2011

Three Essays on Innovation and Regional Economic Development

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THREE ESSAYS ON INNOVATION AND REGIONAL ECONOMIC DEVELOPMENT

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submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN URBAN STUDIES AND PUBLIC AFFAIRS

at the

CLEVELAND STATE UNIVERSITY

DECEMBER 2011

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DEDICATION

To Eleanor and Myra

ACKNOWLEDGEMENTS

Success is the journey, not the destination

Every journey begins with a first step… and then a second step. This journey has taken me through four careers. The first was meritorious service in the United States Marine Corps. The second was a successful entrepreneurial enterprise. Third was professional service with multiple awards and recognition in four Fortune 500 corporations. The fourth was a scholarly pursuit through five academic degree programs. The journey is never traveled alone and those that have shaped this journey are acknowledged here.

Jesus Christ… through Him all things are possible.

Eleanor… a mother's love and guidance endures.

Frank… an uncle who taught me more about business and life than any course.

Myra… a wife's support that was unwavering. I could not have done it without you.

U.S. Marine Corps… Attitude, Discipline, Direction. "Semper Fidelis."

Sam… a friend who made the journey more enjoyable and is forever in my memory.

True success becomes the quality of that journey. I have been blessed with that success.

I would like to acknowledge my dissertation committee for their encouragement and support. It is a pleasure to have such a distinguished group of scholars as my committee. Special thanks to my academic mentors: Larry Ledebur for his sage council and Ned Hill, who brought "life" to the body of work. Special thanks to Bob Scherer for his business insight. Thanks to the faculty and staff at the Urban College who have lent their expertise to help me "keep all the ducks in a row."

Again, thank you…

And the journey continues…

THREE ESSAYS ON INNOVATION AND REGIONAL ECONOMIC DEVELOPMENT

JON R. SHELTON

ABSTRACT

The first essay develops a typology that identifies the multiple pathways, functions, and operations where innovation can occur in a firm's internal business cycle based upon the extant literature, which includes both technological and non-technological activities. This is an important step toward developing a comprehensive strategy for a regional economy and provides a common platform for the discussion of innovation among academics and practitioners.

The typology adds to the existing knowledge of how innovation works in organizations by describing the pathways, business functions, and operations in a firm's internal business process; the business strategies used to advance innovation to the market; and the market impact that innovation has in a regional economy.

The typology is enhanced by the different threads of literature—innovation, technology, organization, and marketing. The integrated approach allows academics and practitioners to understand how and where innovation occurs in firms and lays the foundation for robust metrics of the behavioral relationship between variables under study. The result is a set of assessment tools that permits diagnostics of the firm, industry, market, and region.

The second essay examines the relationship between innovation, emerging technologies, business firms' investment structure, and specialized types of private equity used to finance emerging technologies. A conceptual framework is developed for financial investment and a set of hypotheses tested for investment between Ohio and U.S. firms. Ohio

firms take a different investing approach than U.S. firms when investing in a firm's stage of business development but are not significantly different when using specialized types of financing, investing in industry/technology niches, and investing in geographic markets.

The third essay explores the role of innovation in business firms. The essay examines the reasons firms invest in innovation and then tests the difference in the innovation behavior of firms. Descriptive analysis is performed in differences in why firms engage in innovation, their preferred means of pursuing product innovation, and the reasons for engaging in product innovation. Hypothesis testing on the influence of innovation on firms' financial performance follows, as do tests on differences in firms' regional economic impacts. The t-tests of the difference in means in six dimensions of economic impact performance confirm that innovative small to mid-sized firms have greater impacts on their regional economies than do their non-innovative peers.

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ESSAY 1

A TYPOLOGY OF BUSINESS INNOVATION:

AN ACADEMIC AND PRACTITIONER'S GUIDE

1.1 INTRODUCTION

The innovation performance of firms is critical to economic development and is the bedrock for growing economies and incomes. Understanding the different forms that innovation takes is critical to both business managers and economic development policy. Too often publicly supported development efforts to stimulate innovation take an overly narrow view of the subject, most frequently tying innovation to science and engineering as a basis for developing new platform technologies. Despite the popularity of identifying new technologies with innovation, substantial areas of competitive business advantage are missed when innovation is too narrowly defined. To view innovation in a broader context one needs to look no further than a critical innovation in manufacturing management—the Toyota production system and its numerous progeny that exist under the banner of "lean manufacturing." Lean production systems represent a process innovation that created a seismic shock to the competitive global landscape in the automotive industry.

This study adds to the existing knowledge of how innovation works in business organizations by building a typology of innovation that categorizes the specific types of innovation that can affect a firm's internal business processes.

There is strong evidence in the literature to support the view that innovation in firms is one of the main reasons for industrial competitiveness and national development through what has become known as endogenous economic growth (Romer, 1986, 1990; Zaltman et al., 1973). But over the last few decades, while the literature on innovation in the manufacturing sector "has evolved exponentially, there is still no precise prescription for successful innovation" (Rothwell, 1992). Coombs et al., (1996) concluded that "the innovation process is still poorly understood and the current state of the literature contributes little to improving the understanding of the phenomenon (innovation)."

