The Open Innovation Imperative: Perspectives on Success From Faculty Entrepreneurs

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The Open Innovation Imperative: Perspectives on Success From Faculty Entrepreneurs[1]

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To Dad, whose attitude, curiosity, dedication to excellence, and friendship has been a true inspiration in life. And to Jennifer, my best friend and fellow explorer, who helped me rediscover how to live and love.

Abstract of Dissertation

The Open Innovation Imperative: Perspectives on Success From Faculty Entrepreneurs

University spinoffs are an important vehicle for the dissemination of new knowledge – and have the potential to generate jobs and economic growth. Despite their importance, little research exists on how, from the perspective of faculty entrepreneurs, spinoff success is defined – and the factors responsible for that success. Given the nascent nature of the literature and lack of data regarding university spinoffs, this dissertation employs a sequential exploratory strategy to understand and determine success factors for university spinoffs. The findings indicate that commercialization is a distinguishing characteristic of initial spinoff success and that a multitude of factors such as financial resources and the technology licensing process are responsible for that success. Using logit regression, the quantitative phase yields several significant predictors of commercialization including venture capital, multiple and external licenses, outside management, joint ventures with other companies, previous faculty consulting experience, and – surprisingly – a negative relationship to post-spinoff services provided by universities.

These results strongly support an open innovation approach for spinoff success and have important implications for public policy. The results will be of especial interest to university leaders seeking to enhance the role of their institutions in economic development and for state and federal policymakers when developing new policies and programs to improve economic growth and entrepreneurship. Finally, the dissertation makes a modest but important contribution to the evolving Knowledge Spillover Theory of Entrepreneurship (KSTE).

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CHAPTER ONE: INTRODUCTION[2]

We live in a rapidly changing world where the creation, dissemination, and commercialization of new knowledge into innovative products and services are critical to economic growth and prosperity. Public research universities are a primary source of new knowledge and receive billions of dollars from federal and state governments to support their research mission. New knowledge generated in universities is disseminated into society through a number of disparate pathways, including publication, student training, extension, informal faculty relationships, technology licensing, and academic entrepreneurship, among others. The latter pathway – academic entrepreneurship – is the establishment of new companies based on the research of university faculty; it is unique, important, not well understood, and the topic of this paper.

At least since the mid-nineteenth century American policymakers have sought to encourage the dissemination of new knowledge from universities. For example, the Hatch Act of 1887 and Smith-Lever Act of 1914 created agriculture experiment stations and the Cooperative Extension Service, respectively, to encourage the dissemination and application of new knowledge from newly created state Land-grant universities

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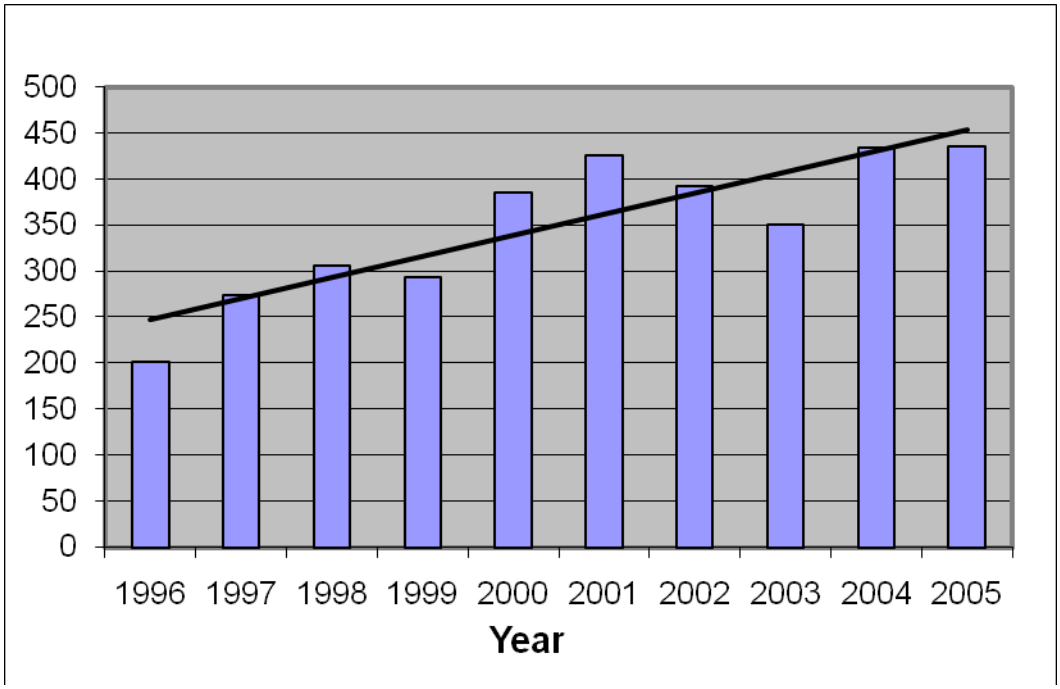
(McDowell, 2001).[3] More recently, the Universities and Small Business Patent Procedures Act of 1980 – otherwise known as the Bayh-Dole Act – was passed to encourage universities and other non-profits to disseminate the results of their research.

Prior to the passage of Bayh-Dole, the government owned all intellectual property arising from federally sponsored university research. While universities petitioned the federal government for ownership of the intellectual property, such cases were infrequent

FIGURE 1: TOTAL NUMBER OF UNIVERSITY SPINOFFS PER YEAR (1996-2005) ACCORDING TO AUTM DATA



Source: AUTM STATT database.
NOTE: Slope of the trend line is y = 22.958x + 224.13. The slope implies that for each additional year X (beginning in 1996), approximately 23 additional spinoffs have been established.

[3]The Morrill Act of 1862 gave federal lands to states to sell in order to establish universities dedicated to the "agricultural and industrial arts." The Hatch and Smith-Lever Acts are regarded were regarded as "improvements" to the Morrill Act to improve the applicability and impact of these institutions. See McDowell (2001) for more information.

and handled on a case-by-case basis. Ownership and licensing regulations differed by funding agency and were, at best, onerous. The result was that government sponsored university research typically remained "on the shelf" and was rarely disseminated outside the university for economic or social uses.[4]

The Bayh-Dole Act encourages knowledge dissemination by giving universities title to intellectual property (IP) resulting from federally funded research within their institutions and by harmonizing patent policies among federal mission agencies. Since the passage of Bayh-Dole in 1980, knowledge dissemination vis-à-vis the patenting and licensing of university IP has grown dramatically. Furthermore, the number of entrepreneurial ventures established using university intellectual property – companies that Shane (2004) terms *university spinoffs* – has also grown. While figure 1 above only represents spinoffs that have intellectual property agreements with their respective universities, it nonetheless represents the growth of academic entrepreneurship.

1.1 Academic Entrepreneurship

Academic entrepreneurship – the act of establishing a spinoff by a university faculty member – is not only a pathway for knowledge dissemination, it is also an important but little-studied aspect of entrepreneurship. Research shows that entrepreneurship writ large is critical to national and regional economic development (Carree et al., 1999) and for its role in job creation (Birch, 1981). Furthermore, the microeconomic process of firm creation and failure – what Audretsch (1995) calls

[4]For an in-depth discussion of Bayh-Dole and its resultant impacts, see Mowery et al. (2004).

turbulence – is a critical catalyst for innovation.[5] New firms generate knowledge and while a few succeed and commercialize their technologies, knowledge externalities from those that fail also contribute to the evolutionary process of technology development (Utterback, 1994).

Academic entrepreneurship is an intriguing topic of study given its importance to knowledge disseminations and dissimilarity to other forms of new firm creation. The seed corn for academic entrepreneurship, embodied in the university spinoff, is research conducted by university faculty members. Unlike most research conducted in the private sector, the main goal of university research is the production of new academic knowledge, not necessarily the creation of new commercially viable technologies (Shane, 2004). Furthermore, the traditional mission of the university is teaching, basic research, and knowledge dissemination; thus, there are many structural and cultural barriers to the commercialization of new technology (Clarysse et al., 2007; Bercovitz and Feldman, 2004; Chiesa and Piccaluga, 2004; Kenney and Goe, 2004; Markman et al., 2004; Slaughter and Rhodes, 2004; Siegel et al., 2003; Franklin et al., 2001; Samson and Gurdon, 1993).

1.2 Benefits of Academic Entrepreneurship

Despite these challenges, recent research shows that academic entrepreneurship is an important phenomenon worthy of additional inquiry – and of increasing interest to policymakers. First, most university research is embryonic and requires additional

[5]Audretsch's discussion of turbulence draws from Schumpeter's (1942) notion of "creative destruction" by which radical innovation transforms economies. In his vision of capitalism, Schumpeter saw that the entry of innovative entrepreneurs in the market sustained long-term economic growth, even as it destroyed the monopoly positions of established companies. This remains true today; see Christensen (2001) for contemporary examples.

development. Given that large companies often find little interest in undeveloped university technology, spinoffs offer university faculty an alternative pathway for disseminating and commercializing their research (Shane, 2004; Lowe, 2002). Spinoffs are therefore an important vehicle for developing risky, relatively radical technologies, particularly in dynamic, knowledge-intensive industries such as biotechnology and computer software (Shane, 2004; Lowe, 2002; Audretsch, 1995).

Second, once university spinoffs have been established, they have a very high propensity for survival. For example, of the 3,376 university spin-offs that were established in the United States from 1980 to 2000, 68 percent remained operational in 2001 (Pressman, 2002), a finding that has been supported by research at individual universities (Lowe, 2002) and within other countries (Mustar, 1997). University spinoffs also have a high likelihood of attracting early-stage finance such as angel or venture capital (Shane, 2004) or of going public (Goldfarb and Henrekson, 2003).

Finally, knowledge spillovers tend to be geographically bounded within the region where knowledge is created (Audretsch and Feldman, 1996). As a vehicle for new knowledge, academic entrepreneurship is a local phenomenon and therefore important to regions where spinoffs are established (Shane, 2004; Lowe 2002). Pressman (2002) reports that 80 percent of all university spinoffs are located in the same state as the university from which they were spun off. Consequently, spinoffs are an important driver of regional economic development and may serve as catalysts for the formation of geographic clusters of new firms (Carree et al., 1999; Lowe, 2002). This stands in contrast to technology licensing where the majority of licensees come from outside the state (Tornatzky et al., 1995).

1.3 Opportunities in the Literature

Scholars have claimed that research inquiry of academic entrepreneurship is "virtually non-existent" (Shane, 2004). Others argue that the literature on university spinoffs is quite robust, especially when embedded in the Resource Based View (RBV) of the firm (Lockett and Wright, 2005; Heirman and Clarysse, 2004; Penrose, 1959). These RBV-based studies may provide insights with regard to the similarities of university spinoffs relative to other new firm ventures. Yet they provide little insight as to why university spinoffs are theoretically unique. This paper employs the fledgling Knowledge Spillover Theory of Entrepreneurship (KSTE) in hopes that it will provide a useful theoretical lens by which to explore academic entrepreneurship in the context of knowledge dissemination (Audretsch, 1995).

In any case, much work remains to understand the factors that explain the transition of university research into IP, the formation of spinoff companies around that IP, and the processes surrounding spinoff growth and development (Shane, 2004; Acs and Audretsch, 2003). The literature is limited with regard to how, compared to other firm founders, academic entrepreneurs define success and the factors that influence that success (Phan and Siegel, 2006; Shane, 2004). Finally, additional scholarly research is needed in order to better understand the conditions and policy levers that promote and support academic entrepreneurship (Phan and Siegel, 2006; Hart, 2003).

1.4 Policy Interest

Federal, state, and university leaders are seeking ways during these tough economic times to encourage prosperity and job creation. Many are convinced that university spinoffs hold promise. High-profile spinoff successes such as Lycos from Carnegie Mellon University and Silicon Graphics and Genentech from Stanford University have policymakers interested in ways to encourage and support academic entrepreneurship. Specifically, policymakers seek "best practices…evidence on specific organizational practices related to incentives, strategic objectives, and measurement and monitoring mechanisms, which might enhance technology transfer effectiveness" (Phan and Siegel, 2006).

Unfortunately, due to a relatively hands-off relationship with universities systems and the undeveloped nature of the literature, policymakers lack the capacity and tools to understand university governance and culture, academic entrepreneurship, and their relationship to public policy and programs (National Governors Association, 2007a; Hart, 2003). At best, a lack of understanding of these issues may result in policies that do not best support academic entrepreneurship; at worst, it may result in policy and programs that discourage or weaken the efforts of academic entrepreneurs. Therefore, this paper not only seeks to contribute to the literature but also provide findings relevant to policymakers at multiple levels of government and university leadership – and aspiring and current academic entrepreneurs.

This paper will explore the following research questions:

- **How do academic entrepreneurs – faculty who have started a university spinoff – define success?**

- **What are the main factors that contribute to- or detract from the success of the university spinoff?**
- **How do university, local, state, and federal state policies impact the success of university spinoffs?**

The following chapters address the questions above through a methodological scholarly inquiry. The next chapter (Two) provides a detailed review of the academic literature relating to spinoffs, how success is defined within spinoffs, and factors responsible for that success. Chapter Three delves into the theories underpinning academic entrepreneurship, including the emergent KSTE. Chapter Four broadly outlines the study methodology, Sequential Exploratory Strategy (Creswell, 2003), which reflects the undeveloped state of the literature, unique nature of university spinoffs, and lack of supporting data. The fifth chapter summarizes the first, qualitative phase of the research, which includes a series of interviews designed to inductively understand how academic entrepreneurs define success and the factors they see responsible for that success. Chapter Six reviews the second, quantitative phase of the research designed to empirically test the strength of the first-phase findings among a larger sample of academic entrepreneurs. The seventh and final chapter provides a discussion of the research findings, their relevance to public policy, and offers suggestions for future research.

CHAPTER TWO: LITERATURE REVIEW

Before the research questions can be addressed, the existing scholarly and theoretical foundations of academic entrepreneurship must be established. Academic entrepreneurship is typically a subset of research on the role and governance of universities, technology transfer, entrepreneurship, and regional economic development. Academic entrepreneurship is included and indeed crosses over a wide range of academic disciplines including management, economics, sociology, psychology, and organizational behavior, among others.

Research on the phenomenon of academic entrepreneurship *per se* is limited mostly to the *number* of spinoffs established out of individual universities and the macro determinants thereof. Efforts to analyze spinoff impact, individual characteristics, and the factors that contribute to spinoff success have been severely limited by the scarcity of data, including the lack of a comprehensive contact database. Nonetheless, the section below encapsulates the findings of more than 150 publications related, at times only tangentially, to academic entrepreneurship.

2.1 Academic Entrepreneurship: Research Subset

Academic entrepreneurship is often included in the broad conceptual context of Academic Capitalism (Slaughter et al., 2004; 1999) or the Triple Helix (Eztkowitz, 2003), paradigms that emphasize the role of universities in a knowledge-based economy. Other scholars term the role of universities in the economy as "university entrepreneurship" and include patenting, licensing, incubator facilities, science parks, and the creation of new firms among their economic contributions (Rothaermel et al., 2007). Academic entrepreneurship is most commonly framed within the literature as part of a narrow, more linear technology transfer model. In this model, disclosure, patenting, and licensing – a process managed by a technology transfer office (or TTO) – precede spinoff formation (Phan and Siegel, 2006).

Comprehensive reviews of the technology transfer literature find that scholarly interest in its various subfields, including academic entrepreneurship, has grown rapidly over the past 10 years (Rothaermel et al., 2007; Phan and Siegel, 2006). The growth in the literature corresponds with the aforementioned interest among policymakers regarding the contributions of universities to economic development (National Governors Association, 2007a, 2007b). Unfortunately, the number of studies that specifically examine success factors for academic entrepreneurship is small and limited to spinoffs from 'prestigious' universities or other countries (Shane, 2004; Mustar, 1997).

2.2 Measures of Success for University Spinoffs

Very few studies examine how academic entrepreneurs define success (see Table 1 for a summary of these studies); researchers often assume various proxies for spinoff

TABLE 1: SUMMARY OF LITERATURE: DEFINITIONS OF SPINOFF SUCCESS

AUTHOR	SUCCESS MEASURE
Rothaermel and Thursby (2005); Leitch and Harrison (2005); Shane (2004); Shane and Stuart (2002)	Whether or not the spinoff continues to exists.
Blair and Hitchens (1998)	Productivity measures: sales per employee
Samson and Gurdon (1993)	View of the entrepreneur and spinoff profitability
Wright et al. (2006); Lockett et al. (2005); Zucker et al. (2002); Lockett et al. (2002); Shane and Stewart (2002)	Whether or not the spinoff attract early-stage finance, especially venture capital funding
Shane (2004); Goldfarb and Henrekson (2003)	Whether or not the spinoff has an initial public offering (IPO)
Zucker et al. (2002)	Number of patents and scientific papers
Roberts (1991)	Index based on average sales growth and projections, how long the company has been in business, and its profitability
Vohora et al. (2004)	Achieved by passing through a series of iterative, non-linear "critical junctures"; specific resources and capabilities they must be acquire in order to pass to the subsequent phase
Meyer (2003)	Defined in terms of the prospect to pursue their academic agenda through their entrepreneurial activities, not spinoff growth or profits
O'Gorman (2008)	Defined in terms of how well entrepreneurial activities bolsters their academic career through peer recognition and traditional university rewards

success. Rothaermel and Thursby (2005); Leitch and Harrison (2005); Shane (2004); and Shane and Stuart (2002) use a basic measure for spinoff success: whether or not a firm continues to exist. Blair and Hitchens (1998) incorporate productivity measures such as sales per employee to represent spinoff success while Samson and Gurdon (1993)

incorporate both the view of the entrepreneur as well as profitability in their definition. Other studies have used a firm's ability to attract early-stage finance, specifically venture capital, as an indicator of success (Wright et al., 2006; Lockett and Wright, 2005; Zucker et al., 2002; Lockett et al., 2002; Shane and Stewart, 2002). Shane (2004) and Goldfarb and Henrekson (2003) measure success by whether or not a spinoff had an initial public offering (IPO). Zucker et al. (2002) use the number of patents and scientific papers as a measure of success for a university spinoff. Roberts (1991) chooses to proxy the success of high technology spinoffs, including university spinoffs, with an index based on average sales growth – and projections, how long the company has been in business, and its relative profitability.

In one of the few explorations of the spinoff process, Vohora et al. (2004) suggest that success is achieved during an iterative, non-linear process. During this process spinoffs must pass through a series of "critical junctures" in terms of the resources and capabilities they must acquire to progress to the next phase. They identify four different critical junctures including:

- Opportunity recognition, which includes the disclosure process;
- Entrepreneurial commitment, which includes the decision to establish a firm;
- Attaining credibility, which may be preceded by obtaining financing, technology demonstration, and commercialization; and
- Achieving sustainable returns within their respective markets.

Critical junctures arise because the venture requires new configurations of resources, capabilities, and network ties if it is to progress to the next phase of development.

Limited research suggests that success in academic entrepreneurship may look very different than success among other nonacademic spinoffs and startups. Meyer (2003) suggests that "entrepreneurial academics" in public sector organizations may not define success by spinoff growth or profits but rather by the prospect of finding other

avenues to pursue their academic research agenda, especially if they remain a university faculty member. O'Gorman et al. (2008) finds that university faculty members were less interested in the financial success of a spinoff and more strongly tied the "benefits of commercialization" to their role as academics: recognition by their peers and more traditional university reward structures.

Limited research also examines qualitative differences in the relative success of university spinoffs: the so-called "living dead" phenomenon. Roberts (1991) finds that many of the firms in his sample, which includes university spinoffs, have survived for years with little or no sales or profitability. Reitan (1997) laments the lack of research that examines the differences between survival and success and finds that a large number of firms in his sample, including but not limited to university spinoffs, were not profitable despite their high rate of survival.

2.3.1 Factors that Influence the Success of University Spinoffs

Researchers have found a number of factors that influence the success of university spinoffs (See Table 2 for a summary). These characteristics include factors related to the academic entrepreneur, the home university, development funding, business decisions and factors, geography, and public policy (Rothaermel, 2007). The sections below review the literature related to each categorical factor.

Characteristics of the University Entrepreneur

For decades, studies have attempted to determine what personal characteristics "make" a person an entrepreneur. We know that high-technology entrepreneurs generally

have an educational background in science or engineering, are relatively young, and typically have industry experience (Roberts 1991). Beyond these basic nuggets, the research has not provided a clear understanding of these characteristics, much less predict who will become an entrepreneur and who will not (Gartner, 1986; 1991).

In what little comparative research exists, university entrepreneurs are older and more established, but have far lower spinoff rates compared to non-university entrepreneurs (Roberts, 1991). Another prevalent determinant of start-up activity is the high need among entrepreneurs for achievement. Roberts (1991) finds that this may not be the case for university entrepreneurs for whom entrepreneurship may be a way of pursuing their academic goals with little consideration for commercial objectives. Furthermore, many if not most academic entrepreneurs wish to retain their academic positions within their university contrasting with other types of spinoffs; entrepreneurs who spinoff from a company typically sever their affiliation with the incubating institution (O'Gorman et al., 2008; Johansson et al., 2005, Clarysse and Moray, 2004; Samson and Gurdon, 1993).

Commercial Experience

Beyond personal characteristics, experience working with industry impacts the ability of entrepreneurs to recognize commercial value in new knowledge and therefore recognize entrepreneurial opportunities (Vohora et al., 2004; Nerkar and Shane, 2003). Previous experience working within industry or commercializing technology may be a prerequisite for commercial success as an academic entrepreneur (O'Gorman et al., 2008). For example, Zahra et al. (2007) find that university spinoffs lack the human entrepreneurial and social capital necessary to develop an awareness of market

opportunities that can offset the limitations of their experience. Furthermore, O'Gorman et al. (2008) finds that industry often does not understand the potential value or benefit of university research exacerbating the "information gap" between researchers and industry.

Murray (2004) finds that the attitudes of university faculty are strongly shaped by the direct experience built up though a career in academic science, which typically does not include industry interaction. When faculty spinoff a company, they typically lack the business acumen and experience needed for successful spinoff and focus mainly on the scientific and technical aspects of innovation (Nicolau and Birley, 2003; Franklin et al., 2001; and Radosevich, 1995). This lies in sharp contrast to the focus of 'full time' professional managers who likely focus their efforts on founding and managing their company, including but not limited to the technical aspects (O'Gorman et al. 2008).

The source of academic research funding, whether or not it comes from industry, may also matter. Dietz and Bozeman (2005) find, for example, that scientists who receive government grants have higher publication rates relative to their peers and a lower likelihood of patenting their invention. Conversely, university scientists that have industry experience, have received industry funding, or work on translational or development projects, have a higher propensity to patent, license, consult, and establish a company (O'Gorman et al., 2008; Dietz and Bozeman, 2005; Gulbrandsen and Smeby, 2005; Roberts, 1991). Audretsch et al. (2005) find that the participation of scientists in a broad array of activities with industry, such as co-publication, co-patenting, and serving on company or scientific advisory boards, leads to higher levels of commercialization.

TABLE 2: SUMMARY OF LITERATURE: FACTORS THAT INFLUENCE SPINOFF SUCCESS

Characteristics of the University Entrepreneur	
Roberts (1991)	High–technology entrepreneurs have educational background in science or engineering, young, and have industry experience; high need for achievement
O'Gorman et al. (2008); Johansson et al. (2005); Clarysse and Moray (2004); Samson and Gurdon (1993)	Successful spinoff entrepreneurs typically sever ties with the incubating institution
Commercial Experience	
Vohora et al. (2004); Nekar and Shane (2003)	Experience working with industry improves an entrepreneur's ability to recognize "entrepreneurial opportunities"
O'Gorman et al. (2008); Audretsch et al. (2005)	Previous experience working within industry, including co-publication, co-patenting, and serving on company scientific advisory boards may be prerequisite for commercialization success as an entrepreneur
Murray (2004)	Faculty attitudes are shaped by career in academic sciences that typically does not include industry experience
Nicolau and Birley (2003); Franklin et al. (2001); Radosevich (1995)	When faculty spinoff a company they typically lack the business acumen needed for successful spinoff and instead focus on scientific aspects of the enterprise
O'Gorman et al. (2008); Dietz and Bozeman (2005); Gulbrandsen and Smeby (2005); Roberts (1991)	University scientists with industry experiences have a higher propensity to patent, license, consult, and establish a company
Highly Productive Faculty	
Shane (2004); Jensen and Thursby (2001); Franklin et al. (2001)	Faculty involvement is critical to the continuing development of university technology, including its scientific basis and application
Agrawal (2002)	Faculty involvement improves the performance of technology licenses
DiGreggorio and Shane (2003); Louis et al (2001); Zucker et al. (1998)	Higher intellectual capital "rates" (or "intellectual eminence") within specific universities lead to greater numbers of university spinoffs

Meyer (2006)	Nano-scientists who patent appear to outperform non-inventing peers in terms of publication counts and citation frequency
Zucker et al. (2002; 2001)	"Star" scientists enhance the performance of U.S. biotech firms in terms of patents granted, number of products in development, and the number of products on the market
Social Networks External to the University	
Martinelli et al. (2008); Landry et al. (2002)	Informal networks often facilitate more formal relationships that facilitate spinoff (and licensing arrangements with established firms)
Rothaermel et al. (2007); Johansson et al. (2005); Murray (2004)	The quality depth, and diversity of a faculty member's non-academic, professional network is important to the success of their spinoff
Grandi and Grimaldi (2003)	Faculty relations with the non-academic, professional world help mediate how well technology is transferred to a spinoff
O'Gorman et al. (2008)	Networks helped academic entrepreneurs understand the opportunities for applying and commercializing their expertise in retrieval software – and help the entrepreneur develop a business plan, raise early-stage finance, and develop links with potential customers
Rappert et al. (1999)	Informal networks are important to the commercialization success of a spinoff
University Factors: Academic Culture	
Slaughter and Rhoades (2004); Franklin et al. (2001); Chiesa and Piccaluga (2004); Samson and Gurdon (1993)	"Traditional" norms, attitudes, and institutional rules of academia often clash with a more recent focus on commercialization outcomes
Bercovitz and Feldman (2004)	Faculty members have difficulty combining commercial and academic goals
Samson and Gurdon (1993)	Academic culture is a key inhibitor to spinoff formation and success
Etzkowitz (2003); Jacob et al. (2003); Clarke (1998)	Universities must transform their mission and culture to encourage technology transfer and entrepreneurship if they are to promote better commercial outcomes

Shane (2004); Bauer (2001); Feldman and Desrochers (2001); Hsu and Berstein (1997); and Roberts (1991)	Entrepreneurial culture, social norms, and role models are critical to the formation of university spinoffs
University Policy	
O'Gorman et al. (2008); Siegel et al. (2003)	Faculty reward systems influence technology transfer; faculty members take traditional academic awards into account when considering the payoff of commercialization activity
Markman et al. (2004); Colyvas et al. (2002)	Financial incentives play little or no role in motivating faculty to commercialize their research compared to traditional academic awards and the prospect of additional federal R&D grants
Bekkers et al. (2006); Kenney and Goe (2004); Shane (2004); Tornatzky et al. (1995)	Leave of absence and other personnel policies help faculty become involved in commercialization activities including spinoff
Golub (2003)	Spinoff activity increased at New York University when restrictions were removed on the use of facilities by spinoff companies
Renault (2006); Shane (2004); and Matkin (1990)	Conflict of interest rules have a "chilling" effect on the formation of university spinoffs
University TTO Characteristics	
Shane (2004); Bauer (2001)	The perception of the TTO as a regulator or enabler matters to the success of university spinoffs
Lockett and Wright (2005)	Expenditure of IP protection, business development capabilities, and the royalty regime of the university impact spinoff success
Markman et al. (2004)	The experience of TTO staff is negatively related to university entrepreneurial activity
Audretsch et al. (2005)	Scientists who lack entrepreneurship networks typically seek guidance from the TTO; the TTO typically recommends licensing the technology. Conversely, scientists not assisted by their TTO are more likely to choose entrepreneurship as their mode of commercialization

