entrepreneurial
I completely disagree, it is a necessary evil, it lowers the quality of research, it is not related to my area. Have no role to play, I don't mind if someone else does it, I understand younger scientists need the funds for research. Being pushed by financial needs, it is almost immoral to patent research, it contradicts publications, sets a bad example for students. IP is a nonsense.	Only if it is not distracting but complementary, could bring in more funds to the university, must not be the primary function, it could work to help fund research. Only at arms-length, such as non-tenured scientists or younger staff, someone else should do it, should be used to complement science.	Then we are going to spin out a company at the university and license part of our IP and then maybe we will be bought out. I'm very excited about the prospects. We have a tremendous opportunity to commercialize our research but the TTO managers don't recognize the value of our idea.	Forming a USO is a great idea, it helps economic development. Helps fund further research, also benefits scientists, but is very hard. After starting the USO we realized we were ill prepared. It provides a good balance, gets us out of our Ivory Tower, makes us feel useful to society. We started the USO despite inadequate support.

Table 5

Expanding the Major Entrepreneurial Categories into Sub-categories

Categories/sub-categories of LSAs			
Non-entrepreneurial	Semi-entrepreneurial	Pre-entrepreneurial	Entrepreneurial
Unaware: I don't know there is a possibility.	Advisor: I complement my income by helping companies	Nascent: I want to learn how to create a USO	Novice: I'm building a fantastic company. This is a lot of fun. I am learning a lot.
Uninvolved: I know there is a possibility but I prefer not to participate, another person can do it.	Research funds seeker: I can make useful research and have funds for my team	Dreamer: Starting up is easy. I don't need business skills	Dual: I can be both an academic and an entrepreneur but I'm not the CEO. I need to keep roles separated.
Antipreneur: I know there is a possibility but I am strongly against it.	Delegator: I can help the TTO manager in commercialization but my focus is on research and teaching		Serial: I can be both an academic and a CEO for a short period of time, then I leave the company.
			Oscillator: I can be both an academic and a CEO of a struggling company
			Harvester: I have moved out of academia to focus on starting and growing a company

Table 6

Examples of Entrepreneurial Paths

Categories/sub-categories of LSAs			
Non-entrepreneurial	Semi-entrepreneurial	Pre-entrepreneurial	Entrepreneurial