The many nontechnical definitions of innovation give the term a broad meaning. Webster's Dictionary defines *innovation* as the introduction of something new (a *new idea, method, or device).* The Encarta Dictionary definition of innovation is twofold: *the act or process of inventing or introducing something new (organization), and a new invention or way of doing something (new idea or method).* The American Heritage Dictionary defines innovation as *beginning or introducing something new as if for the first time.* From the Wikipedia Encyclopedia definition, *innovation is the process of making changes to something established by introducing something new.*

Despite these broad dictionary definitions of innovation, the popular conceptualization applied to business and economic development is much narrower. There is a tendency to think of innovation just in terms of technology development, despite the fact that the terms innovation, creativity, and entrepreneurship are interwoven. Each of these acts—innovation,

creativity, and entrepreneurship—is a distinct element in a firm's internal innovation process. The idea or discovery is the creative element, which is combined with technology by the agent of change, which is an entrepreneur or the management of an existing firm. The implementation of this combination of creativity and technology is the innovation process. From the successful implementation of an innovation, the firm develops a positive change in its competitiveness that drives its growth or is partially responsible for the firm's profitability.

Much of the recent literature concerning innovation and entrepreneurship can be traced to the work of Joseph Schumpeter (1934). Schumpeter's *Theory of Economic Development* helps us to understand the modern function of innovation in economics as well as the role of the innovator. Schumpeter described the key process in economic change as the introduction of an innovation into the market, where the entrepreneur is the innovative agent. Schumpeter identified five forms that economic innovation can take:

- Introducing a new product or a qualitative change in an existing product;
- Process innovation new to an industry;
- Opening of a new market;
- Developing new sources of supply for raw materials or other inputs;
- Changes in industrial organization or the organization of the firm.

The result of implementing these changes is what Schumpeter later called "creative destruction," where resources or factors of production used in making products are redeployed to a new combination of production. Schumpeter's description of the forms of innovation highlights the breadth of business innovation. It is a vision that appears to escape current public policy or the popular understanding of innovation.

Business strategies are about the deployment of new or improved products, services, and processes, along with resulting expected firm profits. Schumpeter proposed that the search

for profits led individuals and firms to innovate and seek new practices and technologies. New products almost by definition give the businesses producing them a monopoly, if only a temporary one and enable firms to earn higher profits until their product is successfully imitated by a competitor or displaced from the market by yet another new product. New businesses, with new ideas, change the definition of markets, not simply by lowering the price of some commodity. New products and the technologies they embody are the driving forces behind economic growth and appear to be the driving force behind increased total factor productivity (Cortright, 2001).

Much of the intellectual attention paid to economic growth in recent years has been stimulated by Paul Romer's work, which has become known as New, or Endogenous, Growth Theory. Romer (1994b) states:

> "Ultimately, all increases in standards of living can be traced to discoveries of more valuable arrangements for the things in the earth's crust and atmosphere… No amount of savings and investment, no policy of macroeconomic fine-tuning, no set of tax and spending incentives can generate sustained economic growth unless it is accompanied by the countless large and small discoveries that are required to create more value from a fixed set of natural resources."

Romer (1994a) repeats Schumpter's argument about the disruptions inherent in economic progress. In Romer's view, much job destruction is part of the natural process of replacing outmoded technologies:

> "We achieve higher productivity by instituting new processes, procedures and organizations that invariably displace old ones. The displacement produces real losses to those whose jobs or investments were tied to old ways of doing things, but absent this creative destruction, there is no technological improvement."

Cortright (2001) concludes that New Growth Theory is a view of the economy that incorporated two important points:

> "First, it views technological progress as a product of economic activity. Previous theories treated technology as a given, or a product of non-market forces. New Growth

> Theory is often called "endogenous" growth, because it internalizes technology into a model of how markets function. Second, New Growth Theory holds that unlike physical objects, knowledge and technology are characterized by increasing returns, and these increasing returns drive the process of growth."

A central tenant of New Growth theory is that the economic returns associated with new knowledge or technology in a production function contrasts with the resource-based components of a production function. Physical inputs—land, labor, and capital—are all subject to decreasing or diminishing returns in a production function, while knowledge, whose use is not rival, generates either constant or increasing returns. New Growth Theory helps make sense of the ongoing shift from a resource-based economy to a knowledge-driven economy. It underscores the point that economic processes that create and diffuse new knowledge are critical to shaping the growth of nations, regions, and industrial firms (Cortright, 2001).

While much of the past literature focused on technological innovation, recent literature of the past decade highlights the iterative nature of the innovation process where non-technological activities in the organization and marketing fields play a crucial role in a firm's capacity to innovate (Alegre & Chiva, 2008; Armbruster et al., 2008; Black & Lynch, 2005; Gera & Gu, 2004; Hall & Bagchi-Sen, 2007; Lam, 2004; Lokshin et al., 2008; OECD, 2005; Mothe & Thi, 2010; Murphy, 2002; Schmidt & Rammer, 2007; Tatikonda & Montoya-Weiss, 2001; Uhlaner et al., 2007). A study by Mothe and Thi (2010) shows non-technological activities play a major role in the innovation process and highlights the effects of organizational and marketing innovation strategies on technological innovation performance.