University IP Policy	
Shane (2004); DiGreggorio and Shane (2003); Jensen and Thursby (2003)	Making equity investments in lieu of charging patent and licensing costs is important to spinoff success. The inventor's share of royalties also matters
Siegel et al. (2003)	IP policies and organizational practices can enhance or impede technology transfer effectiveness
Claryesse et al. (2007); Steffensen et al. (2000)	Aggressive university patenting and conflicts over intellectual property rights are one of the biggest barriers to the dissemination and commercialization of new knowledge
Roberts and Malone (1996)	Nonexclusive licenses favor the open dissemination of new knowledge from universities
Shane (2004)	Exclusive licenses encourage spinoff especially in the biosciences
Business Development Factors: Development Funding	
Heirman and Clarysse (2004); Shane and Stuart (2002); Hellman and Puri (2000)	Initial and operational resources differentiate firms and help predict their success
Aldrich (1999); Aldrich and Fiol (1994)	Less than one percent of all start-ups founded in the U.S. raise more than $1 million in financing
Roberts (2009; 1991)	Venture capital, angel capital, bank loans, and friends and family are all important sources of financing among spinoffs in the Boston area
Founding Team and Surrogates	
Rothaermel et al. (2007); Clarysse and Moray (2005); O'Shea et al. (2005); Shane and Stuart (2002); Roberts (1991)	Composition of the founding team, their collective industry experience, management capability, and knowledge are critical factor to spinoff success. Unfortunately, most university spinoff teams lack these characteristics
Shane (2004)	Managerial experience among academic entrepreneurs increases their changes for obtaining development financing
Franklin et al. (2001); Radosevich (1995)	"Surrogate" entrepreneurs and managers are critical to the success of spinoffs; they bring commercial experience, social networks, and a motivation for financial gain

Linkages with the "Home" Institution	
Klepper and Sleeper (2005); Cooper (1973, 1984)	Spin-offs usually inherit general technical and market-related knowledge from their parent organization (company, university, etc.)
Zahra et al. (2007)	Academic spinoffs differ from company-based spinoffs given that their technology is initially incubated in a non-profit educational institution: the university
Samson and Gurdon (1993); Doutriaux (1987)	Spinoff success may depend on completely "breaking away" from university culture, norms and regulations
Johansson et al. (2005); Rappert et al. (1999)	Academic entrepreneurs maintain strong ties to universities with high degrees of trust; spinoffs benefit through access to university expertise, the use of equipment and instruments, and by keeping abreast of university research
Characteristics of the Technology and Related Industry	
Perez and Sanchez (2003); Nerkar and Shane (2003) and Utterbach (1994)	Spinoff success is dependent on technological advance; the characteristics of technology inventions affect the likelihood that firms commercialize inventions
Thursby and Thursby (2003)	University inventions are very early-stage technologies and have a very high failure rate
Nekar and Shane (2003)	The "radicalness" of a technology combined with broad patent scope helps reduce new firm failure
Gulbrandsen and Smeby (2005); Shane (2004); Golub (2003); Lowe (2002)	Spinoffs are concentrated in high-technology areas such as biotechnology, computer software, medical devices, and pharmaceuticals. Spinoff success is likely impacted by various characteristics of these industries
Bekkers et al. (2006)	Spinoff success factors differ greatly among biotech and IT-related industries
Regional Factors	
Audretsch and Feldman (1996); Jaffe et al. (1993); Jaffe (1989)	Knowledge tends to spillover within geographically-bounded regions and this promotes clustering among firms in similar industries

Saxenian (1994); Piore and Sabel (1984)	Industrial networks aid in the transmission and absorption of knowledge
Cohen and Levinthal (1990)	The capability of a region to "absorb" knowledge spillovers is dependent on the scientific and innovation capacity of the industries in the region
Audretsch and Lehman (2005)	Spillovers from universities may affect firm growth; the closer that firms are located to a university and the higher the number of academic papers published at the university, the higher the growth rates for these firms
Bekkers et al. (2006); Almeida and Kogut (1999)	Company success is correlated with its proximity to industry clusters due to the mobility of labor within
DiGreggorio and Shane (2003)	The availability of VC in the region where the university is located and the level of sponsored research does not have a significant impact on the number of spinoffs from that university
Powers and McDougal (2005); Degroof and Roberts (2004)	Universities in regions with strong entrepreneurial support require little provision of support from the university and vice-versa
Public Policy	
Dietz and Bozeman (2005); Dietz (2000)	*How* university research is supported, especially by the federal government, may have a profound impact on the propensity of academic entrepreneurs to spinoff and the subsequent success of these spinoffs
Blair and Hitchens (1998)	Access to infrastructure, such as entrepreneurship services, financial and technical resources, and incubators is important to university spinoff success
Audretsch, Lehmann, and Warning (2005)	Incubators improve the flow of knowledge spillovers to university spinoffs
Link and Scott (2005)	University spinoffs constitute a larger proportion of firms in parks that are geographically closer to their university as well as parks that have a biotechnology focus
Westhead and Storey (1994, 1997)	Firms located in science parks (though not specifically university spinoffs) those with relationships with universities have a higher

	survival rate than those firms without such a relationship
Siegel et al. (2003)	Firms located within science parks have slightly higher research productivity than off-park firms
Shane (2004); Lowe (2002)	Spinoffs from the most prestigious institutions like MIT and Berkeley, respectively, often need to obtain public sector capital before they can obtain private capital
Gulbranson and Audretsch (2008)	Proof of concept centers such as the University of California at San Diego's Von Liebig Center and MIT's Deshpande Center offer intensive services designed to provide resources, technical assistance, and guidance for faculty members (and students) interested in technology commercialization; they may be critical to spinoff success

Highly Productive Faculty

Faculty involvement is critical to the continuing development of university technology, including the development of new technology in university spinoffs (Shane, 2004; Jensen and Thursby, 2001). Agrawal (2002) also finds a positive relationship between active faculty involvement and the performance of technology licenses. Franklin et al. (2001) find that it is important to involve the faculty researcher because of her intimate understanding of the technology and its potential application.

Recent research suggests that there is a relationship between productivity of university scientists, their intellectual reputation, and their propensity to engage in entrepreneurship. For example, Louis et al. (2001) and Zucker et al. (1998) suggest that higher intellectual capital rates lead to greater numbers of university spinoffs. Their research is supported by DiGreggorio and Shane (2003), who find that a university's "intellectual eminence" influences its spinoff rates. Some of this research may be

attributed to individuals who see market-related projects as a complement to their research. Meyer (2006) finds that in Europe, nano-scientists who patent appear to outperform their non-inventing peers in terms of publication counts and citation frequency.

Other studies look at how the involvement of "star" scientists enhances the (research) performance of U.S. biotech firms as measured by three proxies: the number of patents granted, number of products in development, and number of products on the market (Zucker et al., 2001; 2002). In other words, the most commercially active scientists may also be the most productive and respected among their peers. They also find that these "ambitious faculty" are proactive and seek out external (industry) contacts, rather than external parties seeking access to the new knowledge within the university.

Social Networks Beyond the Boundaries of the University

The quality, depth, and diversity of a faculty member's professional network, beyond their academic environment, are important factors for spinoff success (Rothaermel et al., 2007; Murray, 2004). Johansson et al. (2005) find that active faculty members learn and exchange research findings and other information critical to venture creation through the relationships that they establish with communities outside academia. These relationships are not only important unto themselves but also help mediate how well technology is transferred to a spinoff (Grandi and Grimaldi, 2003).

Formal networks can help counterbalance a faculty member's lack of industry experience. For example, O'Gorman et al. (2008) find that connections with outside experts helped academic entrepreneurs understand the opportunities for applying – and

later commercializing – their expertise in information retrieval software. They also find that external networks are essential in helping the university entrepreneur write and develop a business plan, raise early-stage finance, and develop links with other important firms that are potential customers.

Informal networks also play an important role in the success of spinoffs and commercialization of technologies (Rappert et al., 1999). These informal networks "provide a means of receiving general and specific expertise from universities in a manner which responds to the contingencies of innovative activity (p, 886)." This research is supported by Meyer-Krahmer and Schmoch (1998) who find that university researchers rank informal contacts and collaborative research as two of the most important aspects for university-industry relations. Furthermore, Martinelli et al. (2008) and Landry et al. (2002) find that informal networks often facilitate more formal linkages that facilitate both spinoff and licensing arrangements with established firms.

2.3.2 University Factors

Academic Culture

As we have seen, university faculty members have different backgrounds, interests, and sources of research funding; these factors combine to form faculty culture. Research focuses on the clash between "traditional" norms of academia including academic freedom, peer review, public research support, and transparency versus Academic Capitalism, the commercialization of university outcomes through patenting, licensing, consulting, and spinoff (Slaughter and Rhodes, 2004; Franklin et al., 2001; Samson and Gurdon, 1993). Chiesa and Piccaluga (2004) find that different facets of

academic culture, including life-long employment and tenure, risk-adverse attitudes, and the lack of managerial experience among faculty and administrators, creates substantial barriers to entrepreneurial behavior.

Many faculty members (and universities) have difficulty combining commercial and academic goals; Bercovitz and Feldman (2004) show that in a population of academic engineers, academic and commercial goals are unlikely to converge. As it relates to university spinoffs, Samson and Gurdon (1993) find that culture is a key inhibitor to the success of a spinoff (and in some cases spinoff formation). Less than 1/3 of their sample faculty are able to successfully manage their university responsibilities and their off-campus ventures; most end up severing their ties to academia.

For universities wishing to improve their contributions to local and state economies, Etzkowitz (2003), Jacob et al., (2003) and Clarke (1998) recommend they transform their mission and culture to encourage technology transfer with an emphasis on entrepreneurship. Shane (2004); Bauer (2001); Feldman and Desrochers (2001); Hsu and Bernstein (1997); and Roberts (1991) find that an entrepreneurial culture, social norms, and role models matter: the presence of entrepreneurs either among faculty or in the surrounding business community is crucial to the formation of spinoff companies. Faculty entrepreneurs provide other faculty and graduate students with an informal curriculum in such things as how to find venture capital and start a firm (Bauer, 2001).

University Policy

Research suggests that faculty policy impacts the propensity of faculty to spin off and the subsequent success of the spinoff. Siegel et al. (2003) find that organizational

factors such as faculty reward systems influence the overall transfer of technology. O'Gorman et al. (2008) find that faculty members take traditional academic rewards into account when considering the payoff of commercialization activity. In fact, financial incentives play little or no role in motivating faculty to commercialize their research relative to traditional reward structures and the lure of additional federal R&D (Markman et al., 2004 and Colyvas et al., 2002).

According to the literature, flexible leave of absence and other personnel policies are critical to faculty involvement in technology commercialization and spinoff (Bekkers et al. 2006; Shane, 2004; Tornatzky et al., 1995). For example, Kenney and Goe (2004) show that leave of absence policies hinder spin-off formation out of the computer science department at the University of California at Berkeley compared to the Stanford University computer science department which has similar academic strengths but less restrictive policies. Golub (2003) finds that spinoff activity increased at New York University when it removed prohibitions on the use of university facilities by spinoff companies. Renault (2006), Shane (2004), and Matkin (1990) find that conflict of interest rules (and laws) have a "chilling" effect on the formation of university spinoffs.

University TTO Characteristics

TTO structure and operations impact the spinoff of companies from the university. Shane (2004) and Bauer (2001) find that perception of the TTO matters to the success of university spinoffs: in some places they are viewed as regulators enforcing disclosure rules, but do little to help license technology or create spinoffs. In other universities, TTOs are thought to play a more beneficial role, according to academic

entrepreneurs, providing important guidance and services (Shane, 2004). Lockett et al. (2005) find that expenditure on IP protection and the business development capabilities of the TTO are positively associated with university spinoff rates and external investments in spinoffs. Markman et al. (2004) find that the experience level of TTO staff is significantly but negatively related to entrepreneurial activity.

Recent research finds that academic entrepreneurship is an important dissemination and commercialization alternative for scientists who do not wish to license their technology. For example, Audretsch et al. (2005) finds that scientists who lack entrepreneurship networks of their own seek guidance from their TTO. The TTO in-turn typically recommends they license their technology. For these scientists, licensing is not only the most prevalent mode of commercialization, but is a substitute for entrepreneurship. Conversely, scientists not assisted by TTOs are more likely to utilize entrepreneurship as their mode of commercialization. Lockett et al. (2003) find that universities that generate the most startups have clear, well-defined strategies for the formation and management of startups.

University Intellectual Property, Royalty, and Equity Policies

Several studies have explored the impact of specific IP, royalty, and equity policies on spinoff rate and success. Shane (2004) and DiGreggorio and Shane (2003) find that making equity investments in lieu of patent and licensing costs is important to spinoff success; the inventor share of royalties also matters. Jensen and Thursby (2001) find that equity promotes inventor involvement, which is critical to the success of university spinoffs. Siegel et al. (2003) find that IP policies and organizational practices

can enhance or impede technology transfer effectiveness. Furthermore, aggressive university patenting activity may retard the pace of knowledge "exploitation" retarding industrial innovation – and conflicts over intellectual property rights are one of the biggest barriers to the spin-off process (Clarysse et al., 2007; Steffensen et al., (2000). Roberts and Malone (1996) find that nonexclusive licenses favor the open dissemination of new knowledge from universities; Shane (2004) finds that exclusive licenses encourage spinoff, especially in the biosciences.

2.3.3 Business Development Factors

Development Funding

Development funding is a critical aspect of success for entrepreneurial firms although there is a lack of understanding for how funding needs may differ with university spinoffs. Though not specific to university spinoffs, entrepreneurial firms face what Zeira (1987) calls "structural uncertainty." Given the early-stage nature of university technology and the lack of commercial experience among faculty, academic entrepreneurs do not know *a priori* if their technology holds commercial potential. Thus, additional development funding allows spinoffs to hire staff, conduct more research, and pursue services to make this determination. Financial resources are a particular focus of the Resource-Based View (RBV) of the firm, a theoretical lens stipulating that initial and operational resources differentiate firms and help predict their operational success (Heirman and Clarysse, 2004; Shane and Stuart, 2002; Hellman and Puri, 2000).

Though no data exist on the amount of capital raised by spinoffs as a whole or the "average" university spinoff, Shane and Stuart (2002) find that the mean level of capital

raised by MIT spinoffs from 1980 to 1996 is $5.3 million. Furthermore, some 30 percent of companies spun off of MIT have received venture and angel capital financing. With that said, Aldrich reports that less than one percent of all start-ups founded in the U.S. raise more than $1 million in financing (Aldrich, 1999; Aldrich and Fiol, 1994). There is also little understanding of the sources of funding among spinoffs but studies of the Boston metropolitan region finds that venture capital, angel capital, bank loans, and friends and family all play an important role in spinoff success (Roberts, 2009; 1991).

Founding Team and Surrogates

The composition of the founding team, their collective industry experience, management capability, and knowledge are critical factors to the success of a spinoff (Rothaermel et al., 2007; Clarysse and Moray, 2005; Roberts, 1991). Unfortunately, many, if not most, university spinoff teams lack these capabilities, negatively impacting their ability to recruit new employees, and attract early-stage finance (O'Shea et al., 2005; Clarysse and Moray, 2005; Shane and Stuart, 2002).

We have seen that faculty members often lack the requisite industry experience needed for commercialization; this may also apply to the ability of academic entrepreneurs to manage their spinoff. Shane (2004) finds that the more managerial and industry experience academic entrepreneurs possess the more likely they are to obtain development financing.

A limited research also focuses on the importance of professional (non-faculty) management to spinoff success. Radosevich (1995) recommends a "dichotomous approach" where the academic entrepreneurs takes an important role in establishing the company and – later – technology development but that spinoff management is handled

by an experienced, "surrogate" manager. Franklin et al. (2001) find that a key advantage to using a surrogate entrepreneur is their commercial experience, their motivation for financial gain, and their linkages to social networks of entrepreneurs for recruiting staff and raising capital.

Spinoff Linkages with the "Home" Institution

Most spinoffs in the United States come from existing firms (Acs, 1999; Roberts, 1991); spin-offs usually inherit general technical and market-related knowledge from their parents (Klepper and Sleeper, 2005; Cooper, 1973; 1984). For example, most new spinoffs serve the same market or utilize the same general technology as their parent company – and spinoff performance may be impacted by the performance and culture of the parent company (Dahlstrand, 1997). In some cases, the parent company may take an active, supportive role in the spin-off by sharing facilities and equipment, providing business services, or making equity investments through corporate venture capital (Gompers and Lerner, 1999).

Academic spinoffs differ markedly from company-based spinoffs given that their technology is initially incubated in a non-profit educational institution, the university (Zahra et al., 2007). Corporate and academic spinoffs may therefore differ substantially in their capability to transform research and scientific discoveries into successful products and goods. Some researchers suggest that the success of university spinoffs may be dependent on "breaking away" completely from university culture, norms, and regulations (Samson and Gurdon, 1993).

Other research focuses on more positive aspects of the relationship between

spinoffs and their incubating university. Johansson et al. (2005) find that academic entrepreneurs retain and cultivate a small number of strong ties to universities with a high degree of trust. Rappert et al (1999) find that spinoffs benefit from relationships through access to expertise, entrepreneurial assistance, use of equipment and instruments, and by keeping abreast of university research. Westhead and Storey (1994, 1997) find from matched pairs of firms (though not specifically university spinoffs) in the UK data for 1986 and 1992, a higher survival rate among firms located in science-parks with a university relationship than firms without such a relationship. Link and Rees (1990) find spinoffs are particularly adept at exploiting their university-based relationships to generate innovation.

While these spinoff–home university linkages are important for the continuing transfer of complex knowledge, the strength of these ties also make them difficult to substitute because the spinoffs remain dependent. In fact, Doutriaux (1987) finds that university spinoffs founded by university faculty are more likely to grow if the faculty member cuts his or her ties with the university. He finds a "seemingly negative effect" on the growth and development of a sample of Canadian university spinoffs that continue their contacts with the university.

Characteristics of the Technology and Related Industry

Spinoff success is necessarily more dependent on technological advance and development than, at least initially, marketing, sales, or distribution (Perez and Sanchez, 2003). Nerkar and Shane (2003) and Utterbach (1994) find that the characteristics of technology inventions affect the likelihood that firms commercialize inventions;

university inventions are very early-stage technologies and have a very high failure rate (Thursby and Thursby, 2003). Nerkar and Shane (2003) find, however, that the "radicalness" of a technology combined with broad patent scope may help reduce new firm failure. Recent research on the IT industry may also yield insights with regard to the increasingly international and disintegrated value chain that have emerged within the industry (Breznitz, 2007; Sturgeon, 2002).

With regard to specific technologies, Shane (2004) finds that MIT spinoffs are concentrated first in biotechnology and second in computer software. Lowe (2002) finds that two-thirds of the spinoffs from Berkeley are comprised of biotechnology, pharmaceutical, or medical device firms. Golub (2003) finds that half of NYU spinoffs are biomedical firms, with remaining firms in computers and software. Gulbrandsen and Smeby (2005) compare university entrepreneurship in the health and physical sciences and find that the health sciences offer an "easily, seamlessly integrated" translation to a spinoff company. Bekkers et al. (2006) find that spinoff success factors differ greatly among the biotech and IT-related industries, especially software.

2.3.5 Regional Factors

Research shows that success is related to where the spinoff is located. Knowledge tends to spillover within geographically-bounded regions and this promotes clustering among firms in similar industries (Audretsch and Feldman, 1996; Jaffe et al., 1993; Jaffe, 1989). Integral to this clustering is the formation of industrial networks that aid in the transmission and absorption of knowledge (Saxenian, 1994; Piore and Sabel, 1984). The capability of a region to "absorb" knowledge spillovers is dependent on the scientific and

innovation capacity of the industries in the region (Cohen and Levinthal, 1990). From the firm-level perspective, scholars have produced evidence that innovation networks are beneficial for overall firm productivity and R&D capability (Murray, 2004; Zucker et al., 2002; Zucker and Darby, 2001).

Audretsch et al. (2004) find that, compared to large firms, smaller firms derive greater benefit from their proximity to knowledge. Audretsch and Lehman (2005) find that spillovers from universities may affect firm growth; the closer that firms are located to a university and the higher the number of academic papers published at the university, the higher the growth rates for these firms. Bekkers et al. (2006) and Almeida and Kogut (1999) find that company success is correlated with its proximity to industry clusters due to the mobility of labor within.

Related to specific characteristics of a region, DiGreggorio and Shane (2003) find that the availability of VC in the region where the university is located and the level of sponsored research does not have a significant impact on the number of spinoffs from that university. Powers and McDougal (2005) and Degroof and Roberts (2004) find that universities in regions with strong entrepreneurial support require little provision of support from the university and vice-versa.

2.3.6 Public Policy

A few academic studies have explored the impact of public policies, such as science parks, incubators, and government seed programs on the success of university spinoffs (Rothaermel et al., 2007; Phan and Siegel, 2006). At a basic level, *how* university research is supported, especially by the federal government, may have a

profound impact on the propensity of academic entrepreneurs to spinoff and the subsequent success of these spinoffs (Dietz and Bozeman, 2005). Dietz (2000) posits: "by favoring capacity – in the form principally of the generation of human and social capital – policymakers could be emphasizing policy-relevant variables that encompass not just knowledge outputs, economic outputs, or social outputs, but all three." In other words, the fact that the federal government funds research without consideration of its application – social, commercial, or otherwise – may very well retard spinoff and/or impact spinoff success.

Blair and Hitchens (1998) find that access to infrastructure, such as entrepreneurship services, financial and technical resources, and incubators is important to university spinoff success. Audretsch, Lehmann, and Warning (2005) find that incubators improve the flow of knowledge spillovers to university spinoffs. Link and Scott (2005) find that, in the United States, university spinoffs constitute a larger proportion of firms in parks that are geographically closer to a university as well as in parks that have a biotechnology focus. Westhead and Storey (1994, 1997) find that among firms located in science parks (though not specifically university spinoffs) those that have relationships with universities enjoy a higher survival rate than those firms without such a relationship. Using Westhead and Storey's (1994, 1997) data, Siegel et al. (2003) find that firms located within science parks have slightly higher research productivity than off-park firms.[6]

Recent research examines government research and capital funding programs in the context of inquiries concerning the success of university spinoffs. Shane (2004) and

[6]See also Link and Scott (2007) and Link and Scott (2003) for reviews of the science park literature. See also Wessner (2009), which explores the international dimensions of sciences parks and their implications for U.S. competitiveness.

Lowe (2002) find that even spinoffs from the most prestigious institutions like MIT and Berkeley, respectively, often need to obtain public sector capital before they can obtain private capital. Furthermore, a recent inquiry by the Kauffman Foundation investigates the emergence of Proof of Concept Centers, including the University of California at San Diego's Von Liebig Center and MIT's Deshpande Center, intensive services designed to provide resources, technical assistance, and guidance for faculty members (and students) interested in technology commercialization (Gulbranson and Audretsch, 2008).

Many companies, including spinoffs, turn to government grants and contracts to close early stage funding gaps (Shane, 2004; Lerner, 1999). Principal among these are the Small Business Innovation Research (SBIR) grants, the now-defunct Advanced Technology Program (ATP), and state-sponsored programs to encourage university technology commercialization. Link et al. (2008) and other research emerging from a multi-year Congressionally-mandated National Academies study of the SBIR program may also offer insights as to the impact of the program on university spinoffs.[7]

2.4 Opportunities in the Literature

The sections above are based on a review of more than 150 scholarly articles and have drawn heavily from other recent literature reviews (Rothaermel et al., 2007; Phan and Siegel, 2006). With a few exceptions (Shane, 2004), most literature reviews focus on academic entrepreneurship as a subset of broader topics such as university technology transfer. Nonetheless, Rothaermel et al. (2007) and Phan and Siegel (2006) find that the

[7]For more information on the on efficacy of the SBIR program and its impact on commercialization, see the National Research Council series *Capitalizing on Science, Technology, and Innovation: An Assessment of the Small Business Innovation Research Program* and the project's publications, available at http://www7.nationalacademies.org/sbir/.

broader technology transfer literature is currently in the "embryonic stage of development" (Rothaermel, p. 698). While technology transfer is slowly gaining the attention of researchers, many see the narrower topic of academic entrepreneurship as much less developed or – according to Shane (2004) – "virtually non-existent."

The extant technology transfer literature draws from a number of disparate disciplines, including economics, management, sociology, higher education administration, public policy, and others. Rothaermel et al., (2007) find that theories underlying what he calls university entrepreneurship have been "barrowed" from the aforementioned fields allowing "deductively derived hypotheses to be tested, thus circumventing the need for developing new theory specifically for the realm of university entrepreneurship (p. 698)."

Specific to academic entrepreneurship, the literature employs case studies or conceptual models that have not been tested empirically; a strong foundational theory does not yet exist. For example, spinoff research has been classified as "primarily atheoretical and non-cumulative" (Rothaermel et al., 2007; O'Shea et al., 2005) or "more descriptive in nature and perhaps more atheoretical" (Mustar et al., 2006). According to Rothaermel et al. (2007, p. 699) spinoff studies are "less sophisticated in sampling frames, hypotheses development, statistical analysis, and dynamic longitudinal analysis than are organizational studies in more established disciplines."

The main challenge for researchers lies in the lack of systematic, longitudinal data needed to produce studies for premier journals; there exists no equivalent to

COMPUSTAT for academic entrepreneurship research.[8] Most quantitative studies have relied upon data collected in the annual Association of University Technology Managers (AUTM) survey or patent data from the U.S. Patent and Trademark Office (Rothaermel et al., 2007; Phan and Siegel, 2006). As a result, much of the current research on university spinoffs examines the *number* of university spinoffs and their relationship with institutional or environmental factors. Therefore, future scholarly contributions to academic entrepreneurship may be dependent on insights and foundations provided through field research (Davidsson, 2004; Shane, 2004).

Scholarly research that collects and analyzes primary-source data from university spinoffs and academic entrepreneurs is rare. In their review of the broader university entrepreneurship literature, Rothaermel et al. (2007) find a total of 39 articles that use the firm as their unit of analysis. The most prevalent data source for firm-level studies is direct interviews with informants (11). Only 5 studies use the individual entrepreneur as their unit of analysis. When research on academic entrepreneurship does exist, it is typically limited to individual universities, typically elite institutions like MIT (Shane, 2004; Roberts, 1991) – or university spinoffs in other countries (Vanaelist et al., 2006; Druilhe and Garnsey, 2004; Mustar, 1997). These cases, while informative, lack generalizability. Therefore, a great opportunity exists to contribute to the academic entrepreneurship literature.

[8]While there is no comprehensive database of academic entrepreneurs, other entrepreneurship data collection efforts exist, such as the Panel Study for Entrepreneurial Dynamics at the University of Michigan. For more information, see http://www.psed.isr.umich.edu/psed/home.

CHAPTER THREE: RELEVANT THEORETICAL PERSPECTIVES

The academic entrepreneurship literature is often deemed nascent and atheoretical. Where theory does exist, Rothaermel et al. (2007) posit that the most common starting point for university entrepreneurship is the theory of the firm (Baldwin and Scott, 1987; Cohen and Levin, 1989; Scherer, 1984, 1991; Dosi, 1988). With such theories, firms are exogenous and their performance in generating technological change is endogenous (Cohen and Klepper, 1992; Scherer, 1991; 1984; Arrow, 1962). Audretsch (1995) asserts three major schools of thought for the role of the firm in economic growth (p. 41):

1. A production function. The firm is a solitary, rational actor; the goal of the firm is to maximize profits. Firms compete with one another in markets for homogenous products. Technology is considered to be exogenous and firms combine inputs to produce outputs (Nelson and Winter, 1985).

2. The second view describes the firm as an organization that reduces transactions costs through the efficient processing of information. Ronald Coase (1937) is credited with this view. He concludes, "The main reason why it is profitable to establish a firm would seem to be that there is a cost of using the price mechanism." In other words, a great deal of economic activity may be more effectively governed within the boundaries of a firm rather than within the market.

3. The third view is evolutionary and considers the firm as a repository of knowledge. The importance of the relationship between the firm and knowledge dates back to Alfred Marshall (1920), who defined capital largely in terms of knowledge and organization, "Capital consists in a great part of knowledge and organization…

> knowledge is our most powerful engine of production; it enables us to subdue Nature and force her to satisfy our wants. Organization aids knowledge."

The first, production function-view of the firm has driven the majority of neoclassical economic research with models of economic growth emphasizing the link between capital, labor, and economic performance (Solow 1956, 1957). Coase (1937), the father of the second view, is credited among others with the emergence of professional management disciplines that examine the firm and its role in mediating efficient market transactions. The firm does this by internalizing activities that might otherwise be left to the market for the purpose of reducing uncertainty and therefore transactions costs. While the production function and Coasian approaches are useful, industrial competition is increasingly determined by innovation, incorporating the third view: the firm as a repository of knowledge applied to the production of new products and services.

With regard to the literature, many see technological change as the driver for economic growth. In the most prevalent model of technological change, Griliches' (1979) knowledge production function includes exogenously existing firms engaging in the pursuit of new economic knowledge as an input into the process of generating innovative activity. The most decisive input in the knowledge production function is new economic knowledge. As Cohen and Klepper (1992) conclude, the greatest source generating new economic knowledge is generally considered to be R&D. For example, Penrose (1959) also attributes the distinguishing characteristic of an enterprise to be knowledge embedded in a firm.

3.1 Resource-Based View of the Firm

According to Rothaermel et al (2007), much of the research on university spinoffs is generally based on the theory of the firm and most frequently embedded in the theoretical Resource Based View (RBV) (Lockett and Wright, 2005; Heirman and Clarysse, 2004; Penrose, 1959). RBV focuses on the resources of the firm as a differentiator and a predictor of competitive advantage. These include differences in initial resources at startup (Heirman and Clarysse, 2004; Shane and Stuart, 2002), financial resources (Hellman and Puri, 2000) or technical resources. Comprehensive approaches, involving combinations of social, technological, financial, and human resources have also been developed (Druilhe and Garnsey, 2004).

While this section is not meant to offer a detailed critique of the RBV, the theory proves inadequate to satisfy Davidsson's (2004) criterion for theoretical abstraction in entrepreneurship research: *university spinoffs are a special case of what?* In fact, a great deal of research has emphasized how *similar* university spinoffs are compared to other startups and spinoffs. Researchers have found that university spinoffs and other startup firms are similar, for example, in the problems and difficulties they encounter once they enter the market (Doutriaux, 1987; Doutriaux and Peterman, 1982); success rates for bringing technologies to the market (Lowe and Ziedonis, 2006); and challenges with creating sustainable financial returns (Vohora et al., 2004).

The RBV literature acknowledges that university spinoffs emerge from a non-commercial environment – the university – and that this environment lacks resources and personnel with entrepreneurial expertise (Vohora et al., 2004; Wright et al., 2004). For purposes of this paper, however, RBV does not provide a "useful distillation" of the

specific elements that make university spinoffs unique: their foundation on new knowledge generated from university research, the role of the inventor in the spinoff process and its success, and the relationship of the spinoff to the its home university and region throughout its life cycle (Davidsson, 2004; Shane, 2004).

Furthermore, RBV attributes the success and failure of university spinoffs to the adequacy and combinations of different resource "bundles" (Penrose, 1959). It does not specifically address the inherent longevity of knowledge[9]; a firm may fail but knowledge lives on, embodied in scientists, faculty members and workers, and may spillover to aid in the development of new technologies in other firms (Audretsch, 1995). RBV also does not specifically recognize that there is social and economic value for the dissemination of new knowledge into society (Romer, 1986; Griliches, 1979; Arrow, 1962).

3.2 Endogenous Growth Theory

Unlike the first two views of the firm, Romer (1986) encompasses a more dynamic view – the firm as a producer and repository of knowledge. Building on Arrow's (1962) research, Romer (1986) creates an endogenous growth model whereby economic growth occurs through the generation, accumulation, and spillover of new technological knowledge.

Romer (1986) assumes that new knowledge automatically spills over allowing third-party firms and economic agents access to new technological knowledge; spillovers are non-excludable and non-exhaustive. Romer keeps with the traditions of neoclassical economic theory that holds that knowledge spills over effortlessly to third-party firms.

[9]Reitan (1997) finds, for example, that among defunct firms in his sample, 50 percent had their business ideas utilized by other businesses supporting the hypothesis that spinoffs are critical to the dissemination of new knowledge.

Scholars have more recently termed this knowledge that is easily transmitted across distance and among economic agents as codified (Kogut and Zander, 1992). Codified knowledge, distinct from tacit knowledge – which is discussed later, is embodied in the form of books, articles, blueprints, software programs and other vehicles, often protected by copyright. Copyright, patents, and other forms of IP protection promote the spillover of knowledge in return for certain legal rights (Kogut and Zander, 1992). With codified knowledge, a firm does not necessarily need to be the originator of knowledge to enjoy its benefits. Spillovers therefore theoretically offer firms a valuable opportunity to enhance process efficiency, make product improvements, and develop any number of technological innovations (Romer, 1986, 1990).

Though Romer (1986) did not specifically address entrepreneurship, his work provides the foundation for research that seeks to better understand the absorption and commercialization of knowledge spillovers. When knowledge is assumed to play an important role in technological change, the greatest contribution of small firms, along with employment, is their role in entrepreneurial discovery. Indeed most new knowledge-intensive firms eventually fail but in the process utilize, improve upon, and often commercialize new knowledge – a contribution that survives the life expectancy of firms.

From a broader perspective, Audretsch (1995) finds that about 10 percent of all firms in the U.S. economy are new each year, while another 9 percent exit. He defines this continuous cycle of firm creation and destruction as *turbulence.* And though research shows that this process does little to contribute to overall economic output (p. 105), it is very important for the overall vitality and dynamism of the economy. Studying the birth

and death of organizations and jobs in 382 labor market areas from 1980 to 1988, Paul Reynolds finds that a high level of turbulence is indirectly associated with economic expansion. However, the entry and exit of firms is not, *per se*, a source of economic growth. "Entry and exit can cancel each other out but innovative entry causes the range of opportunities to expand. Thus, for stable macroeconomic growth to take place, a great deal of micro heterogeneity and instability is necessary" (Carlsson, 1999, p. 109).

Therefore, Romer's (1986) New Growth Theory is far superior to production function and transaction cost views of the firm but does not completely account for the specific role of entrepreneurship in knowledge dissemination. Furthermore, not all knowledge is codified. Only recently have researchers begun to ask how endogenous growth and entrepreneurship relate theoretically, a question of great validity when exploring academic entrepreneurship. The next section examines a theoretical lens that attempts to reconcile the two theoretical concepts.

3.3 Knowledge Spillover Theory of Entrepreneurship

The nascent, but emerging Knowledge Spillover Theory of Entrepreneurship (KSTE) challenges some of Romer's (1986) assumptions, yet embraces his guiding maxim: new knowledge is the source of innovation, productivity, and economic growth (Audretsch et al., 2006). KSTE challenges two fundamental assumptions of the endogenous growth model (Acs et al., 2004). The first is that new knowledge is automatically equated with economically useful knowledge. Not all knowledge is necessarily economically useful; Arrow (1962) emphasizes that while the economic value of traditional inputs such as labor and capital is relatively certain, knowledge is

intrinsically characterized by a high degree of uncertainty. This results in a broad spectrum of potential usefulness between "basic" knowledge and economic knowledge creating asymmetries among economic actors related to its perceived applicability and value.

The second assumption challenged by KSTE involves the "automatic" spillover of new knowledge. As discussed above, Romer (1986) assumes that when knowledge is created, it automatically spills over and yields endogenous growth. Recent empirical evidence contradicts these assumptions suggesting that knowledge spillovers are subject to legal, geographic, and cost constraints (Cohen et al. 2000, Jaffe, 1989, and Jaffe et al., 1993). Furthermore, the cost of transferring such knowledge is a function of geographic distance and gives rise to localized externalities (Siegel et al, 2003). KSTE's original theoretical contribution is based on an exploration of *how* knowledge spills over, transforming entrepreneurship from a routinized process of establishing firms into a vehicle where knowledge is embedded, commercialized, and disseminated.

3.3.1 Knowledge Filter

Exploring the contextual elements of entrepreneurship, Audretsch et al. (2006) and Acs et al. (2004) introduce the concept of the "knowledge filter," a barrier impeding the spillover of new knowledge from the firm or the organization where it was originally generated to other third-party firms. The knowledge filter exists due to the high degree of uncertainty combined with "non-trivial asymmetries, combined with a broad spectrum of institutions, rules and regulations" (Audretsch et al., 2006; Acs et al., 2004). Put simply, the knowledge filter is the gap between knowledge that has potential commercial value

and knowledge that is actually commercialized. Acs et al. (2004) posit that if the originating organization has a different (presumably lower) valuation of the potential innovation, that organization may decide not to pursue its development. If this occurs, then the knowledge filter prevents spillover and therefore utilization by third-party firms.

To better understand the knowledge filter, one must look beyond the homogeneous notion of "knowledge" to understand its distinctions. While neoclassical economic theory specifies that knowledge spills over effortlessly to third-party firms, many scholars differentiate between codified and tacit knowledge (Kogut and Zander, 1992). While codified knowledge is easily transmitted across distance and among economic agents, tacit knowledge – often referred to as *know-how* – is not easily codified and is typically embodied in individuals, organizations, and processes (Mowery and Ziedonis, 2001; Audretsch and Feldman, 1996).

Lundvall (1998) finds as industry and universities generate new knowledge it evolves and develops toward a product or application and in the process becomes cumulative and contextually non-transferable (Tassey, 1991). While IP policies impact the dissemination of codified knowledge, the spillover and commercialization of tacit knowledge is more complex. It is not easily defined or valued given that it is embedded in human, institutional, and facility forms which are immobile and place specific – what Von Hipple (1994) calls "sticky knowledge." In this case, culture, trade secrecy, regulations, and other mechanisms may act as barriers to knowledge, yet we have little understanding of how these factors are theoretically relevant to the composition and strength of the knowledge filter (Acs et al., 2004).

Audretsch et al. (2006) and Acs et al. (2004) posit that entrepreneurship provides an important mechanism for permeating the knowledge filter, facilitating the dissemination of new knowledge and ultimately economic growth. For example, Acs and Plummer (2005) show that – in a study of the Denver metropolitan area – entrepreneurship plays a critical (and significant) mediating role in the relationship between the spillover of new knowledge and benefits that accrue to specific locales within the region. For KSTE, the vast uncharted research territory lies with understanding the mediating factors for entrepreneurship.

Traditional theories of entrepreneurship have typically held the entrepreneurial context constant and then examined how individual characteristics impact entrepreneurial choice (Audretsch, Keilback, and Lehman, 2005; Gartner, 1989). But in order to understand these unique facets of knowledge-based, Audretsch (1995) suggests shifting the unit of observation away from exogenously assumed firms to individuals, such as scientists, engineers, or other knowledge workers – agents with endowments of new economic knowledge. If knowledge is now embedded in the individual inventor then, according to KSTE, individual characteristics may be held constant and the research focus shifted to other contextual factors such as the organization of the spinoff company, the incubating organization (in this case, the university), the economic and policy environment in which the spinoff occurs in addition to the spinoff process itself (Gartner, 1989).

3.3.3 Knowledge Filter in Educational Institutions; Universities are Unique

Given the undeveloped nature of KSTE, no research has been undertaken to differentiate organizational differences among corporate spinoffs, startups, and university spinoffs. Furthermore, little understanding exists, in general, concerning the composition and elements of the knowledge filter and variations among the aforementioned ventures. This is especially true when universities are the incubating organization; the vast majority of spinoffs form out of for-profit firms (Acs, 1999). Understanding university structure, policies, and operations and their impact on knowledge dissemination is crucial to understanding the composition of the knowledge filter.

While Romer (1986, 1990) lays the foundation for KSTE, Coase (1937) provides an analogous framework for describing and understanding how the boundaries of the university translates into insights for the knowledge filter. Coase (1937) wrote extensively about the boundaries between the market and the firm. Coase argues against theory that assumes the direction of resources is "dependent directly on the price mechanism" especially when functions can be incorporated within the organizational structure of the firm. He understands that there is a cost at least in the form of information asymmetries to employing the market/price mechanism and that – in many cases – it may be more efficient for a firm to internalize these functions.

> Outside the firm, price movements direct production, which is coordinated through a series of exchange transactions on the market. Within a firm, these market transactions are eliminated and in place of the complicated market structure with exchange transactions is substituted the entrepreneur-coordinator, who directs production. It is clear that these are alternative methods of coordinating production (p. 2).

He sees the boundaries of the firm – through the actions of the entrepreneur – as flexible. Boundary decisions can be thought of in terms of the marginal product of the entrepreneur answering the question: what is the cost and benefit of bringing an additional market transaction under the organizing authority of the firm? This calculus provides a foundation for modern management theory and practice – how do firms optimize resources absent direct market levers?

As the foundation for KSTE emerges, Coase (1937) is useful in order to frame how academic entrepreneurship is different. While both a firm and university may have discernable organizational boundaries, the mission of a university is quite distinct. Public universities are non-profit, educational state-chartered institutions that receive public funds for the education of students, conduct of research, and outreach. Relative to large firms, universities lack centralized mission and resource management functions; many jokes have offered that universities are loose confederations of faculty that share common parking or heating systems. Given the decentralized nature of these institutions, market boundaries may differ significantly within the same institution as policies, pay, and faculty/personnel quality differ by college, department, administrative office, and campus.

Coase's notion of optimizing resources, understanding where market transactions end and begin, and determining the marginal product of faculty entrepreneurship is useful to sort through this complexity. By combining the notion of organizational boundaries with KSTE – with the understanding that the knowledge filter is heterogeneous – theory emerges at the micro level by better understanding the exact composition of these boundaries. In the literature, spillovers are measured by the amount of money spent on

R&D, number of articles published in journals, number of employees or patents (Varga, 2000) but these have little to do with actual *market* impact. In fact, most research finds that there is little correlation – beyond the minimum threshold for such activities – between R&D funding and economic outputs proxied by licensing, patenting, and publications (Nelson, 2005).

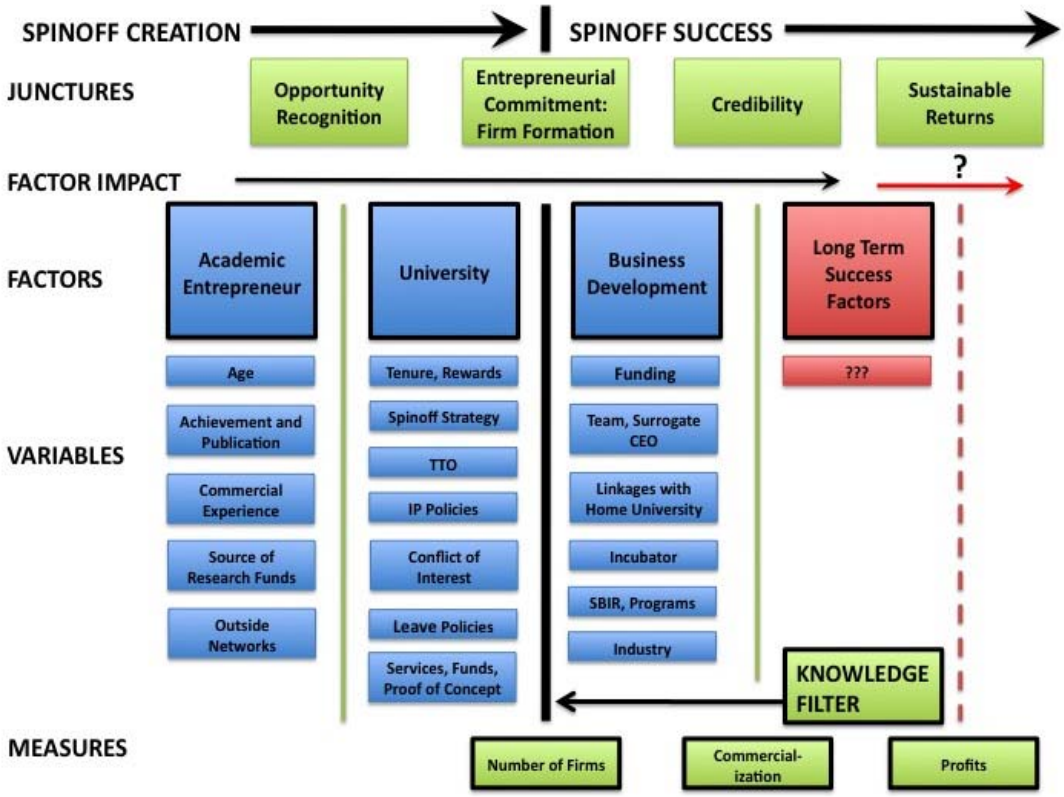
Coase discusses how costs can also be defined in terms of information asymmetries and sees the firm as a way to mitigate these costs. The market gives firms an instantaneous signal of the state of consumer demand. In the case of a university, the marginal cost decision of a technology assumes that a modicum of market levers exists. Yet, in the case of an early-stage esoteric university technology, it is impossible to ascertain this cost if a technology's application is not yet known and a market does not yet exist. Coase would likely hold that traditional markets signal consumer rejection of university technology because they do not understand its utility (and neither do the inventors).

Yet, somehow these asymmetries are overcome; at least some university knowledge is indeed disseminated and commercialized. University spinoffs seem to be one boundary-spanner among others between an inherently non-commercial university world and commercial markets. A better understanding of academic entrepreneurs and their spinoffs will not only provide insights into the barriers for academic entrepreneurship but also its enablers: why, despite theories to the contrary, do some spinoffs succeed while others do not?

3.4 Theoretical Model Based on Extant Literature and Theory

Lacking a comprehensive theory for spinoff success, an initial model is developed (Figure 2) that draws from the literature review in Chapter 2 and the relevant theoretical perspectives presented in this chapter. The model is developed into two principle sections: spinoff establishment and spinoff success. Given the aforementioned lack of data, most studies focus on the former using characteristics of the academic entrepreneur and the university (both listed in the variable section) to predict spinoff establishment. These studies use *number* of spinoffs established – obtain from AUTM data – as their dependent variable illustrated on the bottom line of the model.[10]

FIGURE 2: THEORETICAL MODEL BASED ON EXTANT LITERATURE



[10] AUTM data simply lists the number of university spinoffs by university each year with no other amplifying information relating to the spinoffs.

The second, spinoff success section is the least developed in the literature. From what few studies exist – mostly case studies – a number of business development factors (listed in the variables section) *may* predict post-spin off success, especially commercialization and profitability. Furthermore, the literature suggests that many of the same factors that predict spinoff establishment may also impact post-spin off success illustrated by the 'factor impact' line.

The act of establishing a firm provides a natural indication of where the knowledge filter may exist (Acs et al., 2004). As stated, the knowledge filter is defined as institutions, rules, regulations, and structures that create barriers to the spillover of knowledge from the organization where it was originally generated to other firms. Though the literature indicates that the knowledge filter may coincide with the actual establishment of university spinoffs, it should not be deduced that because a spinoff has been established that it has *per se* fully penetrated the knowledge filter especially given the infancy of the literature. Instead, inquiries should seek to understand *how well* new knowledge has been disseminated out of the university and into the new firm. This is why Audretsch et al. (2006) recommends using the individual agents with endowments of new knowledge as the unit of analysis.

Finally, though Vohora et al. (2004) posits that sustainable returns (vis-à-vis profits) is the eventual aim of university spinoffs, there exists little understanding of the predictive variables for long-term success given the state of the literature and lack of a robust time series data.

The theoretical model gives this paper a starting point for scholarly inquiry. The contribution of the research will lie primarily in obtaining primary source data through

two phases of direct interviews with academic entrepreneurs. The first phase interviews will help sort through and refine the theoretical model to form a more robust hypothesis to test during the second-phase interviews among a larger population of academic entrepreneurs. Furthermore, it will help better understand how academic entrepreneurs define success and the factors responsible for that success. Only by understanding these elements and clearing a path for subsequent researchers can there be a contribution to KSTE and useful insights for policymakers.

CHAPTER FOUR: METHODOLOGY

This chapter will articulate a methodology to help address the research questions and develop an understanding of academic entrepreneurship. The methodology will do this by employing Sequential Exploratory Strategy (Creswell, 2003). This strategy includes an initial exploratory phase of inductive qualitative research to create a hypothetical framework for understanding the phenomenon of academic entrepreneurship. This is followed by a second quantitative research phase where the strength of the research framework is tested among a larger sample of academic entrepreneurs.

4.1 Methodology Based on the Pursuit of Theory

The chapter begins by repeating Shane's (2004) definition of a university spinoff: a new company founded to exploit IP created in an academic institution. University IP is used as a proxy for new knowledge but is not limited to a single patent or license and may include pools of patents, exclusive or nonexclusive licenses, and/or copyrighted materials. Audretsch (1995) recommends that researchers use the individual agent(s) with endowments of new economic knowledge – the academic entrepreneur – as the unit

of analysis. An academic entrepreneur is defined as a university faculty member who chooses to establish a company using university IP.[11]

The goal of this paper is to develop an improved understanding of academic entrepreneurship and strengthen KSTE; Davidsson (2004) is instructive. He recommends three research criteria when building entrepreneurship theory: (1) investigate a group of subjects that is representative for the category or phenomenon; (2) understand and measure the frequency or uniqueness of the phenomenon; and (3) compare the results with another group relative to whom they are related or different. He goes on to say that previous and current entrepreneurship research "does not have all the answers needed to develop normative theory…" nor does it hold an adequate understanding of all entrepreneurial phenomena needed to make comparisons to a "general population" of entrepreneurs (Davidsson, 2004, p. 17).

The literature holds that university spinoffs are more likely to survive than other, non-university startups and spinoffs, may likely attract early-stage capital, are an important vehicle for knowledge dissemination and innovation, and are therefore important for regional economic development. Yet little is known about how they differ from other new-firm startups especially with regard to the unique challenges of establishing a new firm based on university IP, along with the factors that influence success (or failure) specific to university spinoffs. In other words, researchers have yet to fully describe the phenomenon of academic entrepreneurship and understand its theoretical distinctiveness necessary to compare it with the broader concept of

[11]Despite the specified research definition of academic entrepreneur, the author acknowledges the existence of many other forms of university entrepreneurship, including companies established by faculty members who do not utilize 'formal' university intellectual property (and therefore do not go through the TTO). For more information, see Link, Siegel, and Bozeman (2007).

entrepreneurship (Shane 2004; Acs and Audretsch, 2003). This paper will address Davidsson's first two research criteria in hopes that it will provide a foundation for researchers to address the third.

4.2 Research Questions

This study seeks to contribute to the literature by describing – from the perspective of the academic entrepreneur – the phenomenon of spinning off a company from a university, from licensing university IP to product commercialization (Vohora et al., 2004). With these findings, the experiences of academic entrepreneurs will be compared to the extant entrepreneurship literature enabling the development of KSTE and paving the way for future research comparing university spinoffs to non-university startups (Davidsson, 2004). Therefore, the guiding research question for this inquiry is stated as follows:

Q: What is the process by which academic entrepreneurs spin off a new company?

Figure 2 lays out a theoretical model of spinoff drawing heavily from Vohora et al. (2004) and the extant literature but there is no indication as to its validity. Furthermore, most studies of university spinoffs examine the phenomenon at the aggregate level, which fails to capture the perceptions of the academic entrepreneur as to whether or not the new venture was successful. KSTE specifies that the agent with the endowment of new economic knowledge should be used as the unit of analysis for research inquiry (Audretsch, 1995). Knowledge is tacitly embedded within the individual entrepreneur and KSTE holds that academic entrepreneurship is a mechanism for unlocking this

knowledge. In order to understand how to unlock this knowledge, the motivations of academic entrepreneurs must be understood. This definition of success will then be used to construct a dependent success variable for use in the second, quantitative phase of the research. Therefore, the first research question can be stated as follows:

Q1 How do academic entrepreneurs define success?

In addition to asking academic entrepreneurs how they define success, the main factors responsible for that success must be explored. These factors will become the independent variables in the theoretical framework, which will be tested during the second, quantitative research phase. Therefore, the second research question is stated as follows:

Q2 What are the main factors that contribute to the success or detract from the success of the university spinoff?

Given the increasing interest of policymakers in academic entrepreneurship, it is important that, among the success factors, public policies are examine that contribute to or detract from the success of the university spinoff. Local, university, state, and federal policies will be examined from the perspective of the entrepreneur. Therefore, the third research question is stated as follows:

Q3 How do university and state policies impact the success of university spinoffs?

4.3 Research Methods Based on the State of the Literature

Given the early-stage nature of academic entrepreneurship research, scholars recommend that most gains will occur primarily through field research. They recommend using multiple methods to understand the academic entrepreneurship phenomenon in order build and inform a broader theory (Phan and Siegel, 2006; Shane, 2004; Gartner and Carter, 2003; Cooper, 2003). Davidsson (2004) recognizes many scholars express "outright disgust" for exploratory research but finds it crucial to theory development in the young entrepreneurship field: "conceptual development has to start somewhere" (p. 49).

University spinoffs represent a unique phenomenon: a series of events that are infrequent, unanticipated, and/or extraordinary. Baumol (1983) finds that phenomena of this kind may be difficult to capture with conventional quantitative approaches. In fact, Davidsson (2004) and Gartner (1985) posit that the goal of building entrepreneurship theory is to focus on its heterogeneity, identifying and understanding variables so that meaningful contrasts and comparisons among new ventures can be made.

Field research is also necessary due to the lack of comprehensive data for university spinoffs. As previously mentioned, AUTM data are limited to the number of spinoffs generated by institution. Data collection efforts by other organizations, such as the National Council for Entrepreneurial Technology Transfer (NCET2), are in their infancy and are at best incomplete. Many universities collect spinoff contact information and – in a few cases – have conducted studies or reviews of the contributions of their spinoffs.[12] However, the fact remains that there is no comprehensive source for

[12]For example, see University of Washington: Engine of a Knowledge-Based Economy, http://www.washington.edu/research/graphics/pdf/engine_low.pdf

university spinoff contact information, much less one that includes data relevant to factors of success for university spinoffs.

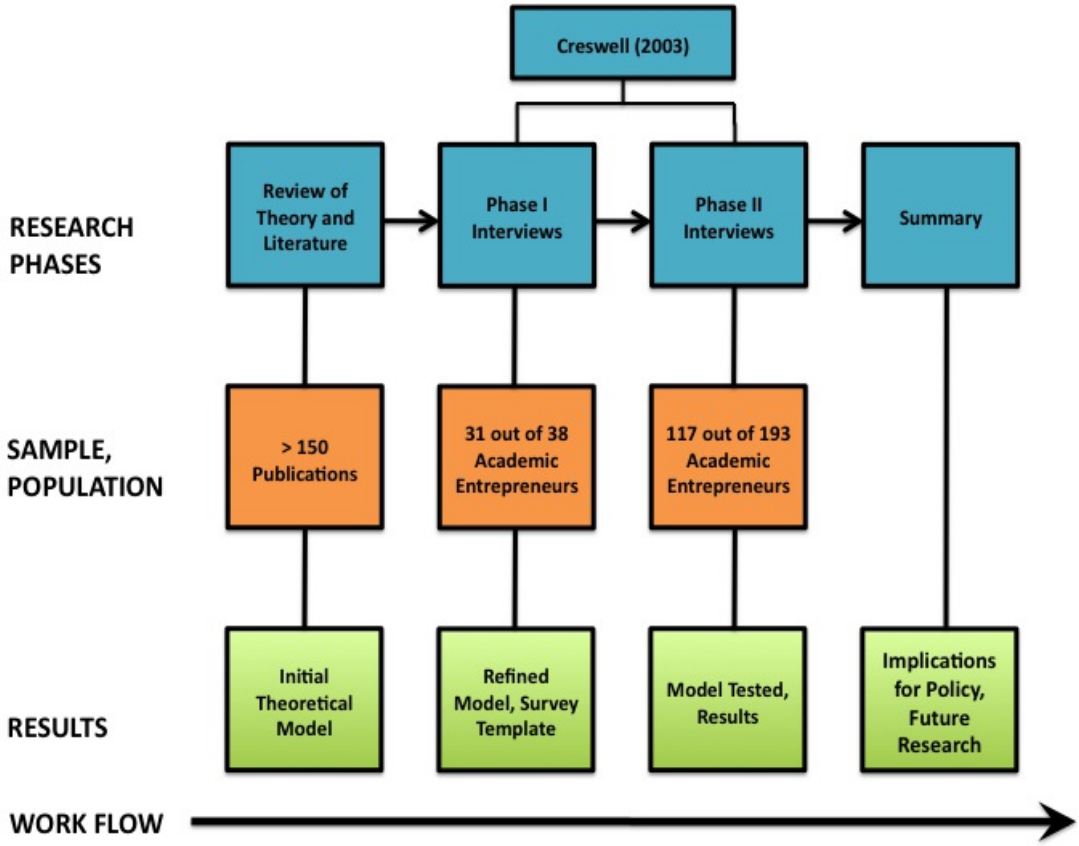
4.4 Sequential Exploratory Strategy

Sequential Exploratory Strategy (Creswell, 2003: 215) is used to collect and analyze both qualitative and quantitative data. Illustrated in Figure 3, the primary purpose of this method is to explain a phenomenon – in this case the phenomenon of academic entrepreneurship. An initial exploratory phase of qualitative data collection and analysis – primarily through interviews with academic entrepreneurs – is followed by a second phase of quantitative data collection in order to test the initial theoretical framework and assist in its interpretation. Figure 3 illustrates this methodology along with the population and outcomes for each research phase. The strategy is "most appropriate" when the phenomenon is heterogeneous, subject to a number variable factors and conditions (Creswell, 2003; Morse, 1991) – like variations in faculty policies, university IP policy, and public policies (Shane, 2004).