1.2 RESEARCH QUESTION AND METHODOLOGY

The overarching research question discussed in this essay is ***how innovation expresses itself in the internal organization of businesses.*** More specifically, the research challenge is inductively to derive a typology that can guide the study of innovation. In many ways Schumpeter‘s five ways in which innovation can be expressed in the economy is the beginning of building such a typology.

In this essay, both the academic and business literatures are used to build the typology of business-related innovation by describing the paths that innovation takes in a firm’s internal business process. Like many terms that find currency, innovation has become a widely used word with many meanings. This leads to confusion in its application and to the formation of public policy. A way out of this linguistic and analytical confusion lies in the creation of a broad typology to classify definitions of innovation on the basis of whether the innovation brings something new or improves on an existing aspect of production. This typology, much like Linnaeus’ biological classification, introduces new descriptive terms and defines their meaning with precision.

The elements of innovation are viewed in relationship to each other to provide the innovation framework. Innovation is reviewed as a set of activities rather than as an isolated event, because the innovation process is recognized as an integral part of a firm’s internal business process (Kaplan & Norton, 1996).

A typology of innovation should provide structure to the body of innovation research by specifying the domain(s) in which innovation can affect the performance of the firm. In general, constructs should first make sense (i.e., have face validity) and second be clearly

defined so that both the intended meaning and the operational implications are clear (Varadarajan, 1996).

Building a typology of innovation from the academic literature has challenges rooted in the disciplinary nature of academic research. Research in economics, business administration, and public policy all wrestle with innovation and its societal impacts. However, researchers within each discipline conceptualize innovation differently and emphasize different aspects of innovation, a business' operations and function, or its impact on business performance because of differences in research focus and variations in the way innovation is defined (Smits, 2002).

Differences in disciplinary emphasis result in a wide range of approaches to conceptualizing and defining innovation. The criteria used to conceptualize innovation in different fields are not completely independent of each other. Those who focus on organizations equate innovation with the adoption of an available idea for use within the organization, and others include both the generation and adoption of an idea as part of their definition of innovation (Gopalakrishnan & Damanpour, 1997).

Economists tend to think about innovation at a high level of abstraction, seeing it as one of the factors in an expanded production function, augmenting land, labor, and capital with knowledge (Mansfield, 1968; Mansfield et al., 1981; Scherer, 1984; Schmookler, 1991; Schumpeter, 1934). The models of economists also abstract away from individual firms and operate at the level of the macro economy or with economy-wide industrial sectors or industries. Economists also model aspects of industrial organization (i.e., market structure) that spur innovativeness within firms or industries.

Economists often operationalize innovation as the value of resources spent on research and development or as the number of patented products and processes produced (Acs & Audrelsch, 1990; Nelson & Winter, 1982; Pavitt et al., 1989). While resources spent on research and developments are indicative of effort put into innovative activity, filing of a patent is a broadly accepted proxy measure of the output from research and development investments. These proxy measures are not truly representative of overall output of innovation in industry. Few studies in economics address problems associated with commercialization of an innovation, its diffusion process within an industry, or the organization's adjustment to the adoption of an innovation (Gopalakrishnan & Damanpour, 1997).

With respect to the type of innovation, economists merely acknowledge the difference between product and process innovations and focus on technical innovations because patenting activity provides a way to measure activity. Additionally, when economists discuss either product or process innovations, they note mainly the innovations that occur within the technical system of an organization. For example, movement along an isoquant of a production function due to minor changes in cost is considered to be a case of factor substitution, not an instance of innovation (Salter, 1960).

Overall, economists view innovation as a phenomenon that both brings about large changes in total factor productivity at the industry and firm level and explains inter-industry variability in growth, productivity, and overall performance. The economist's narrow focus on technological innovation appears to escape Schumpeter's description of the breadth of business innovation. Since innovation cannot be measured in the aggregate, with the exceptions of patents, innovation is most frequently treated as an omitted variable in a

regression equation. That is, what is unmeasured in a regression equation is attributed to all omitted variables, one of which is innovation. Therefore, innovation is typically treated as a statistical artifact with the probability distribution known to all (Nelson, 1991).

Ways in which new technologies are generated; existing technologies improved, and, most importantly, how these two types of technologies result in more competitive products are of central concern to business management researchers. Their work ranges from understanding factors that improve technical performance in R&D laboratories (DiTomaso et al., 1993; Farris, 1988; Gold, 1983; Roberts & Fusfield, 1981) to identifying the criteria that influence the choice and use of technological innovations in various organizational subunits (Leonard-Barton & Sinha, 1993; Gold, 1983; Ettlie, 1983).

Business researchers typically concentrate on either idea generation or problem solving within a business's research and development department, or they focus on the way innovations are adopted in businesses operations. One researcher has labeled this focus on innovation activity within specific departments as the departmental approach to research (Saren, 1984). Again, the emphasis on the movement of an innovation through various departments is based on the department or subunit being the operational unit of analysis (Souder, 1986).