4.4.1 Data Gathering

Davidsson (2004) recommends that researchers obtain data from a sample of cases that are "theoretically relevant", reflecting the critical unit of analysis, the relevant variance in the characteristics of the phenomenon, and are "workable" from a practical

FIGURE 3: RESEARCH METHODOLOGY: SEQUENTIAL EXPLORATORY STRATEGY



point of view. He and other researchers (Yin, 1994) posit that replication, not statistical significance testing, is the crucial test for theory:

> The development and testing of sound theory requires replication in several sub-groups of analyzable size within the same study, as well as across several studies that investigate theoretically relevant samples from different empirical populations (Davidsson, 2004, p. 69).

Therefore, a diverse sample of academic entrepreneurs is needed for this inquiry, to understand the heterogeneity of academic entrepreneurship. A contact database was constructed comprised of university spinoffs of diverse institutions from different states, emphasizing a substantial degree of variance including different stages of development, technological focus, with varying locational and environmental factors. The research

focuses on spinoffs from public (state) universities under the assumption that state economic development and university governance policies may substantially impact spinoff success, acknowledging that the results are not generalizable to private universities.

In order to assemble a contact database of academic entrepreneurs, university officials and governors' offices are contacted from several states based on four factors:

1) Location in one of six geographic regions within the United States: the Northeast; the Southeast; the upper Midwest, the lower Midwest; the southwest, including California; and the northwest.

2) Presence of at least one research university from which at least three firms have spun off between 1996 and 2005;

3) Author's contacts within these state offices and universities; and

4) Willingness of state and university personnel to provide the author with contact information for their university spinoffs.

4.5 First Phase Data Collection

The first research phase is intended to inductively explore the research questions among a small purposeful sample of academic entrepreneurs. The compilation of contact information began in August 2008 and by September over 50 contacts had been accumulated. In mid-September, one state from each region of the country was selected for the initial interviews while the search continued for additional contacts for the second, quantitative phase.

States selected for the first phase include Connecticut, Virginia, Kansas, Oregon, California, and Iowa. Within these states, emphasis was placed on collecting spinoff contact information among universities that vary in student enrollment, research funding, and number of spinoffs. Spinoff contact information was collected from nine different

public institutions with extramural research budgets ranging from approximately $800 million to less than $25 million, total student enrollment ranging from more than 60,000 for a large Land Grant university to around 270 for a public medical school.

In an effort to obtain 30-35 initial responses (as recommended by the dissertation committee), 38 academic entrepreneurs were purposefully selected, representing – when known – a wide variety of scientific disciplines, products, and experiences. Academic entrepreneurs were contacted once through email correspondence to explain the research project and invite them to participate in a case study of their spinoff. If no response was received within one week, entrepreneurs were then contacted by phone and sent a follow-up email. Thirty-four contacts responded, thirty-one of which fit the definition of an academic entrepreneur.

4.1.2 Profile of the First Phase Interviewees

Academic entrepreneurs in the sample are of diverse backgrounds and are at different stages of their career, with different levels of involvement with the spinoff. Two have experience working in industry with the remaining respondents of more traditional academic backgrounds. They are mostly male (29 out of 31), have a Ph.D. (28 out of 31), Caucasian (24 out 31), and were born in the United States (23 out of 31). Their ages range from 28 to 67 with a mean age of 46. Four of the respondents have previous experience establishing a company; one of these individuals has established four companies. Thirteen of the respondents currently serve as chief executive officer (or some derivation thereof) for their respective company; ten serve as chief science officer

or scientific advisor, and six sit on the board of directors but play no role in the daily operations of the company. At least four have no direct role in the company.

Industries represented among the spinoffs established by the academic entrepreneurs include the life sciences, electronics, material science, chemistry, education, software, and aerospace. Products, existing or in development, include online learning tools, noise vibration diagnostic tools, therapeutic drugs, medical devices, cellulosic ethanol enzymes, biosensors, semiconductor etching equipment, disease-resistant crops, and environmentally-friendly protective surface coatings.

Academic entrepreneurs who agree to participate were interviewed by phone or in person; an interview template[13] was created to encourage respondents to volunteer unique and valuable information (Yin, 1994). Academic entrepreneurs were presented with a broad, open-ended question (the research questions) and their responses were recorded. Once respondents finished their initial responses, a round of follow-up questions were administered reflecting the extant literature.

Interviews were conducted from September to October 2008. From these open interviews, data were coded, counted, and then grouped into themes. Outliers were identified and follow-up interviews were conducted to provide insight as to why these factors diverged from the qualitative sample. Chapter 5 summarizes findings from these interviews, including how academic entrepreneurs in the sample defined success and the factors responsible for that success.[14]

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[13]The first-phase interview template, constructed by using the aforementioned open-ended questions guided by the literature, is available in the Appendix.

[14]In the interest of confidentiality and in compliance with George Washington University Institutional Review Board guidelines, the names of respondents, spinoffs, universities, and locations have been withheld and are replaced [in brackets] when mentioned in direct quotes.

4.6 Constructing a Survey Template for the Second Research Phase

Data collected from the first-phase interviews were used to construct a survey template for the second, quantitative research phase. In order to survey a larger population of academic entrepreneurs, a template was constructed based on the factors of success identified during the first research phase.[15] The second-phase data collection plan was molded according to Dillman's (1978) Total Design Method (TDM) customizing the research approach to the audience: the academic entrepreneur. With TDM, Dillman emphasizes (1) rewards, what one expects to gain from participating in a study; (2) minimizing of costs, what one expects to give up, and (3) trust, the belief that the reward will indeed come forward and will outweigh the costs (Dillman, 2000).

In operational terms, the interview request was structured in a way that emphasized the academic entrepreneur and the importance of their response to the quality of the work. Participant academic entrepreneurs were promised a summary of the results once the research is complete. In short, many academic entrepreneurs may have participated because they have asked themselves the same questions and are interested in the responses of other academic entrepreneurs.

Given strict guidelines to protect respondent confidentiality, the greatest cost to potential respondents was likely their time. These individuals already had academic responsibilities in addition to those related to their spinoff, not to mention little time for family or social life. With that said, it was predicted that trust would run high among these individuals. They are themselves researchers and understand the importance of response rates and student development vis-à-vis research projects. Furthermore, many of the potential respondents in the contact database were made through the personal

[15]The final, committee-approved second-phase interview template is available in the appendix.

contacts of the author providing access to many individuals who may not otherwise respond to such a request.

When constructing the survey template itself, the guidelines set forth by Leeuw, Hox, and Dillman (2008) were followed in an effort to minimize response and measurement errors as well as improve construct validity. Campanelli (2008) recommends that researchers consult experts while preparing a survey to ensure that it corresponds with their deep knowledge of the particular topic, their experience conducting field research, and cognitive perspectives. She also recommends that Ph.D. students utilize their dissertation committee members to vet their survey template. This requirement was satisfied by first drafting survey questions based on factors identified in the first research phase and subsequent comparison to the extant literature. The draft survey was then vetted by the dissertation committee, followed by university officials, and a small group of academic entrepreneurs who participated in the first research phase. While the process was time consuming, their feedback was valuable; their comments were used to refine and improve the survey.[16] Once the survey template was complete, request for interviews were sent out to the sample of academic entrepreneurs.

During the first research phase, academic entrepreneurs were identified from six states in different regions of the country for contact and interview: Connecticut, Virginia, Kansas, Oregon, California, and Iowa. Once the first-phase interviews began, additional sources of contact information were sought, including state and university representatives, economic development officials, and entrepreneurship researchers. Representatives from the National Science Foundation and the National Council of

[16]Again, the final, committee-approved survey template is available in the appendix

Entrepreneurial Technology Transfer (NCET2) were also very helpful. Contacts were collected from these sources from August 2008 to February 2009.

By February 2009, contacts from Arizona, Georgia, Illinois, Kentucky, Maine, Maryland, Montana, Nebraska, North Carolina, Utah, and Washington were added to the database, along with additional contacts from the original six states (see Table 3). In total, a contact database of 193 spinoffs representing 32 different public universities had been amassed.[17] All 193 academic entrepreneurs from the database were contacted once through email correspondence to explain the research project and invite them to participate in the study. If no response was received within one week, entrepreneurs were

TABLE 3: STATES AND RESPONSE RATE BY RESEARCH PHASE

	Phase I Research	**Phase II Research**
STATE	Connecticut Virginia Kansas Oregon California Iowa	Phase I States plus: Arizona Georgia Illinois Kentucky, Maine Maryland Montana Nebraska North Carolina Utah Washington
RESPONSES	31 out of 38	117 out of 193
RESPONSE RATE	81.6 percent	60.6 percent

[17]Several representatives did not wish their universities to be mentioned by name especially since a few of the universities only had one or two spinoffs a year (if that). However, listing spinoffs by state was deemed acceptable.

contacted by telephone and sent a follow-up email. Academic entrepreneurs were initially given the option of filling out a survey or answering a series of questions via phone or in-person interview. However, based on initial responses, the survey option was soon dropped (unless asked for) in favor of telephone or in-person interviews.

Although many academic entrepreneurs expressed interest in participating, finding time to connect with these busy individuals proved to be a challenge. Respondents were given one month to arrange for a phone call or in-person interview – or were otherwise considered "nonresponsive." Second-phase interviews began in early December 2008 and last through April 2009. By March 2009, all 193 academic entrepreneurs in the database had been contacted. Based on the criteria above, 117 contacts participated for an effective response rate of 60.6 percent. Chapter 6 outlines these results.

CHAPTER FIVE: PHASE I RESEARCH RESULTS

5.1 Spinoff Success Defined

During the first research phase, 31 academic entrepreneurs were interviewed and asked how they define success for their university spinoff. Though scholars of academic entrepreneurship have constructed their own proxies for success (sales, worker productivity, etc.), a thorough scan of the literature yields very few direct surveys of academic entrepreneurs and *their* respective views of success. During the interviews, academic entrepreneurs volunteered a variety of responses. Answers range from "getting our technology out of the university and into society" to "just staying alive" to "increasing sales of (their) products." In this section, responses regarding spinoff success are grouped by theme and ordered by plurality (See Table 4).

Dissemination of Knowledge

Nearly all of the respondents (27 out of 31) spoke of the desire to "get the technology out of the university." Most academic entrepreneurs in the sample saw the establishment of a spinoff as an important part of their academic duties. Many made clear that this idea of "entrepreneurial duty" is relatively uncommon among their peers.

TABLE 4: SPINOFF SUCCESS DEFINED

1. Dissemination of Knowledge

2. Technology Development
   a. Immediate Commercial Development
   b. Outside resources with no immediate development timeline

3. Personal Financial Gain

4. Career Motives
   a. Impact/public service
   b. Enhance relevance of teaching and research
   c. "Being own boss"
   d. Provide jobs

They see a spinoff, like publishing, as "just another path" for disseminating the results – and application – of their research:

> We conduct research everyday, we teach, we publish and – for some – this is enough…but I think I can get even more mileage out of my work if I can get it into other peoples' hands…you know, for others to actually use.

O'Gorman et al. (2008) finds that university faculty members are less interested in the financial success of a spinoff and tied the "benefits of commercialization" to their role as academics: recognition by their peers and more traditional university reward structures. The interviews seem to support O'Gorman's findings.

Other sentiments ranged from "seeing my technology used in new products," to "bringing a new technology to the market." An academic entrepreneur from an institution in the Midwest posited that, unlike the engineering school at his university, most of the "outputs" within his department are published papers:

> I began to realize that, after a long career that many would consider successful, I wanted to start a company. I looked around and saw that I had produced a bunch of papers…but the real value – various technologies and prototypes – was lying there on the shelf.

Several of the faculty members have consulting projects with companies and see spinoffs as another way to interact with the commercial world. They also see it as a way to have control over the utilization or "take up" of their research: "My research has been licensed out before only to set on someone's shelf…well, I said enough shelves, I want my technology to be put to good use and that led to [his company]." Other faculty members started their company because their university TTO had either (unsuccessfully) attempted to license their technology to another company or were skeptical that the technology held commercial value.

> I knew that if I left it in the hands of these bozos that nothing would happen (with my research)…indeed more than a year after my disclosure, nothing had. So, I started [my company]. In part, it's to show them that they were wrong.

An academic entrepreneur who specializes in display technology said that every time he switches on his TV he is reminded of the chip technology inside because the brand is clearly labeled on the console. This motivates him to continue his research and make sure he gets it "out of the university" vis-à-vis a spinoff so it would one day be a visible brand in consumer products.

Many academic entrepreneurs *also* define success in financial terms. These individuals do not necessarily see entrepreneurship as the quickest way to make money but rather as the most important vehicle for the dissemination of their technology. For example, a faculty member from an institution in the Pacific Northwest explained:

> My company provides me with another way to see what I can do with my research…if I just wanted to make money I would consult more actively…I could make a lot of money consulting with the large drug companies – and have – but [my company] allows me to get my technology out into the world and hopefully witness its impact.

Respondents also spoke of entrepreneurship as a way to disseminate their research in order to "give back" or to provide benefits to society at large.

> Many faculty members (including myself) become enchanted with the idea of starting a company and getting rich…driving a Porsche…but once they realize how much work it entails they often lose interest…for me, I would have bugged out (sic) long ago if I were only in it for the money…I love the thought that my research might have an impact on the world.

Another academic entrepreneur shared that the only way his research could help people is to be "patented, spun off in a company, and eventually developed into a drug…big Pharma doesn't have an incentive to invest in this because it won't be a blockbuster – but we might find a small, specialized company to invest if we can get these to clinicals…or nearly there."

Technology Development: Commercialization vs. Research

The second most common response among academic entrepreneurs (26 out of 31) relates to the development of their technology. Nearly all of the respondents see the success of their respective company tied to a series of "small wins": "it's not something that happens linearly, but there are important milestones along the way." While licensing technology from the university seems to be the first "small win" for respondents, the second typically relates to the ability of the academic entrepreneur to develop their technology with "resources not available within the university."

When coding the responses of academic entrepreneurs in the sample, however, a dichotomy emerged as to how they view technology development. In the first group (15 out of 26), academic entrepreneurs defined development as an important means to commercialize their research. Defined broadly, technology development includes the creation of prototypes, market studies, clinical trials, performance and safety tests, and other actions necessary to develop a technology into a product. Recent research uses commercialization or derivations thereof as a proxy for firm success (Link and Ruhm, 2009).

The second group (11 out of 26) defined technology development differently. While these respondents do not necessarily preclude commercialization, development proceeds with no immediate timeline for commercialization and is more closely tied to the academic research of the entrepreneurs. These individuals view their spinoff as a vehicle to consult and pursue other sources of funding not available within the university.

> In addition to our duties at [the university], we consult, we spend time in the lab, and we've hired a couple of people to do research…that's plenty with the one day that [the university] gives us…if I can find other sources of money to do these things then, to me, that's success.

While these academic entrepreneurs stated that they "eventually intend" to develop a proof of concept or explore other means to determine the commercial viability of their technology, they see themselves as successful because they have used their company to continue their academic research using outside resources that are not otherwise available – or not as easily obtained – as a university faculty member. Principal among these "outside resources", are Small Business Innovation Research (SBIR) awards.

> I don't really have any desire to run a business but we needed to form a company to go after these SBIR awards…I have R&D money from [this funding agency] and now I have three Phase I awards and one Phase II. That's about a million dollars…a big chunk of change to continue my research. How could you *not* define that as a success?

In fact, eight of these (11) individuals specifically mentioned the SBIR program as one of the primary reasons for establishing their company: "I started my company to take advantage of SBIR awards." Three academic entrepreneurs indicated that, in addition to SBIR, they formed their company to conduct research for large multinational firms and attract additional funding from industry at large.

> [The partner company] is frustrated with [our university]…our overhead is through the roof and then they are tired of dealing with our tech transfer office. We've been working with these guys for years so we licensed the research from the university, formed a company, and now have several contracts with them….that also gives us a great platform to go after (research) contracts from other companies in the industry.

The differences between the two respondent groups were subtle but important. The literature highlights the importance of commercialization to the success of companies and we know that academic culture differs substantially from for-profit enterprises. Yet the extant literature often fails to recognize that some companies may not be established with commercialization as an immediate goal. This idea will be revisited in later chapters.

Personal Financial Gain

A majority of academic entrepreneurs in the sample also define success in terms of personal financial gain; it was the third most common response (16 out of 31). While four entrepreneurs spoke of their desire for substantial financial gain ("I am not ashamed to say that I want to make lots of money"), most respondents articulated modest financial

goals. With one exception, personal financial gain was always given as a motivation among others:

> Yeah, I want to make some money but I am mostly in it to get my technology out the door.
>
> I think with my idea of success, I would definitely be making some money, but – C'mon – if money were the object, I wouldn't have become a university professor.

Three respondents used the exact words, "I am not trying to become a millionaire" while another sees financial success "as a beneficial side effect." Others associate financial success with specific material goals: "I need to get my daughter through college"; "I look forward to buying a boat"; and "I have a lot of bills to pay…alimony, mortgage, and school loans."

Several spoke of how their financial ambitions have changed through their experience as an academic entrepreneur. One respondent established his company with ambitious financial goals ("I set out to make money"). However, during his ten years as an entrepreneur he not only realized that financial success was uncertain, he also learned of the risk for financial loss ("I was lucky that I didn't lose my ass"). For another academic entrepreneur, financial success had become relatively more important: "I woke up one day and realized that I had been 'raped' by the venture capitalists…without making sure that I saw some kind of decent return…now I am working hard to change that."

Career Motives

The remaining views of success are assembled into a broad "career motives" category. Several academic entrepreneurs (6 out of 31) expressed their dissatisfaction with the "status quo of academia" and wanted "something more" from their career. For example, one faculty member from a Midwestern university had taken a sabbatical, realized that he was "more than halfway through my career," and chose to start a company in order to have "much more of an impact on society." These respondents spoke of a personal experience or mid-career realization that it was "time to do something else."

> Frankly, I've done it all, I've brought in millions to [this university], I've won lots of awards, and I enjoy being a professor…but starting a company…that is something that I need to do so I can see if I can do it.

Academic entrepreneurs in the sample see spinning off a company as closely related to the "public service mission" of their institution. To them, spinoffs are an important vehicle to disseminate knowledge and interact with the outside world. A handful of respondents (4 out of 31) also defined spinoff success in terms of enhancing the "relevance" of *their* university work: teaching and research. One academic entrepreneur spoke of the "virtuous cycle" that she had experienced during her involvement with three different spinoffs:

> I have been doing geriatric research for years…much of this has been in the lab but once I started working with [the company she co-founded] we began to work directly with older ladies…I realized the problems that are going to confront society when the baby boomer generation gets older…I think a lot of my colleagues have no idea what is coming but this really gives new life to my academic research.

Another respondent spoke of the impact that his entrepreneurship experiences had on his teaching and advising duties.

> It's a completely different ball game in the classroom now…I mean, I crashed and burned with the company and that's tough but I am now starting my second. These experiences come with a lot of lessons…lessons that I make sure my classes get. It's a different world…tougher…as an entrepreneur…but it comes with a lot of rewards. Now two of my students are part of the new company.

One respondent shares how starting a company helps him be "cutting edge" in both his research and teaching responsibilities: "most of my students will not become academics…they will go into industry…they should know that they can also start their own companies and know what to look for along the way." While modest, the literature supports this notion that faculty members previously involved in commercial activity tend to stay involved in commercial ventures and consistently outperform their peers in terms of publications and citation frequency (Meyer, 2006; Gulbrandsen and Smeby, 2005; Zucker et al., 1998).

Three respondents, all of whom have resigned their position at their respective universities, articulated that success means being their own boss. While most academic entrepreneurs seem reluctant to give up their faculty positions (O'Gorman et al., 2008; Johansson et al., 2005), these individuals spoke of reaching a certain point where they were ready to move on so they "could do my own thing…it's fun and a little scary betting on what you can do." One of the respondents worked for a large chemical company prior to entering academia and needed a change: "I could never go back to working for someone else…especially someone in a large company…lots of bureaucracy…and I basically felt the same after a few years at the university."

Finally, three respondents spoke of success as providing interesting, well-paying jobs to individuals in the region. The majority of university spinoffs in the initial sample employ few people. When they do, they might employ a professional manager, a researcher or two, part time technicians, and/or administrative assistants. However, two of the spinoffs employ 32 and 79 employees, respectively, and in both cases the academic entrepreneurs take pride in their responsibilities as employers.

5.3 Spinoff Success Factors Identified

During the interviews, academic entrepreneurs are also asked what factors they see as critical to the success (or lack thereof) of their company. Through these interviews, 15 broad factors were recorded and coded that register at least three times with respondents. With a Sequential Exploratory Strategy, Creswell (2003) recommends researchers compare and contrast the qualitative data to the extant literature, however limited, and use these observations as the basis for constructing a survey template during the second, quantitative research phase. In this section responses are grouped by theme but are otherwise in no particular order (See Table 5).

TABLE 5: SPINOFF SUCCESS FACTORS

▪ Financial Resources ▪ Previous Spinoff Experience ▪ Industry Ties ▪ Faculty Involvement ▪ Management: Faculty or Outside ▪ Administrative, Peer, Institutional Support ▪ Technology Transfer Offices ▪ University IP Policy ▪ Quality of Life	▪ Multiple and Outside Licenses ▪ Joint Ventures (Open Innovation) ▪ University Entrepreneurship Services ▪ Regional Entrepreneurial Environment ▪ Industry Affiliation ▪ Public Policy

Financial Resources

Nearly all respondents (29 out of 31) spoke of financial resources as a critical factor for the success of their spinoff. Financial resources include: personal funds, investments from friends and family, venture capital, angel capital, bank loans, federal government grants such as SBIR and DOD development funds, state grants, and foundation funding. The importance of financial resources to company success is well documented in the literature (Wright et al., 2006; Lockett and Wright, 2005; Zucker et al., 2002; Lockett et al., 2002; Shane and Stewart, 2002). Several of the respondents emphasized the importance of attracting venture capital to their business: "it is critical that we bring in VC, or else we are sunk…and its going to be difficult in this market to do that." Others have more modest goals; many academic entrepreneurs were happy to receive additional financial resources from family members so that their business could survive.

Discussed below, respondents also emphasized the contribution of federal and state funding programs, especially SBIR. Others mentioned so-called state "Phase Zero" programs that help academic entrepreneurs (among others) apply for SBIR awards and state programs that provide a dollar-for-dollar match for federal SBIR awards. Two respondents have received "startup grants" from their respective states designed to provide early-stage funding to write business plans, purchase equipment, and continue technology development. Recent research, while modest, suggests positive commercialization outcomes in companies that have received NIH SBIR awards (Link and Ruhm, 2009) and anecdotal evidence of their impact among university spinoffs (Shane 2004).

Previous Experience Establishing a Spinoff Company

While only four of the 31 respondents had previously established a university spinoff, all four insisted that their (previous) experience as an academic entrepreneur translates into success for their current company. "You essentially learn what not to do," recalls an academic entrepreneur from a university in the southeast. "It took me about seven years of fumbling around to understand where I was going with my previous company. With my current company, I knew exactly what we needed to do the day we registered it."

Another entrepreneur spoke about the importance of understanding the market and how by "crashing and burning" his previous spinoff, he now at least knows where there "was *not* a market":

> You really need to have some experience that tells you 'this is where you are going, this is your product, this is how you make it, and this is who you sell it to.' Most university professors don't know how to answer any of these questions. Well, a million dollars and several years bought me those answers…but only after it was too late…but you learn and you move on to found another company knowing a lot more about what you need to do this time around.

Respondents also found angel and venture capitalists more willing to talk to them after they had gained experience as an entrepreneur. One faculty member spoke of his first effort to establish a company: "we simply ran out of money but the science was sound and, better yet, we got pretty close to a prototype. I won't say these guys (VCs) are vultures, but they knew exactly when to walk in: my partner and I we're well underway in our second spinoff when they began showing interest."

Ties to Industry

Relationships and experience with industry was a recurring factor of success put forth by more than half of the academic entrepreneurs (17 out of 31). Respondents spoke of their ties with "professionals who's job it is to develop and commercialize products" as a critical factor to the success of their company. For many of the respondents, these relationships emerged through consulting opportunities outside the university:

> You would be surprised what I learn during my 'one-day-a-week consulting job.' We work with these companies to help them overcome technical challenges… many times, we don't have a clue about an engineering problem or challenge but we do bring a different perspective: a knowledge of the science behind it. And that matters to them…I have also greatly benefitted. Working with industry forces to ask the 'right questions' when you are starting your own business…and that has been crucial to our success.

The literature finds that the lack of commercial and management experience among university scientists restricts their understanding of commercial markets (Bekkers et al. 2006; Wright and Lockett, 2004; Franklin et al., 2001). It would therefore be plausible that consulting experiences help bridge the gap of understanding and give commercial relevance to academic research, contributing to the success of a spinoff (O'Gorman et al., 2008; Zahra et al., 2007; Vohora et al., 2004).

Respondents not only spoke of the importance of consulting, they also cited the importance of working with industry in a number of capacities including sponsored industrial research, co-publication with industry scientists, attending conferences, informal meetings with industry researchers, and "just chatting about each-other's work." For one respondent, a company that had sponsored research in his academic lab became an important initial investor in his company. For another, one of his co-founders was a representative at a large company with whom this academic entrepreneur had worked.

Well supported in the literature, university scientists that have industry experience, have received industry funding, or work on translational or development projects, have a higher propensity to patent, license, consult, and start companies (O'Gorman et al., 2008; Audretsch et al, 2005; Dietz and Bozeman, 2005; Gulbrandsen and Smeby, 2005; Roberts, 1991). In contrast, two respondents indicated that *who* you work with in industry really matters. In many corporate and business labs, industry researchers are no more adept at commercialization than their academic counterparts: "they really know the science and basically leave it up to others to do the development work…I mean, they have been asking *me* about *my* commercialization plans."

Faculty Involvement

Though respondents indentified their "involvement" as a critical factor to the success of their spinoff, the *way* they are involved varies widely. This involvement ranges from CEO of the spinoff ("without day-to-day leadership this company would have failed") to chief science officer, technology consultant, Board of Directors, to little or no involvement once the company was established. For faculty CEOs, their involvement is all consuming with little free time – and conflicts at times with their teaching and academic research responsibilities. Other faculty members are the "critical link" to the development of the technology even though they may not be involved in the day-to-day management of the spinoff: "those guys are running the company…but no one knows this technology better than I do so my involvement is critical." A few spoke about "watching the spinoff grow from a distance."

I stay involved…but I guess you could say that it's more as a cheerleader than

> anything. They keep me in the loop and have me over often…and I want to see them do well. After all, I own quite a bit of stock…but – for the most part – I am not very involved…and that's fine by me.

Faculty involvement – and *how* faculty are involved – is explored by the literature. Zucker et al. (2002) find an increase in research productivity among licensees when university faculty members are involved in company research. With that said, quality matters: Louis et al. (2001) and Zucker et al. (1998) suggest that higher 'intellectual capital rates' among university faculty members lead to a greater number of spinoffs.

When it comes to startup/spinoff success, Roberts (1991) finds that among a broad sample of entrepreneurs in the Boston area, those with Ph.D.s (most of whom come from academia) fare less well in their entrepreneurial endeavors, than those with "some" graduate school or an undergraduate engineering education. In a study of Georgia Tech's ADTC incubator, Rothaermel and Thursby (2005) find that having a university professor on spinoff's senior management team reduces the probability of failure but also retards the firm's graduation from the incubator.

Faculty Leadership vs. Outside Management

Related to faculty involvement, there seems to be a division among the 31 respondents between those that see outside management as a critical element of success and those who think their leadership as CEO is critical. Several respondents spoke of the "great pressure" to establish a company within universities and with it the "prevailing notion" that spinning off a company means that the faculty member would establish the company and eventually take leave (or resign her position with the university) to run the

company. Several faculty members accepted this faculty-as-CEO model as a reality. Others deemed the notion "preposterous."

Regardless, even the most enthusiastic academic entrepreneur is hesitant to give up their academic position creating a tension between their academic and spinoff responsibilities. Most respondents agreed that it is nearly an "impossible task" to balance their time between their spinoff and their academic obligations, much less their personal responsibilities.

> There is quite a bit of interest…maybe a little pressure…to start a spinoff companies. I was interested in doing this…it seemed to make sense. The problem is that this is on top of our already busy schedules…how I am I going to run a company, fundraise, hire people, file paperwork, and then continue to teach and do research?

While some view spinoff success as dependent on their involvement in the day-to-day operations of the company, others see spinoff success related to how well they limit their involvement with the company. In the first group, there is a strong desire and curiosity to establish and lead a company – and be good at it. One academic entrepreneur left his home university ten years ago and had gone on to establish four companies.

> I know that some schools don't want faculty running their own companies but that wasn't something I was going to do…I said 'this is my baby so let's see where it goes.' I eventually left the university to do it but a lot of faculty just aren't willing to take that step. You don't see that very often but this was something that I needed to do and the success of our company has been dependent on me being here.

Other respondents see the leadership of their company by an individual with previous management experience as a critical element to the success of their spinoff: "without [the CEO] we would be nowhere with the company…he has come in and breathed new life

into what was a few months ago a side project of mine." Many faculty members describe how outside managements is critical given their time constraints and lack of experience:

> I don't know the first thing about running a business; I am scientist and enjoy teaching and working with students. Starting a business requires a lot details and care…things that I am simply unable to do. I also don't have the same contacts with the business world. That's why hiring [the CEO] was one of the most important decisions we ever made.

Others spoke of the importance of hiring a CEO early in the spinoff process:

> We've learned a lot on this point…you really need someone to come in to get the company off the ground. It's a lot of work and really requires a person who will find the right people, find funding, and really get the business going. We learned this with our previous company and then, of course, in our more recent talks with venture capitalists…any VC funding is dependent on having good, outside leadership.

Among those that had experience with outside CEOs, not all of the experiences were positive and, in fact, two were detrimental to the initial success of their spinoff.

> When I started my first company in the early 80s (the university) told me how important it was to have someone with business experience run my company…I mean, I didn't know what I was doing at the time so I said ok…and then a few weeks later they brought in this bozo from [a nearby city]. Well, that lasted all of about eight months…just long enough for me to figure out that this guy didn't know jack (*sic*)…

In the aggregate, however, the literature is fairly clear: the presence of an outside CEO within a university spinoff increases its probability of commercial success (Radosevich 1995). The literature posits that academic norms and culture may discourage (or at least does not encourage) relationships with industry or interactions with the market, thereby creating barriers to understanding and emulating entrepreneurial behavior (Chiesa and Piccaluga, 2004). Furthermore, "surrogate entrepreneurs" with commercial experience

improve the number and quality of linkages to other business experts and increase motivation for financial gain (Franklin et al. 2001).

Administration, Peer, and Institutional Support

Support by the university administration, especially at the Dean and department head level, was among the lesser-mentioned factors of success (6 out of 31). While respondents articulated the importance of institutional policies on their decision to spinoff a company, post-spinoff institutional support related more to the flexibility and dispensations given to a faculty member to work with their spinoff. In particular, faculty leave policies and flexibility in scheduling were most often mentioned as a proxy for institutional support.

Faculty members typically spoke of the "overwhelming support" of top university leaders – the president and provost – due to the publicity that spinoffs bring their institutions:

> The administration has always been supportive of our efforts because we make the university look good when they are speaking with the legislature…I mean, the president is selling the university as the economic development engine for the state so we are an important part of that case.

With that said, institutional support is a dynamic, multi-level concept; two respondents spoke of a "sea change" in the attitudes toward spinoffs with the arrival of a new Dean. New leadership brought in "a completely new mindset to our role within the university…one where excellence and engagement goes hand-in-hand." Important for this was "a real interest in working with both the outside community and other places in the world…one where we began to meet people that would ask us: 'you ever thought

about starting a company'…and I attribute a lot of our eventual success to those initial conversations."

Conversely, one respondent spoke of the "collapse of everything entrepreneurial" with the hiring of a new department head for his university's chemistry department.

> This new guy comes in who is really well known for his research but has no clue about working with industry or starting companies. His first priority is getting in more government R&D dollars which is fine but all these other activities don't seem to matter. I started my company and was given quite a bit of flexibility…and now, poof, it's gone…it's terrible.

With regard to their peers, a few academic entrepreneurs felt they are part of a "cadre" of individuals who "just think differently about their role as academics." They attributed much of their success to having "people to talk to about what to do next…people who have been exactly where I have been and struggled with the same issues" and this in turn creates "some really strong bonds and has a huge impact on the attitudes of our graduate students and other faculty members…especially new ones." Other academic entrepreneurs lamented that "we just don't have anyone to ask: what do we do next…none of our colleagues have been where we are going…none of them have started companies."

When it comes to other colleagues who have not established companies, most respondents felt their peers are "agnostic" to their entrepreneurship activities especially establishing a company "outside the university."

> There are a few of us who have started companies and we talk…but honestly, I don't think many of my colleagues really care what we do. I will say that when [a colleague] sold his company, that raised a few eyebrows and probably created a little jealousy but it wasn't a huge deal…if anything its got these guys thinking 'hey, maybe I should think about starting a company'…oh, and there is always the occasional old humanities professor who thinks anything to do with industry is taking us all to hell…but you get used to that…it comes with the territory.

While respondents did not speak of larger philosophical debates over the purpose and principles of academia (Slaughter and 2000; Franklin et al., 2001; Samson and Gurdon, 1993), administration support, peer guidance, and the overall culture of their institution clearly matter in the literature. The impact of culture on entrepreneurial activities is well-documented (Chiesa and Piccaluga 2004). Shane (2004); Bauer (2001); Feldman and Desrochers (2001); Hsu and Berstein (1997); and Roberts (1991) find that an entrepreneurial culture, social norms, and role models matter. On the last point, Bauer (2001) finds that faculty peers can provide early mentoring to aspiring academic entrepreneurs in areas such as starting a business and finding early-stage funding (Bauer, 2001).

Technology Transfer Offices (TTOs)

Respondents indicated that the technology transfer process as managed by their university's TTO is an important (and often detracting) factor of success for their respective spinoff. Two distinct camps emerged among the respondents with regard to TTOs: academic entrepreneurs who view TTOs positively or agnostically and those that do not.

For the first group, respondents felt that their TTO is "courteous, responsive, and really gets the bigger picture…we were treated like a customer." Other respondents acknowledged that they had heard of the "bad reputation" of TTOs but speak of their experience in a positive light: "I have heard horror stories from other universities but I have to tell you that our experience was surprisingly good." Another respondent was

very pleased with her experience with the TTO: "I can tell you that [this university's technology transfer officer] is really good…he put me in touch with funders, introduced us to our attorney, and is now finding us someone to run the company…I couldn't have asked for more."

The second, more vocal group seemed frustrated with TTOs primarily for reasons they attribute to "inflexibility, incompetence" and – perhaps related to IP policy – "greed." In one extreme case, an exasperated respondent stated: "I basically equate our tech transfer guy with Satan." Another respondent was also unhappy with the technology transfer process to the point of anger.

> I have to tell you that I went to the mat with these TTO guys and lost…they really nickel and dimed me to death…so now that I have made a little money I can tell you that the university has had its cut and is not going to get any more of my money…I have told them that I'm going to give a substantial contribution to [his undergraduate institution] just to piss them off.

Other respondents were more tempered in their complaints: "TTOs are put in a nearly impossible position…they deal with hundreds of disclosures and smart-asses like me. They have to try and make sense out of some complicated rules and, on top of that, pay for their salaries out of our hides. This drives a lot of the bad behavior that you hear about." Another common complaint related to the "lack of differentiation between large companies and spinoffs…we are university employees…why are they charging us the same licensing fees as a company that is not even located in the state?"

Despite these unhappy accounts, the majority of the respondent academic entrepreneurs did not see the TTOs as playing much of a role *after* their spinoff has been established: "yeah, it was a pain with all the paperwork but after we got our license it was pretty uneventful if you ask me." More common were comments about TTO offices not

having enough staff or simply not having the depth to be able to understand "some very complicated and esoteric technical issues…along with the fact that there is not really an industry that exists around these early-stage technologies…it has got to be difficult."

An academic entrepreneur whose technology came out of his university's School of Education spoke of the difficulty that the TTO had in:

> What to do with us…whether our technology needed to be patented, copyrighted, or none of the above…and then what was our business model. I think they are used to dealing with faculty from engineering or the sciences…but we really broke the mold. With the few people that they have, they can't understand everything under the sun so it was tough for them to really know how to help us."

A more robust literature exists on the mission, staff and resources of TTOs related to their commercialization performance (Phan and Siegel, 2006; Shane, 2004; Roberts and Malone, 1996; Lockett and Wright, 2005; Markman et al., 2004). However, while the literature has examined the impact of TTOs on the overall number of spinoffs out of individual universities, it is not clear what impact they have on the *success* of spinoffs once they have been established.

IP Policy

TTOs are governed by intellectual property policies set forth by their respective university within the parameters of the 1980 Bayh-Dole Act. Siegel et al. (2003) find that IP policies and organizational practices can enhance or impede technology transfer effectiveness. Unlike vocal critics of the technology transfer process, respondents did not speak often about the specific terms of their licensing agreements with the exception of the aforementioned lack of differentiation between large companies and university spinoffs: "In the past, I have felt like there is no preference for faculty members who

actually want to license a technology and then start a company around it…for TTOs, its easier to license to a large company – no questions asked. Luckily [his university] has changed its policies to give spinoffs preferential treatment."

Many responding academic entrepreneurs see IP agreements as "standard language" or "terms that are similar to the other places where I have worked." Their frustrations lie in the perception that TTOs try to "negotiate even higher royalty rates because they think your technology is a slam-dunk." According to the literature, aggressive university patenting activity may retard the pace of knowledge "exploitation" retarding industrial innovation; and conflicts over intellectual property rights are one of the biggest barriers to the spin-off process and knowledge (Clarysse et al., 2007; Steffensen et al., 2000). This did not seem to be a chronic problem among academic entrepreneurs in the sample.

Other academic entrepreneurs spoke about the tension in university IP policy between non-exclusive licenses and the need for spinoffs to hold exclusive licenses: "the TTO wants to charge us a premium for licensing to us exclusively yet we don't have the cash to cover the difference…so you are put in a really tough situation." This is an important point from the literature; Shane (2004) finds that exclusive licenses encourage spinoff, especially in the biosciences.

The most common IP policy factor mentioned by respondents is the willingness of their university to accept equity as payment for patent costs, patent maintenance costs, and other fees associated with licensing. Equity deals are very popular among academic entrepreneurs for cash-flow purposes; they do not need to come up with tens of thousands of dollars in cash at a time when cash is most precious to their spinoff. The notion is

supported in the literature: Jensen and Thursby (2001) find that equity promotes inventor involvement, which is critical to success of university spinoffs.

Multiple and Outside Licenses

When it comes to the success of their spinoffs, several respondents emphasized the importance of taking a "non-linear" approach to licensing technology both from within their home university and from outside sources. In the first case, respondents expressed the importance of pooling patents from their research to create a product: "this is not a one patent equals one product deal," volunteered one faculty member from a university in the pacific northwest. "I have been working in this field for over 20 years so I have a lot of patents to my name. When it came time to start my company, I needed most of these patents…not just one."

In the second case, several respondents spoke of the importance of working with other university researchers and – in some cases – company researchers to develop their technology: "We are trying to develop a complex product – one that has many components…and we must either go out and buy these components or find out who is working in this area. I don't know how we could do this any other way." Other respondents supported this notion by seeing a patent, along with informal relationships with other researchers, as "a piece of a much bigger technology puzzle."

> If you are really focused on creating a product then there are several hurdles along the way, especially technical ones. We have licensed several of our patents from the university but we have also worked with other researchers from other universities and companies…we have licenses or material transfer agreements from several of them.

The literature with regard to licensing and technology sourcing decisions of spinoffs is modest: Shane and Stuart (2002) and Shane (2004) find that the number of patents held by a spinoff at time of establishment reduces the likelihood of company failure.

Joint Ventures

Respondent academic entrepreneurs spoke of the importance of joint ventures to the success of their spinoff. The Organisation for Economic Co-operation and Development (OECD) defines a joint venture as an association of firms or individuals formed to undertake a specific business project.[18] While faculty relationships with industry vis-à-vis consulting and sponsored industrial research are important, respondents characterized joint ventures as an important but more formal cooperative agreement between their spinoff and other companies. These joint ventures, typically contractual, cover a broad range of cooperation: research, product development, manufacturing, product marketing, and supplier purchase agreements, among others.

According to respondents, joint ventures contribute to the success of university spinoffs for two primary reasons: financial stability and technical know-how. Academic entrepreneurs see joint ventures as a way to "tap into the strength of a large company and develop our product while making payroll." While joint ventures vary widely in scope, many spinoffs are small so even the most modest of joint venture can be meaningful: "they have us for one day a week which may not sound much, but that also means we have them for one day a week in our lab." One respondent from a university in the Midwest posited that a joint venture with a large electronics firm essentially "made" his company:

[18]http://stats.oecd.org/glossary/detail.asp?ID=3243

> Compared to our little company of 3 employees, [their partner company] is huge, well known, and has deep pockets…we are a blip on the screen for them…but we now have a research project with them that essentially funds the company for two years…and allows us to grow."

Another respondent spoke of how a joint venture with a large semiconductor company led to a substantial corporate venture capital investment:

> We have been working with [their partner company] for years…they know our technology and we know how we fit into theirs. They aren't interested in buying us – yet they definitely want to see us succeed to the point where they have become our primary investor. I mean, its definitely still 'wait and see' on the technology…but we now have the resources to take it to the next level.

Beyond financial stability, several respondents expressed the importance of partner researchers in the development and commercialization of their technology, especially in the prototyping and manufacturing of products.

> We know the science behind acoustics and vibration…and we have even built devices in the lab that help us detect and interpret vibration in aircraft…testing and mass-producing these sensors is a huge challenge for us…we simply don't have the facilities or equipment that we need…we have been working with [their partner company's] engineers for a few months…one day they come back to us and say, ok, we have built a couple of dozen of these. When can you guys come over so we can test these out?…and they are already talking about scheduling field trials…we could have never done that on our own.

For one respondent whose spinoff is attempting to develop a small-molecule drug, "a joint venture with a Pharma company is really our only hope for success." When asked to expand on what he meant, he explained:

> We can do everything right…we can hire the best people, we can have the best science, we can raise millions in VC and we can show promising results in the lab…but even with that, nothing is guaranteed…20 million, 50 million, even 100 million dollars is a drop in the bucket compared to what it will take to get us through clinicals and FDA approval…so that's why a joint venture is our only option and hopefully we'll get bought out along the way…but we are not the only one…every biotech startup is trying to do the same thing.

Although RJVs primarily serve the technical and financial needs of spinoffs in the sample, other types exist. One respondent has a marketing agreement with a large multinational: "yes, we develop and manufacture diagnostic kits right here but [their partner company] sells them through their distribution network." Another respondent spoke of their joint venture with a large defense contractor and their role in pursuing government R&D contracts: "as a small business, we some have advantages in the procurement process…[their partner] has helped us apply for these grants and closely follows our progress…and has provided some technical assistance along the way…if we prove the technology, then they'll probably scoop us up…it's a good arrangement for us both."

While the literature is lacking with regard to the role of joint ventures in the success of university spinoffs there exists a robust literature on research joint ventures (RJVs), typically among larger companies (Hagedoorn et al., 2000).[19] Studies of formal RJVs in the United States find that individual firms use them to pool financial and intellectual resources, overcome high technological uncertainty, improve appropriability of research outcomes (spillovers), and improve their technological capabilities (Vonortas, 1999). RJVs are especially important in high-technology industries comprising the largest proportion of cooperative agreements in biotechnology (30%) and information technology (27%) (Freeman and Soete, 1990).

[19]Required by the antitrust provisions of the National Cooperation and Research Act (NCRA) of 1984 and the subsequent National Cooperation Research and Production Act (NCRPA) of 1993, companies have registered seven hundred and forty six RJVs between 1985 and 1998 – and hundreds more since (Vonortas, 1999).

Open Innovation

It is striking the degree to which respondents emphasized the importance of technologies and technical assistance external to the spinoff vis-à-vis funders, multiple and external licensing, and joint ventures with other companies. With a few minor exceptions, the initial review of the technology transfer/entrepreneurship literature yielded no deliberate focus by researchers on the relationship between these external linkages – beyond connections with venture capitalists and where noted above – and technology commercialization. It was clear from the interviews that informal and formal partnerships are critical to spinoff efforts to both obtain new technologies and solve complex technical problems relating to their proprietary technologies.

The author returned to the literature, this time casting a much broader net. The corporate management literature yielded a promising paradigm that might be applied to spinoff commercialization: Chesbrough's (2003) concept of Open Innovation. Open Innovation highlights the importance of innovation strategies that focus on solving technical problems by utilizing technologies and research outside the boundaries of a firm (Chesbrough, 2003). Companies like Proctor and Gamble, Apple Computer, and Intel do this by structuring a wide range of formal and informal partnerships designed not only to solve their own internal problems but also help other companies tap into the their intellectual property.

The Open Innovation literature primarily focuses on innovation strategies in large multinational companies or large-scale open source software projects. However, there is increasing interest in applying the Open Innovation concept to other types firms and institutions such as universities (Chesbrough, 2009). Given the first-phase responses

from academic entrepreneurs in the survey, Open Innovation may be an important concept to aid in the construction of KSTE

University Entrepreneurship Services

Respondents were clear on another factor important to the success of their spinoff: the availability of entrepreneurship services, including business 'startup classes', commercialization services, legal assistance, and connections to angel and venture capitalists. Several academic entrepreneurs shared their initial uncertainty as to "where to look" for help in establishing and growing their business. With no clear knowledge of entrepreneurship services, respondents most often consult their technology transfer office, their university's business school, and other academic entrepreneurs within their university (especially within their department) seeking guidance as to where to obtain assistance.

No mention of the role of business schools in the provision of entrepreneurial services to spinoffs was found in the literature. Four respondents spoke of how they approached business school faculty seeking guidance on how to establish and grow their company. In three of these cases, the business school was "worthless…useless" or "never got around to helping me." In another case the business school was quite willing to provide assistance to the respondent academic entrepreneur but did not have the capacity to understand or support entrepreneurship.

> When I was thinking about starting the company, [the technology transfer representative] and I were brainstorming one day and came up with the idea of approaching some of business school faculty. I mean, these are my colleagues and I figured they must know something about starting a company if they are experts about business. Unfortunately, I learned that these guys don't know much

> about small business or spinoffs. They study large companies…but when it comes to companies like mine, forget about it.

Another model is one in which universities have created in-house entrepreneurship services for academic entrepreneurs. Two respondents shared how their university is very proactive ("from the time of disclosure") in providing support to academic entrepreneurs. This university offers a wide range of services to their spinoffs, including legal services, small proof-of-concept grants, scale-up and growth consulting, and a prototyping center – a function very popular with the two respondents from this particular institution.

> Establishing my company couldn't have been any easier. [His university] has several people on staff who have great resumes and who have previous industry experience…they are very professional and helpful. They worked with us from the beginning to help us set up [his company] and I would say they have been a huge factor in our success.

While respondents are located at universities in various regions of the country (rural, urban, and everywhere in between), three distinct categories emerge with regard to services. In the first, the home university is the primary provider of entrepreneurship services whether that university was located in an urban region or not. In the second category, university personnel do not directly provide entrepreneurship services, but rather know how to connect academic entrepreneurs to services in the region or – for universities located in rural regions – to other areas where these services exist. In the third category, the university provides no services and played no role in connecting the academic entrepreneur to services whether the university was located in a region with entrepreneurial services or not.

Regional Entrepreneurial Environment

Respondents also spoke of a locational dimension of these factors; their access to various services, funding, and like-minded entrepreneurs depends on where they are located. Academic entrepreneurs are tied to the regions where they are located – perhaps more then other types of companies since most remain employed with their home university. Among the 31 respondents, 29 of the corresponding spinoffs are located in the same region where they were established. The remaining two spinoffs relocated to other regions of the country: one moved to Silicon Valley while another moved to the Research Triangle after the academic entrepreneur decided to take a position at another university.

Entrepreneurship networks and services are primarily place-based and well-documented in the literature. Powers and McDougal (2005) and Degroof and Roberts (2004) find that the level of entrepreneurial support for spinoffs depends on the region where the university is located: universities in regions with strong entrepreneurial support require little provision of support from the university and vice-versa. Thornton and Flynn (2003) and Saxenian (1994) find that regions demonstrate entrepreneurial advantages based on the density of their entrepreneurship networks and cultures. Interestingly, DiGreggorio and Shane (2003) find that the availability of VC in the region where the university is located and the level of sponsored research does not have a significant impact on the *number* of spinoffs from that university but say nothing as to their success or failure.

Industry Affiliation of the Spinoff

While respondent academic entrepreneurs did not list industry as a *per se* factor in their success, they did point out that there are different requirements for success among various industries. This is abundantly clear in the life sciences where there exists enormous capital requirements to fund research, testing, clinical trials the FDA approval process, and the manufacture and marketing for approved drugs. These capital requirements and the technological complexity of drug development limit development and market access options for most university spinoffs primarily to partnerships with larger pharmaceutical and biotech companies (Pisano, 2006).

At the other end of the industry spectrum, one respondent remembered the ease by which he developed and commercialized his company's product. Specializing in custom online training curricula for service companies, the spinoff was established for less than $50 thousand dollars, brought in sales within six months of operation, and became profitable after one year. "We aren't going to employ hundreds of people, but we do employ six employees and pay them very well…relative to one of those biotech companies, this has been pretty easy…we just don't show up on anybody's radar screen."

A modest literature explores the relative development requirements of various industries, especially those dependent on rapid technological advance (Perez and Sanchez, 2003; Nerkar and Shane, 2003; and Utterbach, 1994). There are few studies that examine technological factors in spinoffs, much less those that compare spinoff success requirements among industries. With that said, several studies do examine the mix of spinoff technologies, with biotechnology and pharmaceuticals being the most

common (Shane 2004; Lowe 2003; and Golub 2003). Furthermore, while Gulbrandsen and Smeby (2005) find that health science research seem to transition well into a university spinoff, Bekkers et al. (2006) finds that spinoffs from different industries – biotech, IT, and software in his study – have very different success factors.

Role of Policy

Respondent perceptions differed with regard to the impact of public policy on spinoff success. For some, policy does not seem to play an important role: "frankly, it plays none." For others, the question elicits a visceral response relating to regulation and taxation: "I've given up a lot to start (his company) and now I see what the government is doing to small business…they are killing it…take any policy you want: taxes, OSHA regs, environmental regs…and I'll find something to say about it." For another academic entrepreneur in the life sciences, the FDA approval process "is the ultimate policy challenge…if getting through FDA approval is not a factor of success then I don't know what is."

For academic entrepreneurs who feel that policy plays (or can play) a positive role, government funding – especially SBIR – is most often mentioned.

> SBIR is very important to our company…I know of no other program as important to small business…it has provided us with a needed infusion of cash in critical times to tackle some very complex technical problems. I don't what we would have done without it.

State funding is also mentioned as an important factor. One respondent has received a $50,000 grant from their state economic development agency: "I appreciate the money but I have wondered if it was worth it; (the state) makes you jump through a lot of hoops

and then they wonder six months later why you aren't employing 100 people." Two respondents mention their respective state's SBIR application fund; one of the states provides a cash match for SBIR phase I awards. Another respondent located at a university in the Midwest received two no-interest loans from his local economic development agency: "it wasn't a lot of money but, man, it was so important to our survival…we wouldn't be around if it weren't for that loan. The role of public funding programs such as SBIR and the now defunct ATP in spinoff success has received some attention in the literature (Shane 2004; Lerner 1999).[20]

Two respondents also mentioned the importance of being located in their university's science park, especially given its proximity to the university and other companies. We know that many university science parks are developed through direct or indirect subsidy and therefore of policy relevance. Similarly, one respondent points out the importance of being located in an off-campus incubator, a 'work space' designed to promote the development and growth of early-stage spinoffs. The provision of 'low-cost' entrepreneurship services by universities is an important factor of success for respondents.

A respondent from a Midwestern university spoke of the difficulty that his company had experienced with state conflict of interest policy. The respondent feels that his spinoff is "subject to a lot of contradictions…conflicting information and decisions abound. On one hand we are told to start a company…on the other we are told that we can't be involved in the company…that I have to remove myself from the situation.

[20]See the National Research Council series *Capitalizing on Science, Technology, and Innovation: An Assessment of the Small Business Innovation Research Program* and the project's publications, available at http://www7.nationalacademies.org/sbir/.

While only one respondent mentioned conflict of interest, it is a documented factor (detriment) of success of among university spinoffs (Renault 2006; Shane 2004; Golub 2003; and Matkin 1990).

Quality of Life Factors

Beyond the elements described above, quality of life was mentioned as a minor but important factor relating to spinoff success. For one academic entrepreneur located in a rural area, companionship for his employees is an interesting but critical issue: "I have no trouble recruiting guys right out of graduate school…they love the area and being near (the university)…but keeping them here is another story…these guys are young and want to start a family…or they just want to date…and you typically need one for the other but that's a problem in this region."

Quality of life is also a positive factor for academic entrepreneurs; one respondent from a university in the northwest speaks of the ease by which "I can get people to stay or move up from California…people love it here…the cost of living is reasonable and there are lots of amenities." For another respondent, not being located near a major airport proved to be a challenge: "I have no trouble presenting our ideas or finding interested parties – but I do have a problem when I have to make two (flight) connections to get there…it really soaks up your time."