A study by Mothe and Thi (2010) looks beyond technological innovation and confirms the importance of non-technological innovations in the firm's internal business process. Research in the resource-based view has highlighted the importance of managing and combining different types of resources and even reconfiguring various capabilities. Firms organize the innovation process efficiently by combining technological capabilities with skills in marketing, management, and organizational competencies.

In summary, the current economic and business literature gives a fragmented view of innovation. The economist's narrow focus on technological innovation in the early literature limits business and public policy decisions aimed at fostering innovation. Business managers are unable to see where innovation can take place within a business. Innovation is broader than most public policies envision, and it is more than technology. Also unclear to managers is the direct effect that non-technological innovation can have on technological innovation or the firm's performance.

The current literature does not provide a conceptual model that brings together the early research that focused on technologically new or improved products and processes with the more recent research of the past decade that focused on the innovation process where non-technological activities in organization and marketing play a crucial role in a firm's performance. This study suggests a typology that identifies the multiple pathways, functions, and operations where innovation can occur in a firm's internal business cycle based upon the extant literature that includes both technological and non-technological activities.

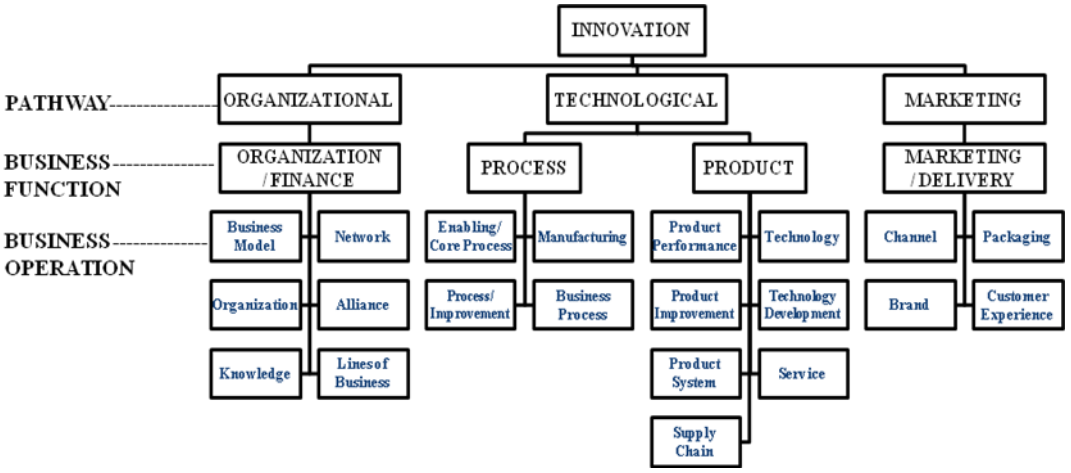
The typology suggests a method for classifying technological and non-technological innovations so practitioners and academics can talk with a common understanding of how a specific innovation type is identified and how the innovation process may be unique for that particular innovation type. The typology is enhanced by the different threads of literature—innovation, technology, organization, and marketing. The integrated approach allows academics and practitioners to understand how and where innovation occurs in firms and lays the foundation for robust metrics of the behavioral relationship between variables under study. The result is a set of assessment tools that permits diagnostics of the firm, industry,

market, and region. This is an important step toward developing a comprehensive strategy for a regional economy.

1.3 A TYPOLOGY OF BUSINESS INNOVATION

A typology of business innovation is created in this section, based on contributions from the economics and business literatures. The typology of business innovation is where innovation can take place within a business—it's broader than most public policies envision and it is more than technology. Meaningful business innovation can take place in the way in which a business is organized and managed; in the way it implements technological advances through product development and deployment or through its operating process; or through its marketing and distribution. For the sake of clarity, each of these is referred to as a pathway in Figure 1. Within each pathway, the innovation is applied or takes place in a specific business function. Within each function, a firm makes specific changes in an operation of the business. That is, the innovation either changes the business's method of work, its use of factors of production, or the type of product or service provided to its customers. The complete typology of business innovation is depicted in Figure 1, and its components are discussed in the remainder of this essay, using the literature as data to support the typology.

Figure 1: A Typology of Business Innovation:
Relationship of Pathway, Business Function, and Business Operation



ORGANIZATIONAL PATHWAY OF FIRM-BASED INNOVATION

Figure 1 depicts three vertical pathways where innovation can take place in a business: organizational, technological, and marketing. The first pathway, organizational innovation, is the implementation of a new organizational method in the firm's business practices, workplace organization, or external relations (OECD, 2005). Within the three pathways, the business literature (*Oslo Manual, 2005*) distinguishes between four areas or functions of a business' operations that align closely with Figure 1: organization, process, product, and marketing. Product and process innovations are two paths along which true technological innovation is deployed. Organization and marketing innovations are two paths along which non-technological innovation is deployed.