5.4 Determining the Dependent Variable: Commercialization

Given the purposeful sample of academic entrepreneurs, accounting for heterogeneity of technology, product focus, and geographic location, spinoffs are

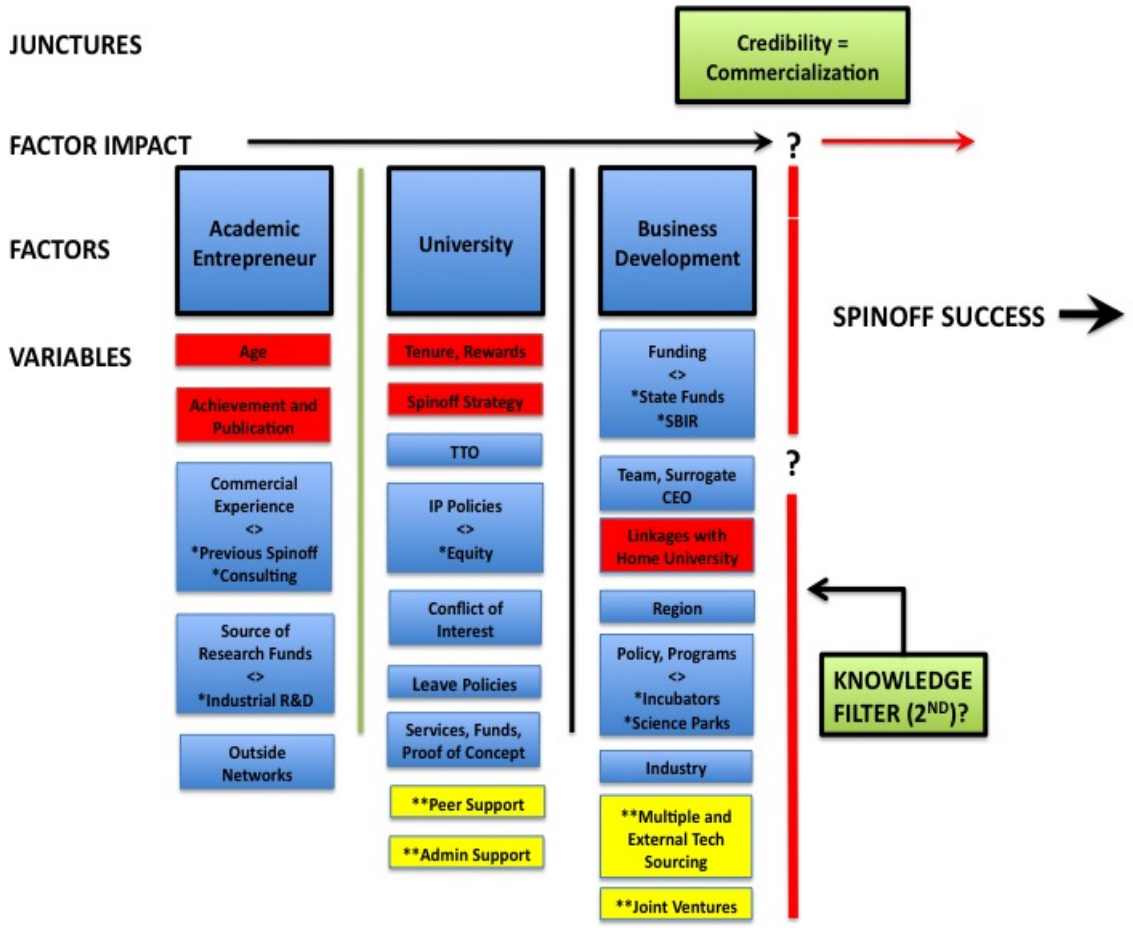
observed in various stages of development. Consequently, academic entrepreneurs described different phases in the development of their spinoff similar to the "critical junctures" offered by Vohora et al. (2004). The authors describe "distinct phases of activity in their development…each venture must pass through the previous phase in order to progress to the next one but each phase involves an iterative, non-linear process of development." Similarly in the current sample, academic entrepreneurs seem to be bounded primarily by commercialization: those whose spinoff has enjoyed product sales and those whose spinoff has not.

Based on these observations and recent research (Link and Ruhm, 2009), commercialization is used to proxy spinoff success. Using commercialization as a proxy for success should not imply that the commercial fate of the university spinoff is somehow assured but rather that it has passed through an initial 'critical juncture' in its development – a point where many other spinoffs have not. Commercialization is specifically defined as revenue earned through sales of a product or service, however modest. Spinoff acquisition is also included in the working definition of commercialization primarily to serve the interest of life science spinoffs, among others, that rely heavily on large pharmaceutical and biotech companies to continue development of their drugs through clinical trials and the FDA approval process (Pisano 2006).

5.5 Revision of the Theoretical Model

As discussed in Chapter 4, Sequential Exploratory Strategy (Creswell, 2003) requires that the results from first-phase interviews be compared to the extant literature

FIGURE 4: REVISED THEORETICAL MODEL



COLOR CODES FOR VARIABLE BOXES:
BLUE – Variable affirmed by respondents as important for spinoff success
RED – Variable was not considered important by respondents
YELLOW – Variable is introduced by respondent but not introduced in extant literature

and then used to specify a theoretical model for testing during the second research phase. Figure 4 presents this revised (and much more simple) theoretical model.

The first phase interviews yielded a clear delineation between spinoffs that have commercialized their technology and those that have not. This (purposely) narrows the focus of the theoretical model to what Vohora et al. (2004) terms the "credibility phase" and factors responsible for commercialization. Given the fact that some firms in the

sample may never commercialize their technology (whether by intention or failure to do so), this suggests that a post-establishment knowledge filter may exist as indicated in Figure 4. In other words, while Audretsch et al. (2006) and Acs et al. (2004) suggest that cultural and structural barriers attenuate the disclosure and licensing of university technology, a barrier (filter) to knowledge dissemination from the university – in this case vis-à-vis commercialization – may exist *after* the firm has been established.

Related to the success variables, the model demonstrates three distinct findings. First, it affirms the importance of variables from the literature, such as commercial experience, the TTO, IP policies, outside networks, and others (in blue) to the success of university spinoffs. Second, it finds no relationship between a few of the variables in the literature, such as age of the entrepreneur and linkages with the "home" university (in red) and success. Finally, it introduces four success variables not well established in the literature but hypothetically important to spinoff success (in yellow).

Variables in the model are used to construct a template (also see Chapter 4) that is used to survey a broader population of academic entrepreneurs. The next chapter discusses the results of this survey.

CHAPTER SIX: PHASE II RESEARCH RESULTS

6.1 Specification of the Model

The second research phase is intended to test the strength of the theoretical model inductively generated – and compared to the extant literature – during the first research phase. One hundred and seventeen (117) contacts responded to the request for interview yielding an effective response rate of 60.6 percent. As explained in the previous chapter, technology commercialization by a spinoff is the dependent variable. The research output is specified as a dichotomous variable taking the value of one (zero) for university spinoffs that have (have not) commercialized products, processes, services or other sales such as rights to technology or (spinoff) licensing revenue by the time of the survey. Acquisition of a university spinoff by another company is also used as a proxy for commercialization largely to account for the unique commercialization process of the life sciences industry (Pisano 2006); only three spinoffs in the sample have been acquired. The mean value of the dichotomous commercialization variable (*comm.)* is .444. In other words, the probability that a university spinoff in the sample commercialized their technology is slightly less than 50 percent.

We have seen the lack of systematic data regarding factors of success for university spinoffs. The data that do exist are focused on predicting the *number* of

companies spun off various universities each year ignoring more qualitative aspects of university spinoffs. Exceptions are few and far between; studies that do exist have focused on top-tier research institutions such as MIT and Berkeley – or spinoffs from foreign institutions. Thus the model below follows mostly from data collected during the initial interviews limited by response factors and degrees of freedom stemming from the small sample size, supported by a selected theoretical literature.

6.2 The Model

Based on the theoretical model presented in the previous chapter, there seems to be not a single 'critical element' responsible for commercialization but rather multiple factors that contribute to commercialization success ("Variables" section of Figure 4). And while the need for (additional) development funding seems ubiquitous many respondents are quick to point out that "money alone is not enough" to determine the success of their spinoff and – in particular – the importance of external sources of technical and business knowledge. A multi-factor approach is also supported in the literature (Roberts, 1991) and deemed important for building entrepreneurship theory (Davidsson, 2004).

The theoretical model posits a correlation between commercialization (*C*) and a number of supporting factors identified in the first research phase and preceding literature review. These factors include: personal characteristics of the respective entrepreneur (*PER*), factors specific to the home university (*UNI*), and business development factors (*BUS*). An additional factor (*REG*) is added to control for differences among regions

where spinoffs are located.[21] These factors may or may not play a role in commercialization; the purpose of the second research phase is to test the strength and relevance of the first phase findings. Thus, the empirical (model) counterpart to Figure 4 (Equation 1) is as follows:

$$\textbf{(1)} \qquad C_{us}^{\beta 1} = PER_{us}^{\beta 1} * UNI_{us}^{\beta 2} * BUS_{us}^{\beta 4} * REG_{us}^{\beta 5} * e_{us}$$

C is a self-reported binary indicator of commercial success where 1 equals some level of commercialization, while 0 indicates that the spinoff has not to date commercialized. The right-hand side factors are disaggregated and empirically operationalized – where possible – through the measures below (also see Table 6). Some variables in our theoretical model are dropped due to non-response or other limitations; this is explained in the footnotes for each factor section below.

TABLE 6: DESCRIPTION OF INDEPENDENT VARIABLES

Independent Variables	Description
Rdratio	Continuous variable, ratio of extramural research funding from the federal government to overall university research budget
Facconsult	Binary variable, for academic entrepreneur indicating that they have consulted with industry, facconsult=1
Facindrd	Binary variable, for academic entrepreneur who has conducted industrial R&D, facindrd=1
Outceo	Binary variable, for spinoffs with a non-faculty CEO, outceo=1
Multlic	Binary variable, for spinoff that has sourced intellectual property beyond the original spinoff license(s), multlic=1
Vc	Binary variable, for spinoffs that have received venture capital, vc=1

[21]Unfortunately, sample limitations do not allow for individual university controls.

Ttoobs	Binary variable, for academic entrepreneur indicating their TTO was "obstructionary", ttoobs=1
Unisrv	Binary variable, for spinoffs that receive initial entrepreneurship services from the university, unisrv=1
Jv	Binary variable, for spinoff that has participated in at least one joint venture with another company, jv=1
Equity	Binary variable, for academic entrepreneurs whose home university has taken equity stake in the spinoff, equity=1
Peers	Binary variable, for academic entrepreneur indicating that their peers are 'supportive' of entrepreneurial activities, peers=1
Sbir	Binary variable, for spinoffs that have received at least one SBIR award, sbir=1
Prevspin	Binary variable, for academic entrepreneur who has previously established a spinoff, prevspin=1
Statef	Binary variable, for spinoffs that have received state entrepreneurship funding, statef=1
Age	Continuous variable, age of firm; years between establishment and time of survey
Bio	Binary variable, for spinoff in the bioscience industry, bio=1
Neast	Binary variable, for spinoff located in MD, CT, or ME, neast=1
Midwest	Binary variable, for spinoff located in IL, IA, OH, KS, or NE, midwest=1
Nwest	Binary variable, for spinoff located in WA, OR, or MT, nwest=1
Swest	Binary variable, for spinoff located in AZ, CA, or UT, swest=1

6.3.1 Personal Factors[22]:

Previous Spinoff (*prevspin*) – This variable takes on the value of one if the academic entrepreneur has previously established a university spinoff. A positive coefficient would indicate that this experience is conducive to the commercialization of university research in their current spinoff.

[22]The age of an academic entrepreneur has been dropped as a predictive variable due to non-response; many respondents were not comfortable volunteering this information.

Industrial R&D (*facindrd*) – This variable captures a formal, typically contractual relationship between the academic entrepreneur vis-à-vis their university and industry. It is expected to have a positive coefficient reflecting the propensity for industry engagement to be positively related to commercialization.

Consulting (*facconsult*) – This variable reflects the extent of both formal and informal linkages between an academic entrepreneur and industry outside the university environment. It is also expected to have a positive coefficient reflecting the propensity for social capital and industry engagement to relate positively to commercialization.

6.3.2 University Factors[23]:

R&D Ratio (rdratio) – To control for university incentives to spin off, this continuous variable is added to reflect the proportion of extramural government research funding received in 2005 by the spinoff's home university with that university's overall research budget that same year. A higher ratio indicates that the university receives a greater proportion of its research budget from the federal government relative to other sources such as internal funding, foundations, and industry-sponsored research. Given that most federal research funding supports basic research at universities, a negative coefficient is expected; a more basic research orientation may indicate less of an internal focus on commercialization.

[23]Administration support has been dropped; all but two respondents felt that their university's administration was supportive or "agnostic" toward their entrepreneurship activities. One respondent remarked: the administration loves us…we are something to show off to the legislature…it's your colleagues and department heads that you have to worry about."

Peer Support (*peers*) – This variable reflects the impact of 'peer culture' on the post-establishment commercial success of university spinoffs. The variable takes on a value of one when faculty peers and/or department heads are supportive or agnostic with regard to an academic entrepreneur's entrepreneurship activities.

TTO Obstruction (*ttoobs)* – This variable reflects the direct impact of the technology transfer office on the success of a university spinoff. A negative coefficient would indicate that those academic entrepreneurs reporting that their TTO is 'obstructionary' have a lower propensity to commercialize their research.

Equity (*equity*) – This variable reflects variation in university licensing agreements to spinoffs; a value of one indicates that the home university has taken an equity stake in the spinoff as a partial or full replacement for patent costs, royalties, and/or other fees. A positive coefficient would indicate that this equity arrangement has a positive impact on technology commercialization.

University Entrepreneurship Services (*unisrv*) – This variable takes on the value of one when an academic entrepreneur's home university is the primary provider entrepreneurship and commercialization services to the academic entrepreneur after the establishment of their company. If the coefficient is positive it suggests that university entrepreneurship services yield a higher propensity for technology commercialization among spinoffs in our sample.

6.3.3 Business Development Factors[24],[25]:

SBIR (*sbir*) – This variable takes on a value of one for academic entrepreneurs whose spinoff has been awarded at least one Phase I SBIR award. A positive coefficient would indicate that an increase in funding from government agencies facilities spinoff commercialization.

State Funding (*statef*) – This variable measures whether or not a university spinoff has received funding in excess of $25,000 from their local state government to support its establishment, operation, or development of technology. If state funding of university spinoffs is conducive to commercialization, a positive coefficient is expected.

Venture Capital (*vc)* – This variable takes a value of one for academic entrepreneurs whose spinoff has received venture capital funding. A positive coeffecient is expected indicating that venture capital funding facilitates technology commercialization for the university spinoff.

Outside CEO (*outceo*) – This variable indicates that an individual other than the academic entrepreneur assumed the role of spinoff CEO within six months of establishment. A positive coefficient would suggest that having outside management increases the likelihood that the spinoff will enjoy commercialization success.

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[24]Aggregate levels of development funding are excluded due to both non-responsiveness and accuracy concerns.
[25]Variables indicating residence in an incubator and science park are dropped due to the small number of spinoffs located in either (eight in total) along with concerns about degrees of freedom. Furthermore, in runs that include science park and incubator variables, these variables are insignificant.

Multiple Intellectual Property Sources (*multlic)* – This variable reflects the decision of the spinoff to pursue licenses beyond the initial licensed used to establish the spinoff – and external to the spinoff. A positive relationship would suggest that multiple licensing and the sourcing of external technology yields a higher propensity for commercialization.

Joint Venture (*jv*) – This variable indicates that the spinoff has participated in one or more joint ventures with another company. If participation in a joint venture were beneficial for technology commercialization then a positive coefficient would be expected.

Age of Spinoff – This variable indicates the age of the spinoff to control for differences in technology development factors. A positive coefficient would suggest that the likelihood of commercialization may increase over time with the maturity of the spinoff.

Life Science[26] (*bio*) – This serves as an industry control variable for whether or not the spinoff is in the life sciences industry. A negative coefficient would suggest that life science commercialization such as drug development and the development of biotech therapeutics is more difficult relative to commercialization in other industries.

[26]While all academic entrepreneurs responded with a specific industry designation, the heterogeneity of the responses and sample size limit us to a binary industry variable. With that said, recent literature documents the difficulty and unique nature of commercialization in the life science industry (Pisano, 2006).

6.3.4 Regional Controls:

Four different binary location variables take on the value of one for the northeast (*neast*), which includes all states north of Washington, D.C., including Maryland, Connecticut, and Maine; the Midwest (*midwest*), including Illinois, Iowa, Ohio, Kansas, and Nebraska; the northwest (*nwest*), including Washington, Oregon, and Montana; and the southwest (*swest*), including California, Utah, and Arizona. The base region is the southeast and includes Virginia, Kentucky, North Carolina, and Georgia. Those regions that tend to have a culture more supportive of academic entrepreneurship such as the southwest and northeast might be expected to have a positive coefficient (Saxenian, 1994).

6.4 Multicollinearity

Given that responses related to success factors in the first-phase interviews were often closely related ("our venture capitalist insisted that we have outside management as a condition of funding") the possibility of multicollinearity exists among the variables listed above and its impact on the econometric estimates.

According to Table 7 below, medium correlation – as defined by Cohen et al. (2003) (>.30) – exists between only a few independent variables. The strongest of these relationships is between the presence of an outside CEO and the decision to source intellectual property from multiple and outside sources (.44) and the decision undertake at least one formal joint venture (.29). There is also medium correlation between faculty consulting and the conduct of industrial R&D within the university (.37) the presence of an outside CEO (.31), and spinoff participation in a joint venture (.26). Other notable

TABLE 7: CORRELATIONS AMONG INDEPENDENT VARIABLES

Variables	faccon~t	facindrd	outceo	multlic	bio	midwest	nwest	swest	neast
facconsult	1.0000								
facindrd	0.3749	1.0000							
outceo	0.3077	0.2716	1.0000						
multlic	0.1683	0.0410	0.4438	1.0000					
bio	-0.2444	-0.2017	-0.1722	-0.2375	1.0000				
midwest	0.0598	0.0423	-0.0747	-0.0023	0.0299	1.0000			
nwest	-0.0171	-0.1627	-0.1200	0.0420	0.0398	-0.1794	1.0000		
swest	0.1471	0.1875	0.0644	0.0229	0.0383	-0.2500	-0.2050	1.0000	
neast	-0.1666	-0.0562	0.0379	0.0794	0.0140	-0.1267	-0.1039	-0.1448	1.0000
vc	0.1372	0.0932	0.1372	-0.0604	-0.0137	-0.1127	-0.1471	0.1640	0.0987
ttoobs	-0.1472	-0.0369	-0.2002	0.0158	-0.0500	0.1707	0.0162	-0.1971	0.0045
unisrv	0.1725	0.0849	0.1725	0.0432	0.0105	-0.2438	-0.0128	0.3232	-0.1412
jv	0.2609	0.1397	0.2981	0.2509	-0.0239	0.0742	-0.0895	0.0000	-0.0339
equity	-0.0445	0.2162	0.0556	0.1664	0.0205	-0.1213	-0.0038	0.2659	-0.0093
peers	0.0552	0.0685	0.1973	0.1745	-0.0895	0.0047	-0.0338	0.2641	0.0693
sbir	-0.1725	-0.2350	0.0690	0.0053	0.0028	-0.2096	0.0552	-0.1237	0.2247
prevspin	-0.0153	-0.1260	0.0191	-0.0231	-0.0261	-0.0950	0.1563	0.0915	0.0516
statef	0.0179	-0.0562	0.2195	0.2245	0.0919	0.1031	-0.2151	-0.0107	0.2449
age	-0.0897	-0.2124	-0.0716	0.0209	-0.0350	0.1328	0.0275	-0.0677	0.0135

Variables	vc	ttoobs	unisrv	jv	equity	peers	sbir	prevspin	statef
vc	1.0000								
ttoobs	-0.0626	1.0000							
unisrv	-0.0752	-0.0637	1.0000						
jv	0.0213	-0.0746	-0.0313	1.0000					
equity	0.1450	0.0066	0.0353	0.1119	1.0000				
peers	0.1773	-0.0688	0.1549	0.1706	0.2045	1.0000			
sbir	-0.0986	0.0284	0.0611	-0.0600	0.0806	-0.0463	1.0000		
prevspin	0.2075	0.0307	-0.1775	-0.0771	0.0260	0.0949	0.0476	1.0000	
statef	-0.0953	-0.0216	0.0008	0.0601	-0.0483	0.1021	0.1236	0.0467	1.0000
age	0.1213	-0.0196	-0.1175	-0.0202	0.0981	-0.0399	0.0124	0.1539	-0.0193

	age
age	1.0000

correlations include a negative correlation between biotech spinoffs and faculty consulting (-.24) and multiple and outside licenses (-.24).

To further account for multicollinearity, the redundant variable impact was tested by computing a variance inflation factor (VIF) to assess the extent to which

multicollinearity is a problem for each independent variable (see table 8). Upon running the test in STATA, the VIF for variables in the model range between 1.18 and 1.76 with a mean VIF of 1.38. Some researchers recommend that VIF not exceed a measure of 10.00 for any single variable and that the mean not vary substantially from 1.00 (Acock, 2008), others indicate that a VIF as low as 5 indicates a multicollinearity problem (O'Brien 2007). In any case, the VIF measures below fall well below these thresholds. Furthermore, the tolerance figures (1/VIF) range from .86 to .57; a tolerance of less than

TABLE 8: VARIABLE VARIATION INFLATION FACTORS AND TOLERANCE FIGURES

Variable	VIF	1/VIF
outceo	1.76	0.569297
swest	1.70	0.589492
facindrd	1.67	0.597592
multlic	1.56	0.640896
facconsult	1.51	0.662025
midwest	1.48	0.677166
equity	1.41	0.707880
unisrv	1.41	0.711534
nwest	1.34	0.746282
peers	1.30	0.769980
statef	1.29	0.777483
neast	1.28	0.778790
jv	1.28	0.781583
rdratio	1.28	0.782385
sbir	1.27	0.785135
bio	1.26	0.793418
prevspin	1.26	0.796077
vc	1.22	0.819343
ttoobs	1.19	0.843382
age	1.16	0.860588
Mean VIF	**1.38**	

0.10 (or 0.20 for a more conservative threshold) indicates a multicollinearity problem. A substantial portion of the variance (in all cases >50 percent) for the independent

variables is available to predict the outcome variable independently. These measures indicate that, in general, multicollinearity is not a problem and that the model may be used.

6.6 Descriptive Results

Descriptive statistics related to the variables are illustrated in Table 9 below, including mean, standard deviation, and minimum and maximum. Differences among spinoffs that have commercialized their technology and those that have not are also examined. Table 10 provides a simple comparison of means for selected independent variables. The last column of the table shows p-values; the null hypothesis is tested to see if the sample means for the two groups are the same. The large, significant differences among several of the variables are striking.

The most important findings are that spinoffs that have commercialized their technology are more than seven times likely to *not* be in the life science industry (57 versus 8). They are about three times as likely (50 versus 15) to have participated in a joint venture with other companies, have sourced multiple and external technologies (77 versus 25), and have hired an outside CEO (87 versus 31). Academic entrepreneurs whose spinoffs have commercialized their technology are more likely to have participated in formal or informal consulting (77 versus 39) and have the support of her peers (48 versus 29). Finally, spinoffs that have commercialized their technology are more likely to have received venture capital funding (19 versus 8, though only significant to the .10 level).

TABLE 9: DESCRIPTIVE STATISTICS FOR PHASE II VARIABLES (n=117)

Variable	Mean	Standard Deviation	Minimum	Maximum
comm.	.4444	.4990	0	1
rdratio	.7245	.1317	.4025	.8853
faccconsult	.5556	.4990	0	1
facindrd	.4786	.5017	0	1
vc	.1282	.3358	0	1
outceo	.5556	.4990	0	1
multlic	.4786	.5017	0	1
ttoobs	.1197	.3260	0	1
equity	.1368	.3451	0	1
unisrv	.2137	.4117	0	1
jv	.3077	.4635	0	1
peers	.3761	.4865	0	1
sbir	.4615	.5007	0	1
bio	.3504	.4792	0	1
prevspin	.5299	.5013	0	1
statef	.2393	.4285	0	1
age	6.060	3.831	1	24
midwest	.1795	.3854	0	1
nwest	.1282	.3358	0	1
swest	.2222	.4175	0	1
neast	.0684	.2535	0	1

TABLE 10: SELECTED SAMPLE MEANS BY COMMERCIALIZATION STATUS

Variable	Not Commercialized (n=65)	Commercialized (n=52)	P-Value of Difference
R&D Ratio	0.713	0.736	0.351
Faculty Consulting	0.385	0.769	<0.001
Industrial R&D	0.415	0.558	0.128
Outside CEO	0.308	0.865	<0.001
Multiple/External Tech	0.246	0.769	<0.001
Venture Capital Funding	0.077	0.192	0.065
TTO Obstruction	0.154	0.077	0.206
University Services	0.231	0.192	0.618
Joint Ventures	0.154	0.500	<0.001
Equity	0.108	0.173	0.311
Peer Support	0.292	0.481	0.037
SBIR Funding	0.462	0.462	1.000
State Funding	0.231	0.250	0.811
Previous Spinoff	0.492	0.577	0.367
Age of Spinoff	5.769	6.423	0.361
Life Science Industry	0.569	0.077	<0.001

Note: Table shows sample means separately for commercialized and non-commercialized projects. The last column shows P-Value for the null hypothesis that the sample means are the same for the two groups.

6.7 Binary Logit Regression

To further test the hypothesis concerning a relationship between the independent and the dependent variables, binary logit regression analysis is used employing the statistical package STATA. Four derivations of model (1) above are used to test the influence of the success factors on the binary commercialization variable. The regression model tests the relationship between commercialization (y = 1) or lack thereof (y = 0) of the technology and the independent variables *rdratio, facconsult, facindrd, outceo, multlic, vc, ttoobs, unisrv, jv, equity, peers, sbir, prevspin, statef, age,* and *bio* as specified above. The regional control variables *midwest, nwest, swest*, and *neast* are also included – with the southeast as the baseline region.

6.7.1 Multivariate Results

The four versions of the model are run with 117 data points with no missing variables. The logit regression model shows that the independent variables for faculty consulting, receipt of industrial R&D funding, outside CEO, multiple and external technology sourcing, venture capital funding, university services, joint ventures, and the life sciences industry have a significant influence on technology commercialization in the sample for all four versions of the model. The control variable for spinoffs located in the southwest is also significant for all but the first version. For R&D ratio, TTO obstruction, equity, peer support, SBIR funding, previous spinoff, state funding, and spinoff age, no significant relationships are found.

Table 11 presents the results; logit coefficients, robust standard errors (in parentheses), and calculated average marginal effects [in brackets]. For binary variables,

the average marginal effects are interpreted as the likelihood of commercialization resulting from discrete changes in the explanatory variable. For logit regression in STATA, the *margeff* command defines quantities of interest as the probability of a positive outcome, unity (Bartus, 2005).

Starting with the personal characteristic variables from Table 11, the results provide evidence of the positive benefits to academic entrepreneurs when they engage in industry relationships outside the university. Spinoffs whose founding academic entrepreneurs participate in outside consulting arrangements with industry are more likely to commercialize their technology; the results are positive and significant at the .05 level. A test of intra-university engagement vis-à-vis industry-sponsored research agreements yields an unexpected negative sign and is significant in three of the four model versions above. Previous establishment of a spinoff by academic entrepreneurs within the sample does not necessarily guarantee success in subsequent spinoff commercialization efforts. The impact of university factors on spinoff commercialization is also examined.

Despite previous research showing the (negative) impact of an 'obstructionary' TTO and the (positive) impact of the home university taking an equity stake in a TTO, neither are significant in this sample. Though negative, R&D ratio is also insignificant; peer culture, though positive, is insignificant. The findings on how university entrepreneurship services affect the probability of spinoff commercialization are new; to the author's knowledge, there has been no prior attempt to empirically examine the relationship between university services and their impact on post-spinoff commercialization. Table 11 shows the surprising result: spinoffs who rely primarily on the university for entrepreneurship services are 17-20 percent less likely to

TABLE 11: LOGIT REGRESSION ESTIMATES (Robust standard errors in parentheses, calculated marginal effects are in brackets)

Variable	1	2	3	4
rdratio	1.696 (2.467) [.1426]	-4.779 (5.087) [-.2208]	-5.917 (5.615) [-.2682]	-15.74 (12.1892) [-.6299]
faccconsult	1.738 (.7856)** [.1628]	3.066 (1.438)** [.1406]	3.097 (1.461)** [.1401]	5.756 (2.867)** [.1856]
facindrd	-1.288 (.8513) [-.1010]	-3.392 (1.539)** [-.1492]	-3.174 (1.607)** [-.1362]	-6.320 (3.789)** [-.1477]
outceo	3.276 (.8346)*** [.3637]	5.504 (1.667)*** [.3363]	5.154 (1.752)*** [.3086]	8.506 (3.777)*** [.2896]
multlic	2.319 (.7785)*** [.2278]	3.729 (1.427)*** [.2082]	4.038 (1.548)*** [.2218]	9.221 (5.016)** [.2897]
Vc		4.009 (1.792)** [.2044]	4.491 (2.000)** [. 2188]	9.024 (4.625)* [.2579]
ttoobs		-.1156 (2.221) [-.0053]	-.3258 (2.206) [-.0146]	-1.186 (2.609) [-.0458]
unisrv		-3.940 (1.584)** [-.1796]	-4.320 (1.709)** [-.1957]	-6.055 (2.881)** [-.1746]
Jv		3.559 (1.427)** [.1826]	3.655 (1.513)** [.1820]	5.892 (3.069)* [.2073]
equity			-.6850 (2.051) [-.0298]	-3.389 (2.941) [-.0987]
peers			.8142 (1.250) [.0373]	1.007 (1.549) [.0420]
sbir			.8362 (1.296) [.0390]	2.624 (2.397) [.0987]
prevspin				3.438 (2.462) [.0966]
statef				1.538 (2.390) [.0545]
age				.5823 (.3665) [.0233]

Bio	-4.275 (1.047)*** [-.4318]	-6.973 (1.926)*** [-.4190]	-7.314 (2.107)*** [-.4195]	-12.487 (5.880)** [-.3724]
midwest	-.0953 (1.008) [-.0080]	.1208 (1.374) [.0056]	-.3935 (1.463) [-.0177]	-2.500 (2.675) [-.0891]
nwest	1.069 (1.143) [.0874]	2.259 (2.278) [.1106]	2.191 (2.596) [.1043]	2.076 (3.296) [.0793]
swest	1.007 (.9359) [.0827]	2.906 (1.515)* [.1352]	2.909 (1.713)* [.1302]	4.609 (2.744)* [.1576]
neast	-1.430 (1.359) [-.1194]	-2.716 (3.123) [-.1163]	-3.185 (3.332) [-.1355]	-5.675 (12.202) [-.1528]
LR chi2	96.89	125.08	125.86	131.42
Pseudo R-squared	.6027***	0.7781***	0.7830***	0.8175***
N	117	117	117	117

*significant at 10%; **significant at 5%; ***significant at 1%

commercialize their technology than those that do not. This finding is significant to a .05 level among the four models.

The next factor, additional development funding is a well-accepted component of entrepreneurial success. Ideally the model would include aggregate funding levels along with variables representing personal funding, non-SBIR federal funding, and other sources such as Angel funding. Unfortunately, these aggregate figures are not available in my data, so binary variables are used to indicate receipt of venture capital funding, SBIR awards, and state grants. Illustrated in Table 11, university spinoffs in the sample that receive venture capital have a 20-26 percent higher likelihood of commercialization compared with spinoffs that do not (significant at .05 and .1 levels). Receipt of additional development funding from the SBIR program or state government does not increase or decrease the likelihood that a spinoff will commercialize their technology.

Importantly, results in Table 11 show that business development variables are strong predictors of commercialization in the sample, above and beyond development funding factors. The binary industry variable for the life sciences (*bio*) is by far the strongest predictor of commercialization in the model; deciding to establish a biosciences spinoff reduces the likelihood of technology commercialization by a whopping 37-43 percent compared to non-bioscience companies. These results for all four runs of the model are significant to the .01 level ($p = 0.001$). Large average marginal effects are also observed for having a non-faculty CEO and taking advantage of multiple sources of intellectual property. With the exception of the last version of the model, both are significant at the .01 level. Spinoffs participating in a joint venture also increase their chances of commercialization as much as 20 percent, significant at the .05 and .1 levels. Spinoff age is the only business development factor does not increase (or decrease) the likelihood of commercialization among spinoffs in our sample.

The control variables for regional location are not significant with the exception of the southwest in three of the four versions of the model. Relative to their counterparts in the southeast, spinoffs located in the southwest are more likely to commercialize their technology, significant to a .1 level. This finding corresponds with case studies of dense entrepreneurial networks in the San Francisco Bay area (Saxenian, 1994) and anecdotal reports of strong institutional and state support for academic entrepreneurship in these regions (National Governors Association, 2007b).

6.8 Discussion

It appears that business development factors, such as the presence of a non-faculty CEO, the sourcing of multiple and external sources of intellectual property, and the decision of a spinoff to participate in a joint venture, have a far greater impact on the post-establishment commercialization than factors associated with the individual academic entrepreneur or university. With that said, the data also support the existence of a second, post-establishment knowledge filter relating to the role of the academic entrepreneur (is he or she the CEO?), the degree to which their research is supported by industrial sources, and the extent by which a spinoff relies upon universities entrepreneurship services once it is has been established.

Given the extant literature, the significance (and positive direction) of the outside CEO variable is not surprising; neither are the importance of VC and faculty consulting. The introduction of joint ventures and the sourcing of IP from multiple and outside sources as positive and significant factors for spinoff commercialization success are notable. Taken together, these variables showcase the importance of entrepreneurship and industrial networks to the commercialization success of university spinoffs, a theme that will be emphasized in the next chapter.

The strength and (negative) direction of the industrial R&D variable is especially surprising given the literature on the importance of industry relationships to commercialization and entrepreneurship (O'Gorman et al., 2008; Vohora et al., 2004; Grandi and Grimaldi, 2003; Nekar and Shane, 2003; and others). Furthermore, the finding seems contradictory to the strength and significance of the consulting variable – another personal factor. The data were reviewed and seventeen follow-up inquiries were

conducted with academic entrepreneurs who have been engaged in industry research in an effort to sort out these findings.

While most respondents saw no direct conflict between their industrial research and the commercialization success of their spinoff, they did characterize industrial sponsored research as something that both occurs "physically" at the university and is governed by contractual obligations such as specific timelines, conflict of interest provisions, and guidelines set forth by university sponsored research offices. This compares to consulting which occurs on an academic entrepreneur's "own time" – and typically offsite.

Respondents specifically mentioned the more urgent nature of industrial-sponsored research; often industry representatives wanted research completed within specific (short term) timeframes while government-sponsored research was much more flexible. All respondents posited that industrial research was especially important to university administrators because – in most cases – it helped defray university overhead expenses. Furthermore, timely performance was encouraged since this might bode well for future industrial R&D contracts.

Finally, respondents also mentioned the enormous time pressures faced by faculty entrepreneurs. Time spent working on an industrial research project may help the faculty member better understand commercialization but it also limits the amount of time that the faculty member can spend setting up her company and commercializing her spinoff's technology. This is especially true for young companies that depend strongly on the actions of the academic entrepreneur (and lack an external CEO, for example).

Another surprising finding was the significant and negative correlation between spinoff commercialization and university entrepreneurship services. Only a small number of spinoffs in the sample (25) relied upon university entrepreneurship services, 15 of which had yet to commercialize their technology. Far more companies (42) commercialized their technology without ever taking advantage of university-based entrepreneurship services or did not have access to these services. In Phase I interviews, respondents mentioned entrepreneurship services as "useful" but not critical to their success – and attributed other factors as much more important.

The significant and negative sign association with spinoffs in the biotechnology industry is also of interest. Of the 41 biotech companies in the sample, only four (4) have commercialized their technology (2) or been acquired by a larger company (2). This may not be surprising given Pisano's (2006) research on the difficulty of commercialization in the biotechnology industry. However, in an effort to further explain the difficulties of spinoffs in the sample, the four-stage model was run again excluding biotech companies and then run again for biotech companies only. The first two runs of the model excluding biotech company yields similar – though weaker – findings compared to the broader results. Degree of freedom problems limit subsequent runs.

The first-stage model is run again only for biotech companies. The run yields no significant variables (to the .1 level) but the relative significance of the CEO and faculty consulting coefficients (.17 and .16, respectively) seem to align with the broader findings. Though insignificant, the variable for multiple and outside licenses is negative (along with an insignificant industrial R&D variable). Indeed, according to Table 7, the two are

negatively correlated. Given these results, the negative direction and strength of the biotech industry variable is affirmed.

The next chapter explores these findings in greater detail and explores their implications for public policy.

CHAPTER SEVEN: RESULTS AND POLICY IMPLICATIONS

7.1 Summary Discussion

The United States, in the context of the global economy, has experienced a fundamental shift from traditional manufacturing to new knowledge-based economic activity igniting the interests of policymakers in the role of universities in economic development. Certainly American public research universities, with their diverse competencies and structures, embedded relationships with industry, and disparate and often generous sources of funding are the envy of the world. Of these assets it is university research – a primary source of new knowledge – that is thought to be the seed corn for transformative innovation and therefore economic growth. The knowledge generated in universities can only have an impact on economic growth, however, if it can flow freely into society and be transformed into useful applications.

Researchers and policymakers alike have focused on "technology transfer" as the critical university interface for economic development; a robust literature has emerged dedicated to understanding the factors that enhance it.[27] This research typically employs AUTM data and triangulates technology transfer through output measures such as

[27]Despite the research and pervasive adoption in the lexicon of lawmakers, industry typically favors more informal relationships with individual faculty members; technology licensing ranked dead last in the list of priorities among industry. For more information, see Thursby and Thursby (2006).

number of disclosures, patents, licenses (and licensing revenue), and spinoffs. Unfortunately, this literature tells us little about *how well* these mechanisms diffuse and commercialize new knowledge or specifically impact regional economies.

Specific to university spinoffs, these fledgling companies *can* diffuse and commercialize technology. Relying on the AUTM data, researchers have examined various institutional, regional, and policy factors that may predict the *number* of spinoffs established from a particular university. This approach treats spinoffs as a homogeneous public good and may have the unintended consequence of promoting the idea among policymakers that "any spinoff is a good spinoff" and therefore "more is better." In a world of limited resources and difficult policy decisions, policymakers would do better to understand the relative impact of spinoffs and the factors responsible for their success yet lack the information needed to do so. The purpose of this dissertation is to bridge this gap of understanding.

This study employs a KSTE framework in an effort to understand the factors responsible for knowledge dissemination vis-à-vis the commercialization success of university spinoffs. Given the nascent nature of the literature, this study makes an important scholarly contribution by first collecting primary source data through two phases of interviews with academic entrepreneurs from a wide range of public institutions. Second, the study inductively explores a wide range of factors – some theoretically unique – in order to test their impact on commercialization success within the sample. Finally, the study offers evidence of the presence and composition of the knowledge filter – and factors that may be responsible for its penetration.

7.2 Challenges with the Research

Before investigating the findings and possible policy implications, several words of caution are offered related to the data and analysis performed. First, the sample is very small with 231 academic entrepreneurs in the contact database whose spinoffs were established over the course of the past 24 years. By some estimates, over 3,000 university spinoffs (as defined in this paper) have been established since 1980, including those from private universities. Furthermore, the sample only includes spinoffs that have formal IP agreements with their universities overlooking other types of spinoffs (Link et al., 2007b). The contact database is not a probability sample, remains painfully small, and is thus subject to sampling error.

Second, given the heterogeneity of spinoffs in the sample, the results are restricted to a dichotomous commercialization variable. This is of concern given that academic entrepreneurs do not always define spinoff success as commercialization or may define commercialization differently. The research definition of commercialization is difficult to misinterpret: does the spinoff earn revenue through sales of a product or service, however modest, or has it been acquired by another company? Nonetheless, a wide range of outcomes may exist within this dichotomy; a binary commercialization variable is a blunt outcome measure.

Most of the explanatory variables are also limited to binary responses due to the lack of specific amplifying information from academic entrepreneurs. For example, specific and differentiated amounts of development funding are unavailable. In some cases, respondents do not feel comfortable revealing funding amounts due to disclosure concerns related to their funding agreements. In other cases, specific funding amounts

are not known or the respondents are unwilling to take the time to investigate this information. If the data was able to better account for the specificity of the independent variables, the paper may have been able to determine more precisely the relative importance of each.

This study is the first to empirically examine several unique factors responsible for post-spinoff commercialization success such as the primary provision of entrepreneurship services by universities, the role of state entrepreneurship funding, and external IP sourcing. Despite this contribution, it is difficult to operationalize these complex factors and capture the refined differences within and among them. Therefore, the research depends on blunt measures that capture broad dichotomous associations, along with a couple of continuous variables. Perhaps with more in-depth data collection techniques (e.g. intensive case studies) better specifications for the independent variables could be obtained.

Greater control variable specificity is also preferred to more accurately account for the location, industry, and home university of the spinoff. Due to the limited number of responses from individual universities and states, locational control variables for large, national regions must be used instead. Similarly, differentiated industry controls would be employed in the sample to control for the multitude of industries represented. Constructing a larger sample of spinoffs and increasing the response rate might allow for greater precision in the institutional, locational and industry controls but, absent this, the research model is restricted to regional controls and a dichotomous indicator of the life science industry.[28]

[28]Increasing the sample size and response rate may not add more specificity to the controls. According to the AUTM data several states have a very small number of spinoffs, if any, just as the majority of the nation's 4000 colleges and

Finally, the data rely on a point-in-time snapshot and subsequent spinoff outcomes are not available without extensive follow-on research. Evidence is offered related to the impact of several factors on the commercialization success for spinoffs in the sample. However, these findings do not necessarily guarantee the future operational success or growth of these enterprises. A point in time approach may also overlook the capacity for spinoffs that have yet to commercialize their technology but may do so in the future.

Researchers and policymakers alike should take these research findings with a grain of salt understanding that it is bound by the limitations of exploratory research. No claim is made as the external validity of the findings but they do offer important insights and topics for future exploration, testing, and inquiry. Policymakers can meanwhile use the findings to guide inquiries of their own – and use as they search for mechanisms to encourage and support academic entrepreneurship within their own contexts. The next section outlines these considerations in detail.

7.2 Findings

Caveats aside, several dimensions of the findings may have significant policy and management relevance. The central finding of the research is that the complexity of entrepreneurship and differences among industries necessitate a more nuanced view of university spinoffs. Furthermore, the emergence of the Open Innovation paradigm – though originally applied to innovation in large multi-national corporations – may have

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universities have not spun off a company. At least three universities in the sample have spun off fewer than five spinoffs in the past 25 years. Similarly, given the esoteric nature of science, it is difficult to predict the industry by which an invention may end up? In the words of one of the respondents "how do you specify your industry if that industry doesn't yet exist?"

far-reaching consequences for public policy and spinoff management.

Spinoffs are true boundary-spanners between the non-profit university and the market-driven commercial world. This research finds a number of factors that may help spinoffs successfully bridge this gap. This section will cover general findings from the research, while later sections will examine the relevance of these findings to university, state, and federal policy.

Motivations of the Academic Entrepreneur

Policymakers would do well to first understand that academic entrepreneurs – individuals who establish companies based on their research – are relatively unique. Academic entrepreneurs are faculty members, they teach and conduct research in public non-profit institutions. They have devoted a great deal of time and effort to obtain their academic credentials and are part of a scholarly world where status and prestige is earned primarily through peer recognition and awards, not profits or financial bonuses. Furthermore, most academic entrepreneurs in the sample wish to retain their position within the university creating – at a minimum – a conflict for time between their academic and spinoff duties.

Academic entrepreneurs in the sample are certainly interested in financial gain but, unlike 'rational, profit-maximizing actors' from neoclassical economics, they are also motivated by a number of other considerations. Primary among these is a desire to see their research "get out of the university and into society." These individuals often see the dissemination of new knowledge as part of their academic duties and feel that a spinoff is their only path to do so. This is due to the fact that, in most cases, their

technology requires extensive development and is therefore not yet ready for commercial application or licensing.

Academic entrepreneurs in the sample also establish their spinoffs for other reasons such as the need for a career change or in an effort to enhance the applicability and impact of their teaching and research. But it is post-spinoff technology development where the companies in the sample differ most: spinoffs that commercialize their technology and those that do not. To be sure, commercialization is a complex endeavor subject to a number factors discussed below. But related to the motivations of academic entrepreneurs, it is important for policymakers to understand that many of these individuals (at least among those within this sample) have little interest in commercializing their technology in the near-term. Instead many see their spinoff as a platform for consulting and access to government grants, especially SBIR awards.

Definitions of success not relating to commercialization may offer support for Reitan's (1997) and Robert's (1991) "living dead" phenomenon where firms have very high survival rates but show no indication of profitability. Not all spinoffs are 'created equally' and perhaps the most basic consideration is the motivations of academic entrepreneurs themselves. It may be nearly impossible to identify the *a priori* commercialization motivations of academic entrepreneurs but for policymakers interested in the success and economic impact of university spinoffs, technology commercialization offers an attractive proxy – and a noble policy goal.

Faculty Engagement with Industry

This research shows that academic entrepreneurs with industry experience in the form of formal and informal consulting relationships have a higher probability of commercialization than those who do not. The lack of industry experience among university faculty members creates information asymmetries related to commercial markets (Bekkers et al. 2006; Wright and Lockett, 2004; Franklin et al., 2001) but interaction with communities outside of academia – in this case industry – can help bridge this gap (Johansson et al., 2005).

Academic entrepreneurs in the sample suggested that industry relationships helped them understand commercial opportunities prior to spinoff (Shane, 2000). Respondents also spoke of how these relationships helped them ask the right questions once the spinoff had been established: "what is my product, what is the market, and what do I need to do to commercialize my technology – and when?" Furthermore, these relationships collectively provide a "reference network" for academic entrepreneurs to pursue technical assistance, advice, and funding. For example, several academic entrepreneurs in the sample received early-stage funding from companies with whom they have worked and consulted.

Interestingly, these relationships need not involve formal contracts; several respondents spoke of their informal relationships with industry scientists and engineers.

> We are all interested in solving similar chemistry problems and I know these guys from [a large chemical company]…they have a lab just down the road. We're friends and colleagues: we meet for coffee or I've had them over to the house to grill out…we're always talking shop: how do you solve this, what about that, etcetera, etcetera – but, for them, its also about what the product…how do we make this, how do we sell it, and to whom…I mean, these are great discussions to have if you are thinking about starting your own company…I think I get a lot more out of it than they do.

Others defined consulting more broadly. For one academic entrepreneur volunteering at a (non-profit) hospital "gave relevance and meaning to my work…and really inspired me to establish my company."

With that said, industry relationships may differ in their relative value pertaining to spinoff commercialization success. According the findings of this research, industrial R&D sponsored "within" the university may impede post spin-off commercialization success. Based on interviews, this may be due to time and opportunity costs of these contractual obligations and the policy and regulatory requirements therein.

Spinoff Business Leadership: Presence of a Professional Manager

For university spinoffs in the sample, the hiring of an outside CEO within one year of establishment is one of the most significant and powerful predictors of commercialization in the sample. A professional business manager, carefully selected, brings a different and valuable set of skills, perspectives, and outside business contacts to the spinoff. These individuals are hired to lead and grow the company; find outside investors; develop, produce, and market a product; and earn profits for the owners and investors.

Faculty entrepreneurs come from an academic environment whose culture and norms may conflict with those of a commercial for-profit enterprise. Given their lack of commercial experience and perspectives, academic entrepreneurs themselves may be part of the knowledge filter. Therefore, the presence of a professional CEO not only signifies that the spinoff is headed in the right direction managerially, it may also be an indication that the involvement of the academic entrepreneur is "carefully managed" to increase its

chances for commercialization. Instead of CEO, many academic entrepreneurs hold the position of chief science officer (CSO). For others, this means varying degrees of separation from the spinoff: from technology consultant to no role whatsoever. The latter is the least common with only four individuals (out of 117) in this category.

For most academic entrepreneurs in the sample, the presence of outside management is a criterion for the receipt of venture capital. Only 15 companies in the sample have received venture capital funding but 11 of these have hired outside CEOs; the other four are either in the process of hiring an outside manager or the academic entrepreneur had "previously proven" themselves by establishing and running a spinoff. One respondent commented: "venture capitalists won't invest without having someone else run the company, typically someone that they choose – they are very involved in the process."

For policymakers, the role of the academic entrepreneur within their own spinoff is a critical yet sensitive topic. Many respondents spoke of the "pervasive notion" among faculty members that they are expected to establish and lead a spinoff, an expectation that may include their resignation from their home university to do so. If these findings are externally valid, then policymakers can play a role in helping faculty understand that the success of their spinoffs may depend on the presence of outside management; they can also help academic entrepreneurs connect with professional management talent. While many exceptions exist, the interests of the university and state may generally be better served if academic entrepreneurs do not leave the university but rather continue their roles as boundary spanners.

Venture Capital

Venture capital funding is a well-accepted factor for spinoff success in the literature; this seems to be no different in the sample. Venture capital provides much needed funds for the hiring of staff, the purchase of equipment, and other capital needs. Venture capitalists also provide what one academic entrepreneur in the sample described as "a guiding role in the development of my company." The aforementioned involvement of venture capitalist in the hiring of outside CEOs is illustrative.

Along with their important "mentoring" role, respondents also spoke of the capability of venture capitalists to provide spinoffs with expertise, services, and technologies relevant to the commercialization efforts of the spinoff.

> We wouldn't be where we are without VC funding but we also wouldn't be where we are without the contacts that (our venture capitalist) has to other experts…I mean she is a engineer and knows the field…but what's amazing to me is that she can pick up the phone and pretty much call anyone in the world who is working in composites…we've overcome a lot of challenges this way, especially on the manufacturing end.

The results involving venture capital are limited; only 15 spinoffs in the sample have received venture capital funding. Furthermore, venture capital is not the only critical factor for commercialization: 42 spinoffs in the sample have commercialized their technology with no VC funding. Regardless, the findings are clear: venture capital increases the likelihood that a spinoff will commercialize its technology compared to spinoffs that have not received VC.

Open Innovation: External Technology Sourcing and Joint Ventures

Another important finding from the research is the critical importance of sourcing innovations from sources outside a particular spinoff. By licensing technology from other companies, the home university, and other research institutions, spinoffs take a proactive, commercialization-centric approach; they are continuously pushing the boundaries of their own technologies by tapping into the innovations of others.

Several academic entrepreneurs describe their initial spinoff license as simply the "starting point for licensing other technologies."

> Commercialization is not a linear process…it is a process of iterative learning…patents and licenses are important means but certainly not an end unto themselves. I would say a license is only as good as its contribution to a product and – with complex products like ours – we will have used dozens of patents once we finally get our product up and running and there is a story…learning…behind each one.

The importance of a "non-linear", application-driven view of commercialization is a recurring theme among academic entrepreneurs in the sample. Patents represent codified and appropriated knowledge but require a high degree of tacit learning – absorptive capacity – to understand their value, potential application, and therefore limitations (Kogut and Zander, 1992; Cohen and Klepper, 1990). This tacit understanding is important in order to understand how other companies have solved particular technical problems and for spinoffs to build their own internal capabilities.

Just as licensing outside technologies helps spinoffs understand the importance of codified knowledge sourced from external sources to commercial success, joint ventures – another significant predictor of success in the sample – provide an indication of the importance of tacit relationships. Spinoffs participate in joint ventures with other companies to satisfy a range of learning needs. Joint ventures in the sample take the form

of joint ventures for research, development, manufacturing, and distribution and marketing. While all types of joint ventures are represented in the sample, research and development joint ventures are most common.

The external sourcing of technology and joint ventures are development factors closely relate to the management and operations of an individual spinoff. Nonetheless, it is important for policymakers to recognize the emergence and importance of Open Innovation and to tailor new and existing spinoff support services accordingly. In particular, entrepreneurship services might encourage linkages between university spinoffs and technology experts within the region and other parts of the world.

Industry Classification

By definition, the industry classification of a university spinoff is closely tied to the scientific discipline of the founder. Previous studies have utilized samples where life science spinoffs are most common among all industry classifications (Shane 2004; Lowe 2003; and Golub 2003); this sample is no different. Over the past 20 years, private investment in the life science industry – at least until recently – has been massive as federal funding for basic life science research, primarily through the National Institutes of Health, has concurrently grown in real terms. Billions of dollars of public and private investment in the life sciences has proven to be a powerful incentive for entrepreneurs, academic and otherwise (Pisano, 2006).

Despite these incentives, recent research highlights the stark commercialization challenges faced by the industry, including enormous capital requirements, increasing complex health and drug issues, long lead times for clinical trials and FDA approval, and

limited post-approval patent lives (Pisano, 2006). It may come as no surprise then that life science entrepreneurs in this sample spoke of the "staggering challenges" that they face attempting to commercialize their technology. Given the limitations of the data, all industries within the sample cannot be accounted for. However, a simple binary control for the life sciences yields stunning results: spinning off a company into the life sciences industry is the most significant (negative) predictor of commercialization in the sample.

Non-life science spinoffs in the sample are a very diverse group but yield some valuable perspectives. In particular, spinoffs in industries with relatively simple products and therefore low capital startup requirements, such as online training curricula or speech therapy software, seem to enjoy an easier path to commercialization. For example, a spinoff from a small public university in the southeast has developed and commercialized an online diagnostic and treatment tool for children with speech impediments. The underlying academic research was funded through several modest grants (~$15,000 each) from a small philanthropic foundation; the research developed and commercialized for less than $70,000 in additional development funds; and the resulting spinoff makes more than $1 million in revenues and employees five individuals full-time.

7.3 Policy Implications

The findings above offer important implications for university, state, and federal policy. Acknowledging that these findings are derived from a limited population of academic entrepreneurs, the policy implications below are only *directly* relevant beyond this sample if other populations of academic entrepreneurs are theoretically similar. Nonetheless, just as the findings above offer scholars a foundation on which future

inquiries can be built, these implications offer policymakers a starting point when designing and evaluating spinoff support programs and policies of their own.

Furthermore, these policy implications – and indeed this research – are based on several implied objective assumptions. This research treats academic entrepreneurship and its success as a *de facto* private and public good. It assumes that policymakers at different levels should design policies and programs to encourage and support this phenomenon not only for its potential contribution to economic growth, but also for its important role in knowledge diffusion. And though this "support" should be weighed against other desired outcomes in postsecondary education and economic development policy, academic entrepreneurship is unique because it has the potential to support goals within each.

Public universities currently face enormous expectations from state legislatures and governors to contribute to state and local economies especially during these tough economic times (NGA 2007b). Public research universities no doubt play an important role in economic dynamism but mostly for their critical role in long-term human capital development, not short-term product commercialization. After all, public research universities are state-chartered, non-profit teaching and research institutions. So while factors of success for academic entrepreneurship are explored here, this research in no way assumes that the phenomenon offers the potential to, for example, completely revitalize regions in economic decline.

Instead, the assumption is made that academic entrepreneurship is a subset of outreach-oriented knowledge dissemination, a *complement* to economic transformation. Academic publishing is a well-established form of disseminating codified knowledge

through scholarly journals and books. Similarly, this research assumes that community outreach, extension, and – in this case – academic entrepreneurship provide pathways for the dissemination of tacit knowledge. Many schools such as the nation's Land-grant colleges and universities have demonstrated a commitment to outreach and extension, at least within their respective Schools of Agriculture. It is within this context that academic entrepreneurship should be viewed: a form of outreach and knowledge dissemination whose success is dependent on technology commercialization, or at least the pursuit thereof.

Furthermore, this research assumes – and indeed finds – that the transfer of knowledge is a two-way process. Academic entrepreneurs transfer their knowledge to society vis-à-vis their spinoff (among other routes) but also help transfer knowledge *into* the university strengthening the quality of their teaching and the direction of their research by helping them derive new, unique academic research questions.

With these assumptions in mind, the policy implications below are divided into three sections: implications for university policymakers, state policymakers, and federal policymakers.

7.3.1 Implications for University Policymakers

Universities often treat academic entrepreneurship as an outcome of a linear technology transfer process: research, disclosure, patent, license, and spinoff. This "process" is part of a larger institutional evolution within universities that arguably began with the passage of the Bayh-Dole Act in 1980. Depending on the institution, research universities have at different times over the course of the past 29 years established a

TTO, hired TTO staff, tweaked IP policy, promoted disclosure, sought to increase licensing revenue and – in some cases – promoted academic entrepreneurship (Phan and Siegel, 2006).

Much has been written questioning the efficacy of the Technology Transfer model, with some calling for the separation of academic entrepreneurship from the licensing of university technology (Litan et al., 2007). Though not significant, anecdotal responses from this sample indicate that most academic entrepreneurs do not see their *TTO* as a barrier to spinoff establishment or commercialization. However, from a broader perspective including the emergence of an Open Innovation model, these factors may indicate inadequacy with the broader university-centric technology transfer model, and incremental derivations thereof, for enabling spinoff success.