Organization and Finance Function: Within the business organization and finance function, the literature on innovation management shows a variety of approaches to the organization of the innovation process in firms (Brown & Eisenhardt, 1997; Burns & Stalker, 1995; Christensen, 1997; Leonard-Barton, 1995; Wheelwright & Clark, 1992). Van den Ende & Wijnberg (2003) distinguish *two types of approaches* to the organization of innovation in firms. One form focuses on the innovation process itself—the way in which innovation is implemented. The other form focuses on the organizational structures employed to promote innovation activity. Quoting from Van den Ende and Wijnberg:

> "The first type focuses on the innovation process, particularly the phases and sequences of phases within that process (Baker & Hart, 1999; Carmel & Becker, 1995; Kotler & Armstrong, 1991). Several of these approaches stem from authors with a marketing background, and represent the innovation process as a fixed series of phases from idea conception, via design and development to market introduction, with decision points between the phases marking when those responsible consider the continuation and/or adaptation of the project. The most well-known example is the stage-gate approach of Cooper (1993).
>
> The second approach focuses on organizational forms for innovation activities, particularly, on the choice between internal and external organizational forms (Burgelman et al., 1996; Roberts, 1980, 1985; Teece, 1986) and on the use of alliances for new product development." Van den Ende and Wijnberg (2001) contend the different modes of internal development are most important for managing increasing returns in (software) firms. Most notably are the characteristics of product development teams, especially their internal independence from the rest of the organization (Anonca & Caldwell, 1992; Campion et al., 1993; Steward & Barrick, 2000; Tushman & Anderson, 1997). Their findings clearly show that "giving the team involved with the innovation a high degree of autonomy, including the responsibility for handling external relations, increases the chances of managing bandwagon and network effects successfully to the advantage of the firm"

Amidst this diversity of researchers from different academic disciplines, there have been few attempts at integrating the vast amount of knowledge on innovation into a compact model. Tang (1998) examined a broad range of literature concerning how innovation takes place in organizations in order to extract key concepts and map six constructs of innovation:

information and communication, behavior and integration, knowledge and skills, project raising and doing, guidance and support, and the external environment. From the six constructs, the associated key concepts and their interactions allow a picture of innovation to emerge. The concepts, constructs, and their linkage form the basis of Tang's *integrated model* of innovation in organizations:

> "The six constructs and their relationships form the basis of the integrated model of innovation in organizations. The model and the multidisciplinary literature cited show that innovation is more complicated than usually realized or depicted. Hence, it is all the more important for managers to approach the management of innovation with awareness of the many factors and their interactions underlying innovation."

Recent empirical research tested how organizational learning capability affects product innovation performance (Alegre & Chiva, 2008) and, more generally, investigated the numerous factors that influence innovative performance (Hall & Bagchi-Sen, 2007). Schmidt and Rammer (2007) concentrated on the determinants of the various types of innovation and showed that they were very much identical with a significant rho (the measures for the correlation of the error terms of two equations) between technological and non-technological innovations. Another important result was that the combination of technological and non-technological innovation has a positive impact on a firm's return of sales. This effect could only be related to the combination of organizational and product innovation. No other combinations of technological and non-technological innovation lead to a significant higher return on sales.

Mothe and Thi (2010) studied the relationship between non-technological innovations and technological innovation and noted that little has been written on the care firms should take when considering the types of innovation that may lead to technological innovation, such as innovation in organization and/or in marketing. Both types of innovation were,

however, included in the third edition of the *Oslo Manual* (OECD, 2005), thus expanding the definition of innovation. They are now considered as innovation types that should be differentiated from technological innovations.

Within the organization function, a firm makes specific changes in an operation that changes the business's method of work. The literature distinguishes several of the operations shown in Figure 1: business model, network, alliance, and lines of business. Each is discussed briefly below.

Business Model: A business model describes the rationale of how an organization creates, delivers, and captures economic, social, or other forms of value. Business model innovation refers to the creation or reinvention of a business itself. Whereas innovation is more typically seen in the form of a new product or service offering, a business model innovation results in an entirely different type of firm that competes not only on the value proposition of its offerings but aligns its profit formula, resources, and processes to enhance that value proposition, capture new market segments, and alienate competitors. Francis and Bessant (2005) contend that:

> "Business model innovation relates to the situation in which a reframing of the current product/service, process and market context results in seeing new challenges and opportunities and letting go of others."

Markides (2006) argues:

> "Business model innovation is the discovery of a fundamental different business model in an existing business. To qualify as an innovation, the new business model must enlarge the existing economic pie. It is important to note that business model innovators do not discover new products or services; they simply redefine what an existing product or service is and how it is provided to the customer."
>
> Markides suggests that: "a disruptive technological innovation is a fundamental different phenomenon from a disruptive business model innovation as well as a disruptive product innovation. These innovations arise in different ways, have different

> competitive effects and require different responses from incumbents. All three types of innovation (technology, business model, and product) may follow a similar process to include existing markets and may have equally disruptive effects on incumbent firms, but at the end of the day, they produce different kinds of markets and have different managerial implications."

Business Network: Business networking is a socioeconomic activity by which groups of like-minded business people recognize, create, or act upon business opportunities. Business networking organizations create models or networking activity that, when followed, allows the business person to build relationships and generate business opportunities at the same time. Perks and Jeffery's (2006) study of the network operation contends:

> "In many industries, firms are increasingly locked into a state of network innovation. Innovation, in such context, is often driven by firms who configure the network to access and control critical innovation knowledge widely dispersed throughout the network. The empirical findings suggest that successful innovation network configuration involves recognizing where the innovation value resides in the network and developing capabilities and mechanisms to understand and access such value. However, this is problematic for firms embedded in their own base of knowledge and patterns of relationships."

Business Alliance: A business alliance is an agreement between businesses, usually motivated by cost reduction and improved service for the customer. Alliances are often bound by a single agreement with equitable risk and opportunity share for all parties involved and are typically managed by an integrated project team. Cowan et al., (2006) contend that in an alliance operation:

> "Pairs of firms combine their knowledge in an attempt to innovate. Whether this attempt is successful depends in part on whether the pair has been successful in the past: accumulated experience teaches a pair of firms how to innovate together, but at the same time increases the similarity of their knowledge stocks. A tension exists between the desire for a familiar partner, and desire for a partner with complementary knowledge. How this tension is resolved depends on the nature of the innovation process itself, and the elasticity of substitution of different types of knowledge inputs in knowledge production. From the alliance-innovation process, a variety of networks

> form. In different parts of the parameter space observed are isolated agents, a dense, connected network, and small worlds."

Line of Business: Line of business is a general term that often refers to a set of one or more highly related products that service a particular customer transaction or business need. A line of business will often examine its position within an industry using a Porter five forces analysis or other industry-analysis method and other relevant industry information. Roberts (1992) contends that in the lines of business operation:

> "The 'Innovation Dilemma' arises from the needs of most corporations eventually to develop major product lines and businesses that are distant from their current base strengths in markets and technologies. Yet their attempts to innovate are marked by high failure rate, especially in unrelated market-technology zones. An assessment of the major alternative strategies for technology-based business development highlights the strengths and weaknesses of each approach. 'The Familiarity Matrix' aligns these strategies with their appropriate use in seeking product line and business innovation."

TECHNOLOGICAL PATHWAY

The second pathway depicted in Figure 1 is concerned with technologically new or improved products and processes. In both the firm's production process and in the mix of products made and delivered, a firm can make many types of changes in its methods of work, its use of factors of production, and its product mix that improve its productivity and/or commercial performance.

Process Innovation: A *product* is a good or service offered to the customer or client, and a *process* is the mode of production and delivery of the good or service (Barras, 1986). Thus *product innovation* is defined as new products or services introduced to meet an external user or market need, and *process innovation* is defined as new elements introduced into an organization's production or service operations (e.g., input materials, task specifications, work and information flow mechanisms, and equipment) to produce a product or render a

service (Ettlie & Reza, 1992; Knight, 1967). Process innovations have an internal focus and are primarily efficiency driven (Utterback & Abernathy, 1975).

A process innovation is the implementation of a new or significantly improved production process or delivery method. This includes significant changes in techniques, equipment and/or software (OECD, 2005). One of the most fundamental examples of innovation in the production process is the invention of lean production methods coupled with structured supply chain management and continuous improvement methodologies.

Damanpour and Gopalakrishan (2001) cite the earlier observations made by Abernathy and Utterback (1978) when they write about the balance between product innovation and process innovation, tying the balance between them to the product's position on the product life cycle:

> "Abernathy and Utterback (1978) developed the widely cited 'product cycle model' at the industry level.* The model describes the changing rates of product and process innovations over three phases of the development of a product class. In the first phase, the 'fluid phase', the rate of product innovations is greater than the rate of process innovations. In the second phase, the 'transitional phase', the rate of product innovations decreases and the rate of process innovations becomes greater than the rate of product innovations. Finally, in the third phase, the 'specific phase', the rates of both types of innovations slow down and become more balanced."
>
> (*Shown in Table 1)

Table 1: Abernathy and Utterback (1978) product cycle model at the industry level

Variable	Fluid Phase	Transitional Phase	Specific Phase
Innovation	Product changes/ radical innovations	Major process changes, architectural innovations	Incremental innovations, improvement in quality
Product	Many different designs, customization	Less differentiation due to mass production	Heavy standardization in product designs
Competitors	Many small firms, no direct competition	Many, but declining after emergence of dominant design	Few, classic oligopoly
Organization	Entrepreneurial, organic structure	More formal structure with task groups	Traditional hierarchical organization
Threats	Old technology, new entrants	Imitators & successful product breakthroughs	New technologies and firms bringing disrupting innovations
Process	Flexible and inefficient	More rigid, changes occur in large steps	Efficient, capital intense and rigid

The first two phases are periods of radical change, where major product innovations and major process innovations are introduced respectively; the third phase is a period of incremental change, where less fundamental product and process innovations are introduced at more congruent rates (Abernathy & Utterback, 1978).

The Abernathy-Utterback model focuses on a single cycle of technological change. More recent studies of the history of industries suggest that technological change is cyclical; i.e., 'dematurity' can return an industry from the specific phase to the fluid phase (Anderson & Tushman, 1991). A "discontinuous change" (Tushman & Anderson, 1986) or an "environmental jolt" (Meyer, 1982) can lead to a new series of product and process innovations in an industry.