First, though most academic entrepreneurs feel that their TTO is "staffed with good, well-meaning individuals," they often lack the capacity to understand a multitude of scientific disciplines and industries that are important for spinoff success. Second, many see the TTO as a centralized "choke point" for both spinoff and the subsequent licensing of (additional) technologies out of the university. Third, lacking previous business experience, entrepreneurs in the sample have no reference point by which to judge the efficacy of the services provided by their university (or other sources for that matter). Fourth, many voiced concern about potential conflict of interest between the provision of entrepreneurship services and the goals of the academic entrepreneur.

> It's a little disconcerting when you think about it…my employer – the university – provides services and advice for my business and in exchange takes an additional (equity) stake. I am beginning to wonder about if these guys are trying to help me or are really in it to make more money for the university…the two aren't always aligned.

Finally, the empirical results indicate that spinoffs that receive entrepreneurship services primarily from their home university have a lower propensity to commercialize their technologies than those that do not. As discussed in the previous chapter, these findings suggest that centralized, university-wide efforts to assist academic entrepreneurs may be contradictory to the changing nature of innovation: open, complex, interdisciplinary, and global.

For policymakers, this does not necessarily mean that universities should not play a role in promoting entrepreneurship or post-spinoff commercialization. Indeed, university policy and culture are no doubt critical to the spinoff phenomena. But it does signify that – at least within this sample – *how* spinoffs are encouraged and enabled impacts their chances for commercialization success.

Encourage Outside Engagement Among Faculty Members

For policymakers, faculty engagement has been – especially among Land Grant universities – a valuable tool for public outreach and the diffusion of new knowledge. What is less often understood is that formal and informal engagement is also a crucial avenue for faculty to learn and give relevance to their work, including their entrepreneurial ventures. Policy can play an important role by including industry outreach in this broader notion of service and engagement – and ensuring that engagement is recognized and rewarded in the formal tenure and promotion process.

Variants of this approach are currently being employed at Texas A&M, Oregon State, and North Carolina State Universities. However, it is too early to understand the impact of these policy changes on academic entrepreneurship. Furthermore, states can

provide subsidies, similar to those provided through the University of Tennessee Center for Industrial Services, for faculty members to engage and assist small companies in the state.

When implementing strategies for engagement, a distinction should be made between outreach activities and funding. For example, according to the findings of this research, sponsored industrial research does not necessarily represent the quality and value of engagement. And with regard to academic entrepreneurship, there is no guarantee that these "in-house" activities will lead faculty to more robust commercialization networks that will bolster their entrepreneurship activities.

Build and Sustain Connections Among Entrepreneurial Faculty and Support Networks

Substantial differences exist among and within scientific disciplines, technology products, and academic entrepreneurs themselves. Therefore, policymakers would be wise not to approach academic entrepreneurship as a monolithic phenomenon or engineer one-size-fits-all solutions based on what "the top research schools are doing." In fact it appears that understanding what "is happening" outside the university and quickly linking spinoffs to this activity, including industry trends and industry-specific entrepreneurship support networks, is much more important to post-spin off commercialization success.

Some universities have augmented their TTO-centric approach by establishing "in-house" programs and services to assist academic entrepreneurs as they spinoff their companies. These services vary widely and may include entrepreneurial management classes, accounting services, legal assistance, SBIR-application assistance, venture-

mentor programs, and early-stage spinoff funds. These services may be valuable but often do not recognize the realities of the Open Innovation: eventual commercialization success is dependent on linkages with expertise and resources outside the university.

Recent inquiries into so-called proof of concept centers, including the University of California at San Diego's Von Liebig Center and MIT's Deshpande Center, offer important insights into the importance of pairing entrepreneurship services with technical and commercial expertise outside these universities (Gulbranson and Audretsch, 2008). Proof of concept centers are university-based organizations that not only provide seed funding for developing early stage research but they also create linkages between faculty members (and students) and industry via mentors associated with these respective programs. While additional research is needed and the results thus far remain anecdotal, the centers illustrate the critical nature of both funding *and* connections to outside networks.

Universities like UCSD and MIT are located in regions with robust industrial and entrepreneurial networks; "plugging in" to local networks is relative easy. However, for more rural universities or universities in technical fields where the locus of relevant industries are located elsewhere in the United States (or the world), this presents a particularly overwhelming challenge. Discussed later, this may also be an area where state policy can plan an important role.

Provide Early Guidance for Entrepreneurial Faculty, Outside Leadership for Spinoffs

Research shows that non-faculty spinoff leadership is important to post-spin off commercialization success. University policymakers can increase the chances of spinoff

success by providing aspiring and current academic entrepreneurs with intensive training that emphasizes the (external) elements associated with commercialization. Among these emphases are connections with outside technical and commercial expertise and the importance of outside leadership.

Within the sample of academic entrepreneurs used for this research, spinoff leadership was often a sensitive issue. Faculty entrepreneurs typically take a great deal of pride and ownership with regard to their "baby" and – according to a few of the respondents – this often becomes a barrier to growth. Several respondents learned "through painful lessons" that the spinoff cannot grow without professional management but that they did not have the time, money, or desire to find an outside CEO. Furthermore, by the time they realized the importance of outside management, they had already made critical decisions that were difficult, if not impossible, to reverse.

Though academic entrepreneurs must be receptive, early guidance on factors responsible for spinoff success is critical, especially for faculty members that have little to no entrepreneurial experience. Programs like the Georgia Research Alliance's Venture Lab program help aspiring faculty (and student) entrepreneurs answer three questions:

- Is there a commercial market for my invention?
- What is my role in building a company?
- What are the steps between laboratory discovery and the commercial marketplace?

While Venture Lab provides services to help academic entrepreneurs develop both their business plans and technologies, it also coaches them on the importance of outside management and then helps them connect with experienced entrepreneurs.

Consider a "Low Investment-High Volume" Technology Transfer/Spinoff Strategy

Finally, vast differences exist with regard to commercialization among various industries and this has substantial implications for university policy. Existing university TTO policies, policy priorities, and entrepreneurship programs often encourage and support spin off in high-investment, high-risk industries such as the biosciences and alternative energy. This approach may come at the expense of spinoffs (or technologies) in industries with a much higher probability of commercialization.

University policymakers would do well to understand these differences and explore options that help identify and support spinoffs in low-investment, and therefore lower-risk technologies and industries. For example, one university participating in this research project has sourced many of the TTO administrative functions to an outside vendor while university personnel focus on finding promising technologies and business ideas from all parts of the university, not just those conducting high levels of federally funded research. Spinoffs have been established from "untraditional" areas of the university such as the school's Speech and Communications Department, School of Education, School of Nursing, and the Philosophy Department.

Administrators from this university acknowledge that such a "low-hanging fruit" approach may not "generate the next Gatorade or Genentech", but has resulted in several small spinoffs that have commercialized their technology, earn revenues, provide a few well paying jobs, and play an important role in the surrounding region. Furthermore, these small spinoffs have attracted the attention of many other faculty members and teams of faculty from different departments. As one respondent put it, "I feel like the culture is really shifting here…the attitude really is 'anyone can be an

entrepreneur'…that its not something that only those guys doing multi-million dollar research in the medical school do…small can be beautiful…and fun."

7.3.2 Implications for State Policymakers

States have an important but often overlooked role regarding their public university system. While independent governing boards manage most public universities and systems, state policy nonetheless can have an enormous influence in the degree to which universities participate in areas of state interest such as workforce and economic development. States do this through a variety of mechanisms and relationships including funding, policy and regulatory frameworks, and directional leadership (or lack thereof).

With regard to economic development, university spinoffs have the potential to contribute to regions within the state. If commercially successful, spinoffs can generate jobs, provide an important example for entrepreneurs – aspiring and current – in a state and region, and help illustrate the relevance and outreach of the state's public universities. It is therefore important that state policymakers, when considering a broader postsecondary education strategy, recognize the unique nature and needs of university spinoffs.

Build and Strengthen Relationships Between State Policymakers and University Leaders

State policymakers have placed an enormous amount of pressure on universities to produce economic results. This is especially true during the current economic recession. While expectations are increasing, state postsecondary education funding is decreasing

while many institutions face legislated tuition caps and increasing enrollments. In this difficult environment, it is even more critical that state policymakers work with their universities to advance state economic development interests, including ways to encourage and support university spinoffs.

First, postsecondary education should be a critical part of any governor's policy agenda. Unfortunately, given its unique governance and the lack of direct budgetary and policy "control", most policymakers have been disinterested or maintained an arms-length relationship with their universities. Furthermore, postsecondary education budgets are often perceived as discretionary since universities also receive funding from other sources such as tuition, federal R&D grants, and private contributions.

Specifically, governors and other policymakers should integrate universities into the state's long-term economic development strategy. All economic development efforts should answer this question: What is the role of postsecondary education in this endeavor? This is especially true when states are considering R&D, commercialization, and entrepreneurship. Furthermore, state policymakers should clearly articulate spin off and spinoff success as an important economic development priority. Most states provide support services to entrepreneurs but rarely, if ever, do these programs consider the unique needs of university spinoffs (NGA, 2004).

Finally, as a condition for their appointment, state economic development officials and policy advisors should understand the relationship between postsecondary education and R&D, industry, commercialization, and entrepreneurship. Due to the relatively low importance placed on postsecondary education, governors' offices and legislatures rarely have the staff capacity to understand university operations and research environments,

not to mention the complexities of academic entrepreneurship. Governor's advisors and legislative advisors need this background so they can fully implement an integrated innovation development policy in cooperation with postsecondary education, entrepreneurs, financiers, and key industry sectors. This will improve the overall capability for state governments to understand and support spin off and spinoff success.

Incorporate Spinoff Success into a Boarder State R&D and Entrepreneurship Strategy

No fewer than 25 states are investing in programs that seek to build an innovation infrastructure (NGA, 2007b). The primary goals of these programs include: attracting federal R&D dollars to universities, supporting university-industry partnerships, and accelerating the commercialization of new technologies. While money available from the states to support these goals is dwarfed by industry and the federal government, states "have the capacity to influence the future in a dramatic fashion" since industry R&D is focused narrowly and federal R&D investment continues to decline relative to other sources (NGA, 2007b). In other words, *how* state money is spent to encourage innovation is critical; the amount is secondary.

Most state innovation programs focus on attracting federal and industry R&D and/or creating research "Centers of Excellence." Painfully absent from these approaches is a focus on getting ideas *out* of the university vis-à-vis university spinoffs. And while most states fund entrepreneurship support programs, these typically do not account for the unique technological and commercialization needs of spinoffs (NGA, 2004). Furthermore, when commercialization programs do exist, they typically focus on commercialization of technology licensed to large companies thereby neglecting the

potential role of university spinoffs.

Recent changes to the Utah Centers of Excellence program illustrate the importance of focusing on spin off, in addition to commercialization, as explicit policy goals for state innovation programs. For nearly 20 years, the previous version of the program provided funding directly to Utah universities and their faculty members to develop and prepare their technology for commercialization. According to state officials, the problem with the previous program was that faculty inventions often did not "make it out of the university" nor was there "an immediate timeline" for commercialization.[29] The new program funds companies directly making spinoff a *de facto* policy goal. Program funding is directly dependent on the completion of a series of post-spinoff commercialization mileposts.

Connect Spinoffs with Industry, Funding, and Entrepreneurship Support Networks

Based, on an evolving literature and results from this research, university spinoffs face a particularly difficult challenge connecting to outside networks of funders, managers, and technical experts, resources critical to their commercialization success. Several regional "networking" programs have been established in the United States and abroad that help build and sustain linkages among university and non-profit research institutions, professional services providers, R&D and business development arms of corporations, and angel venture, and institutional capital providers.

Perhaps the best known among these is UCSD CONNECT – the networking

[29] Personal communication with Ted McAleer, Director of the USTAR program, October 2008 and Nicole Toomey, Director of the Center's of Excellence program. See also 20th Anniversary Report: http://business.utah.gov/site-media/page-media/content/centers/COE20thAnniversaryReport-Body.pdf

program initially established at the University of California at San Diego, CA. UCSD CONNECT was established in 1985 as a membership organization designed to "educate the San Diego region on how to commercialize local research-based discoveries." CONNECT builds on the presence of world-class teaching and research institutions such as UCSD, San Diego State, University of San Diego, Scripps Institute and others. CONNECT emphasizes a number of routes for dissemination of new knowledge but primary among these relationships is that of the commercialization of technology vis-à-vis spinoffs. Though the aforementioned Von Liebig Center at UCSD is now tangentially connected, the strength of CONNECT's relationship with spinoffs is not "formal" entrepreneurship services but rather the social networks that it helps build among spinoffs (and other startups in the region) with professional managers, funders, large companies, and entrepreneurship services.[30]

Given the findings from this inquiry, states policymakers should focus on building linkages among spinoffs and entrepreneurship support networks, funders, and other areas of industry expertise. Unfortunately, what state spinoff assistance exists currently takes the form of small cash grants that typically neglect the network connections that spinoffs need to succeed (NGA, 2007b). For example, among spinoffs in the research sample, 28 received state funding to support their entrepreneurship activities. State funding did not increase the likelihood that spinoffs would commercialize their technologies; however, linkages to outside resources though joint ventures, external sourcing of IP, and VC increased the likelihood of commercialization. This is also analogous to the value of working with venture capitalists, a factor that *did* have a positive and significant impact

[30]Based on interviews with Mary Wolshok, Associate Vice Chancellor for Extension at UCSD and co-founder of UCSD CONNECT, as well as Greg Horowitt, at UCSD Global CONNECT.

on a spinoff's likelihood of commercialization but for reasons – according to respondents – that had more to do with their entrepreneurship and technical support networks and less to do with the funding itself.

Creating and sustaining connections is especially difficult in regions with weak entrepreneurship support services and networks. In other words, attracting top researchers and creating entrepreneurship networks is arguably going to be much easier in population-dense, sunny San Diego than it will be for a rural midwestern research university. This is also the reason why states need to play a role in helping to establish and sustain these networks to connect university researchers and their spinoffs with other universities and regions important to their technology field and important for entrepreneurship support.

For many policymakers a state role in establishing these "connections" to outside pockets of resources and expertise may seem contradictory. Why would state funds be used to support networks that may eventually take a spinoff outside the state only to generate economic benefits elsewhere? However, if the goal is to disseminate new knowledge through commercialization then this may be the only option. Instead, policymakers should focus on designing mechanisms that will help spinoffs succeed while returning value back to the state in the form of locating branch operations in the region, repayment of services, equity investments, or other solutions. Though difficult, these discussions have been occurring at the gubernatorial staff level in Iowa, Maine, Washington, and Georgia.

7.3.2 Implications for Federal Policymakers

The federal government is the primary source of R&D funding for academic entrepreneurs in the research sample. For many agencies such as the National Science Foundation and Department of Energy Office of Science, the primary goals for federally sponsored academic R&D are the production and dissemination of new knowledge. Other agencies, such as the Department of Defense and National Institutes of Health, also fund millions of dollars of basic academic research. While the production and dissemination of new knowledge is also important to these agencies, other primary goals include the application and eventual commercialization of that knowledge.

Though the subject of recent research (Dietz and Bozeman, 2005), respondents did not see the method(s) by which federal academic R&D is funded as a post-spin off factor of success. Furthermore, federal academic R&D grants are typically not an *ex ante* consideration during spin off since much of the foundational research related to the enterprise is typically conducted years before its establishment. Finally, no federal agency funds basic university research with the *explicit* purpose of promoting and sustaining academic entrepreneurship.

The Small Business Innovation Research Program (SBIR) program, however, offers the opportunity for university, state, and federal policymakers to align their interests and better promote spinoff commercialization success. The purpose of the SBIR program, to "encourage small business to develop new processes and products and to provide quality research in support of the many missions of the U.S. government," fits well with the increasing interest of university and state policymakers in economic development outcomes vis-à-vis spinoff commercialization success (Wessner, 2007).

Established in 1982 by the Small Business Innovation Development Act (PL 97-219), the stated goals of the program are to: (1) stimulate technological innovation; (2) use small business to meet federal research and development needs; (3) foster and encourage participation by minority and disadvantaged persons in technological innovation; and (4) increase private sector commercialization derived from Federal research and development (Wessner, 2007). Subsequent program reauthorizations in 1992 and 2000 placed increasing emphasis on commercialization, including the sale of specialized technologies 'back' to mission agencies.

The statutory emphasis on commercialization for SBIR awardees aligns well with the research output of this inquiry; commercialization is used to proxy spinoff success. The SBIR program was very popular among the sample; 52 (44 percent) second phase respondents have received at least one SBIR award with most companies receiving more than one award. Other respondents have applied to the program or plan to do so.

One of the first challenges among respondents in the current inquiry who have received SBIR awards may be intent. Many academic entrepreneurs established their companies in order to apply for SBIR awards with no immediate timeline for commercialization. These anecdotes support the Phase II empirical findings whereby spinoffs in the sample were no more likely to commercialize their technology than those who did not receive SBIR awards. Indeed this may be analogous to the broader tension in the program between the original stated goal for small businesses to help fulfill federal R&D needs (goal number two above) and the evolving statutory and programmatic emphasis on commercialization.

Investigate the Linkages Between the SBIR Program and Universities

An evolving Congressionally-mandated National Research Council study has explored challenges with the SBIR program including the commercialization challenges of small businesses. While this paper will not detail the study reports, several findings relate to this research. The first is that there exists an important link between university research and SBIR. Anecdotally, strong relationships exist between mission agencies and university faculty and administrators relating to SBIR (and STTR) (Wessner, 2004, p. 85). Furthermore, empirically, Link and Ruhm (2009) find among (small) bioscience companies receiving SBIR awards that those with a "relationship with a university" have a higher likelihood of commercialization than those who do not. While the study data limits "university relationship" to a blunt, dichotomous variable, the finding merits further inquiry to better understand the nature of this relationship (is the company a spinoff, is there a faculty consulting relationship, etc.).

Continue to Expand the SBIR Programmatic Emphasis on Commercialization

Several relevant findings also stem from a study conference that explored post-SBIR award commercialization, the so-called SBIR Phase III (Wessner, 2007). During the conference, a number of factors were deemed important to the commercialization success of companies receiving SBIR awards, many of which relate to the findings of this paper. One of the main problems identified early in the study by agency program managers is that small businesses applying for SBIR awards often do so without having established business and technical strategies. In other words, SBIR awards were themselves the goal, not necessarily the means for commercialization.

Many conference participants, which included small business owners and prime (defense) contractors who purchased commercialized technology from these small businesses, recommended that agencies shift SBIR away from funding basic research and focus more on commercialization (Wessner, 2007). For academic entrepreneurs, such an emphasis would communicate the importance of commercialization to their spinoff activities. While SBIR recipients in this sample are not more likely to commercialize than those who did not receive SBIR, the question remains: shouldn't they be?

Bolster SBIR Outreach to States and Universities

During the SBIR Phase III Conference, attendees spoke about the importance of federal SBIR Commercialization programs, the Navy's Transition Assistance Program (TAP) perhaps being the most frequently mentioned. The goal of TAP is to encourage commercialization among SBIR-funded by providing critical technology transition services and "efficiently link" these firms to prime contractors who hold potential as a technology development partner, investor, and/or customer. SBIR program managers and small businesses see this partnering function as one of the most valuable aspects of TAP. Regular meetings, such as the Navy Opportunity Forum brings together SBIR program officers, prime contractors (large companies), small businesses, venture capitalists with the purpose of enabling SBIR-funded firms to commercialize their technology.

Phase III was once seen as an area where agency funding ended and (hopefully) private investment began. However, agencies themselves are increasingly investing in Phase III activities in order to improve commercialization outcomes and better meet

agency technology needs. Procurement agencies such as DOD and NASA often follow SBIR awards with other kinds of development funding. Furthermore, programs such as the Army's OnPoint and NASA's Red Planet Capital are public venture capital initiatives that have provided Phase III funding for companies receiving SBIR awards, among others. Such public Phase III efforts should be closely coordinated with the previously recommended state and university networking efforts (mentioned in the previous sections) to promote spinoff technology commercialization.

7.4 Future Research

This research is exploratory in nature and the results should be interpreted with caution; few inferences should be made about the broader population of academic entrepreneurs given the weak – or at least unknown – external validity of the findings. Nonetheless, lacking a substantive theory for academic entrepreneurship, this study hopefully makes a modest but important contribution to the understanding of university spinoffs, how academic entrepreneurs define success, and factors responsible for spinoff commercialization. The study also provides a few scholarly bricks to build and support the emergent Knowledge Spillover Theory of Entrepreneurship and – surprisingly – Chesbrough's (2003) concept of Open Innovation.

Much work remains to understand the academic entrepreneurship phenomenon and build cogent, underlying theory. Future research efforts must help policymakers and researchers understand how university governance, culture, and programs, along with state and federal policy, can promote spinoff and commercialization. It will need to overcome many of the glaring limitations of this study, the first of which is the current

lack of data for identifying academic entrepreneurs, tracking their spinoff experiences, and following the activity of their spinoffs over time.

This research is limited to a snapshot of spinoffs in various stages of development. The collection of additional contact information and data will allow time-series comparisons and help us follow and understand the life cycle of university spinoffs. In a time-series comparison we will also be able to better determine outcomes related to both the spinoff itself and its contribution to knowledge dissemination and economic activity. It will also help test the "living dead" concept in the literature – and supported in this research inquiry.

Absent robust data, scholars should pursue Davidsson's (2004) recommendation for case studies and field research from which subsequent entrepreneurship research can progress. Future research should explore additional factors that predict spinoff success and seek greater specificity for those factors identified in this inquiry. For example, the identification and further specificity with regard to funding sources and amounts from each and their impact on spinoff success. Particularly valuable would be research focused on the unique aspects of academic entrepreneurship, especially the relationship of these firms to the academic environment from which they emerge.

Additional research is also warranted to better understand the motivations of academic entrepreneurs and their role in technology commercialization. Of particular interest are academic entrepreneurs who establish their spinoffs for reasons other than 'immediate' technology commercialization. What are the contributions of these firms and how do they differ from other spinoffs? And given that many of the respondents in

the sample establish a spinoff to take advantage of the SBIR program, what is the relationship between policy and their motivation to commercialize technology?

Conversely, related research should explore how and why academic entrepreneurs choose to commercialize their research, what commercialization route they select, what mode of commercialization is most effective? For example, do faculty who establish companies that do not 'formally' license their technology from the university have a greater propensity for commercialization or does their lack of patented (university) IP preclude commercialization of their research? How do these decisions relate to previous industry experience, consulting, sponsored R&D, and public outreach?

Another area that holds much promise for researchers is a comparison of commercialization requirements and enablers among different scientific disciplines and technology areas. While many universities have adopted a 'monolithic' linear technology transfer model, this inquiry – while limited to anecdotes and a binary empirical comparison – shows that substantially different needs among spinoffs from different technology areas. The idea of the 'micro-spinoff' is especially intriguing: a low investment, low risk method of commercialization that may hold promise for departments – or smaller universities – not necessarily associated with entrepreneurial activity.

This research has introduced the importance of Open Innovation to the success of spinoff commercialization. Future research should not only seek to better understand spinoff commercialization writ large, it should do so in the context of entrepreneurial networks. Researchers should endeavor to better understand the evolution, composition and function of these networks. Important to this line of inquiry is how these networks differ for academic entrepreneurs and by industry and scientific discipline.

Future research should also examine the efficacy of university, state, and federal programs to promote and support academic entrepreneurship. This is especially important given the findings on university entrepreneurship services. Program evaluation research offers researchers a great opportunity; only a few studies have begun to map the structures and operation of these efforts (National Governors Association, 2007b). Furthermore, the evolving literature on science parks, incubators, early-stage 'startup funds, and R&D support programs such as SBIR should be tailored to focus on academic entrepreneurship.

Program evaluation is an especially difficult task given the heterogeneity of universities, regions, spinoffs, and programs but one that will no doubt attract a great deal of interest from researchers and policymakers alike. Alternative research methodologies such as matched pairs of comparable university spinoffs that have received substantial university assistance and those that have not might be useful for investigating both factors associated with the propensity commercialize as well as the private and social implications from such commercialization.

Hopefully future data collection and research efforts will test the strength and external validity of – and therefore build on – these findings, thus paving the way for KSTE. Furthermore, such efforts will lead to a better understanding of the factors responsible for spinoff success. This understanding will enable policymakers to make better decisions to promote and empower the noble efforts of academic entrepreneurs and – in the big picture – support knowledge dissemination and economic growth.

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Appendices

Appendix 1: Phase I Open-Ended Interview Questions

As an Academic Entrepreneur, how do define success relative to your spinoff?

- **Extant Literature:**

- Date of firm establishment
- Firm continue to exist
- Sales per employee
- Attract Venture Capital, early stage finance
- Number of patents and scientific papers
- Sales, Commercialization
- Sales growth
- Critical Junctures/development phases

What are the main factors that contribute to- or detract from the success of your spinoff?

Extant Literature

Personal

- Age
- Publications
- Commercial Experience, lack thereof
- Source of Research Funds
- Outside Networks

University
- Tenure
- Spinoff Strategy
- TTO Characteristics
- IP Policies, Equity
- Conflict of Interest
- Flexible leave policies

Business Development
- Funding
- Quality of team, Management "Surrogates"
- Linkages with Home University
- Characteristics of the Technology, Associated Industry
- Regional factors
- Policy Programs (see next section)

Does federal, state, local, or institutional policy impact the success of your spinoff? If so, how?

- How research is funded
- Entrepreneurship services
- Public funding programs: SBIR, state programs
- Incubators
- Science Parks
- Proof of Concept Centers

APPENDIX 2: PHASE 2 INTERVIEW/SURVEY TEMPLATE

Public University Spinoffs: Perspectives on Success and Failure from Academic Entrepreneurs

Date of Response/Interview:

BASIC INFORMATION	
Name:	
Phone Number	
Name of Company	
Home University	
Location	
Year Company was established	
PERSONAL FACTORS	
Age	
Male/Female	
Current position with the company	
Have you previously established a spinoff? Other company? How many of each?	
Sources of academic funding (agencies, state, foundations, industry)	
Industry background (Also consult CV)	
Have you consulted with industry?	

Number of patents (CV)	
UNIVERSITY FACTORS	
Has the university administration been supportive of outside engagement? Industry engagement? Spinoff activities?	
Have your peers been supportive of industry engagement? Spinoff activities?	
Has non-IP university policy been problematic to your efforts to establish a company?	
Please describe your licensing deal with the university.	
Exclusive or nonexclusive license?	
Does the university hold equity in your company?	
Has the Technology Transfer Office been at all obstructionary during the licensing process or beyond. How?	
Does/did your university provide entrepreneurship services such as classes, commercialization assistance, legal services, funding, business plan writing, or	

other types of assistance? Specify which. (Proof of Concept?)	
BUSINESS DEVELOPENT FACTORS - FUNDING	
What are the sources of development funding for your company? Please list sources and amounts of funding.	
Personal contributions	
Friends and Family	
University	
Bank Loans	
Loans from other sources (please list)	
Angel Capital	
Venture Capital	
Initial Public Offering	
PUBLIC FUNDING/ POLICY	
Have you applied for a SBIR or STTR award? How many and to what agencies have you applied?	
How many have you won (of Phase Is and IIs)? From what agencies?	
Did you receive assistance at anytime during the SBIR application process? From	

whom?	
Does your state (or other entity) offer a cash or in-kind match for winning an SBIR award?	
If you have won SBIR awards, have you received follow-up funding from the funding agency?	
Other Grants from your state?	
OTHER BUSINESS DEVELOPMENT FACTORS	
Number of FTEs?	
Is your spinoff led by an outside CEO?	
Has your spinoff had product, service, or licensing sales?	
Has your spinoff participated in a joint venture with another company? If so, what was the purpose of the venture? (RJV, manufacturing, marketing, etc).	
Does your spinoff have additional licenses beyond those filed for the establishment of the company?	
Has your spinoff licensed from other sources (beyond your university, e.g. firms, other schools, etc.?)	

Is your company located in a science park? Is it affiliated with the university? Do you receive free or discounted services therein?	
Is your company located in an incubator? Is it affiliated with the university? Do you receive free or discounted services therein?	
Technology field/product Technology? (i.e. electronics, computer hardware, software, materials, mechanical, energy, life sciences, medical devices, environment, sensors)	
OPEN QUESTIONS	
Please describe other experiences with university, local, state, or federal policy during your experience as an academic entrepreneur	