The distinction between product and process innovations is important because their adoption requires different organizational skills. Product innovations require that firms assimilate customer need patterns by identifying the market and designing the product (using an innovation process), manufacturing and delivering the product (involving an operations

process), and servicing the customer (with an accompanying service process). Process innovations require firms to apply technology to improve the efficiency of product development and commercialization (Ettlie et al., 1984). Different factors influence both the adoption of product and process innovations and the extent to which these innovations affect the adopting organization (Tornatzky & Fleisscher, 1990). While it has been established that product and process innovations affect each other, their pattern of interaction at the firm level is unclear. On the one hand, one may drive the other; consequently, they may occur sequentially. On the other hand, they may complement each other and can occur simultaneously (Tornatzky & Fleischer, 1990). Earlier empirical studies typically have examined these innovations separately (Hambrick et al., 1983; Schroeder, 1990). The perceived relative advantage of product over process innovation is affirmed by the surveys of the actual rate of adoption of these innovations at the firm level. For example, Myers and Marquis (1969) reported that industrial firms adopt approximately three times more product than process innovations, and Strebel (1987), in a survey of executives, supported Myers and Marquis's results and reported that firms adopt more product than process innovations in every stage of their life cycle. Further, in a meta-analytic review of the studies of innovation attributes, Tornatzky and Kelin (1982) found that "relative advantage has a positive relationship to innovation adoption."

Damapour and Gopalakrishnas (2001) examined the relationship between them and found that:

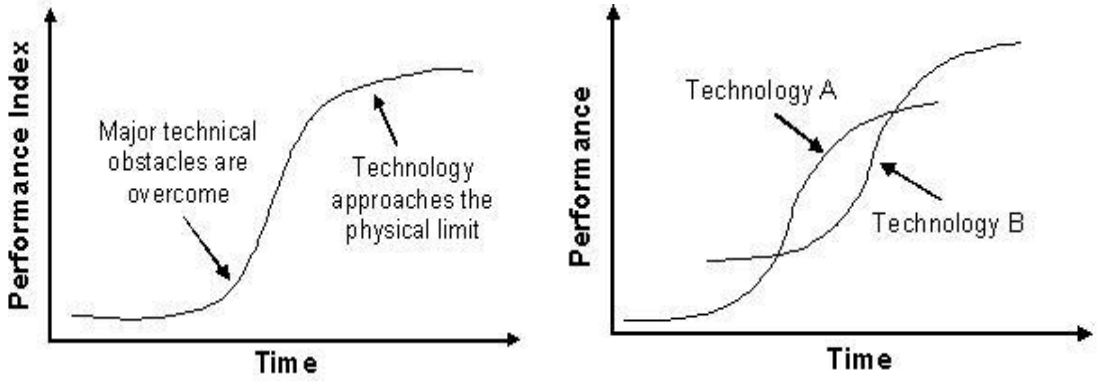
> "(1) Product innovations are adopted at a greater rate and speed than process innovations; (2) a product-process pattern of adoption is more likely than a process-product pattern; (3) the adoption of product innovations is positively associated with the adoption of process innovations; and (4) high-performance banks adopt product and process innovations more evenly than low-performance banks."

Within the process function, a firm makes specific changes in an operation that changes the business's method of work. The literature distinguishes between two of the operations shown in Figure 1: manufacturing process and business process.

Manufacturing Process: The critical component of process development is the creation and implementation of operating procedures and organizational routines needed to control a set of actions required for production. Unlike products, processes do not exist outside an organizational context, and the capabilities created by process development become an integral part of the organization. One of the underlying themes in the existing literature is that only through time or cumulative experience can an organization identify and solve problems. Bates and Flynn (1995) examined whether manufacturing process innovations followed the typical technology innovation pattern and if firms can be classified by the patterns of manufacturing process innovations they adopt.

It is necessary to determine whether the adoption follows the S-shaped pattern typical of other innovations. In the innovation management field, the S-Curve illustrates the introduction, growth, and maturation of innovations as well as the technological cycles that most industries experience. In the early stages, large amounts of money, effort, and other resources are expended on the new technology but small performance improvements are observed. Then, as the knowledge about the technology accumulates, progress becomes more rapid. As soon as major technical obstacles are overcome and the innovation reaches a certain adoption level an exponential growth will take place. During this phase, relatively small increments of effort and resources will result in large performance gains. Finally, as the technology starts to approach its physical limit, further pushing the performance becomes increasingly difficult, as Figure 2 shows (Foster, 1986).

Figure 2: S Curve Framework



Flynn et al.'s (1997) study "provided strong support for the existence of a strategy of building manufacturing capabilities through process innovation over an extended period." The manufacturing process innovations, including non-technology innovations, were adopted in an "S" curve pattern, which has been shown to hold for technological innovations (Abernathy & Utterback, 1994). The authors' findings state:

> "That plants could be classified into clusters by their manufacturing process innovation history suggests that history is important in creating expertise, and plants possess different levels of expertise to innovate. The early innovators create an expertise in manufacturing process innovation, consistent with the claims of Abernathy and Clark (1985) that innovation is the ability to influence more than the technical or scientific features of an innovation. The laggards, slow at all innovations, are passive plants that do not seek or pursue innovation. The human capital adopters continuously seek certain process innovations, while ignoring others.
>
> Accumulated expertise has been identified as knowledge and is based on human (Penrose, 1959) and organizational (Barney, 1991) capital resources. These resources represent tacit knowledge, which is difficult to articulate and often difficult to observe because it is taken for granted, and therefore, extremely difficult to imitate."

Business Process: A business process is a collection of related, structured activities or tasks that produce a specific service or product for a particular customer. It is advisable for firms to build in as many systems controls as possible, since these controls, being automatic, will always be exercised since they are built into the design of the business system software. Rapid changes in business requirements are forcing firms to innovate their business processes

and supporting software systems (Hammer & Champy, 1993; Jacobson et al., 1995). Several strategies currently exist to drive business processes and software reengineering (Bennett, 1995; Bernd & Clifford, 1992; Berztiss, 2001; Sneed, 1995; Steven et al., 2002). Several resource planning and performance optimization methodologies have been discussed in the literature. They are the Enterprise Resource Planning (ERP) system, Quality Function Deployment (QFD) methodology, Goal-Question-Metric (GQM) paradigm, Joint Evolution of Business Processes and Software Systems (JEPS) strategy, and the Balanced Scorecard (BSC). These methodologies mandate goals and provide a way to interpret data in addition to a standard income statement or balance sheet.

The ERP system was first employed in 1990[1] as an extension of material requirement planning (MRP) to integrate internal and external management information across an entire organization, embracing finance reporting, inventory tracking, manufacturing, resource planning optimizing, sales, and service. ERP systems automate this activity with an integrated software application. Its purpose is to facilitate the flow of information between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders (Bidgoli, 2004).

The Quality Function Deployment (QFD) methodology uses a set of matrixes for codifying and progressively transforming imprecise user requirements into product requirements, technical characteristics, and subsystems requirements. QFD is applied in the early stages of the design phase so that the customer requirements or desired product specifications are incorporated into the final product. Furthermore, it can be used as a

[1] Gartner Group first employed the acronym ERP as an extension of material requirements planning (MRP), later manufacturing resource planning and computer-integrated manufacturing.

planning tool as it identifies the most important areas in which the effort should focus in relation to its technical capabilities (Cohen, 1995).

The Goal Question Metric (GQM) paradigm is an analytical goal-oriented approach that is measurement based. Its main characteristic is the use of quantitative evidence for identifying where performance improvement is needed. The result of the application of the GQM approach is the specification of a measurement system targeting a particular set of issues and a set of rules for the interpretation of the measurement data (Basili & Weiss, 1984; Basili et al., 1994). GQM, like Kaplan and Norton's (1996) Balanced Scorecard (BSC), which is discussed below, offers the opportunity to implement a quantitative analysis of performance improvement. GQM's strategy differs from the BSC in that GQM does not support alignment of business and operative goals.

JEPS, like QFD, takes into account all the participants involved in the enterprise's activities. However, it differs from QFD in its key objectives, which addresses the evolution of the organization, business processes, and software systems rather than the development of new products. JEPS exploits the underlying ideas of the QFD and BSC methodologies and uses the GQM paradigm for defining the evaluation methods related to specific performance improvements and investments. JEPS supports the joint evolution of the business processes and software systems of an enterprise, considering the needs arising from the organization. More specifically, JEPS analyzes the roles and opinions of all the stakeholders who play an active role in the organization: managers, employees, users, providers, and so on. All the information they provide is evaluated and used in decision-making activities in order to identify ways to improve the production system. JEPS integrates measurement, decision-making and critiquing techniques for analyzing business processes, identifying activities and

software systems to be innovated, and mapping critiques onto specific innovation actions (Aversano et al., 2005).

Among the approaches that have been proposed for supporting the assessment of the organizational aspects of enterprises, the Balanced Scorecard (BSC) is a management approach that provides senior executives with a comprehensive set of measures of how the organization is progressing towards achieving its strategic goals. BSC starts with an analysis of the mission and vision of an enterprise and then defines the financial objectives to be achieved considering the customer's requirements. It was initially developed as a business planning tool and was later operationalized as a software-based management planning system (Aversano et al., 2005).

BSC emphasizes that financial and nonfinancial measures must be part of the information system made available to employees at all levels of the organization. BSC translates a business unit's mission and strategy into tangible objectives and measures. The measures represent a *balance* between external measures for shareholders and customers and internal measures of critical business processers, innovation, and learning and growth. The measures are *balanced* between the outcome measures—the results from past efforts—and the measures that drive future performance. The scorecard is *balanced* between objective, easily quantified outcome measures and subjective, somewhat judgmental, performance drivers of the outcome measures. The Balanced Scorecard is more than a tactical or an operational measurement system. It is a strategic management system used by companies with a long-term focus to manage their strategy (Kaplan & Norton, 1996).

Product Innovation: Product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes

significant improvements in technical specifications, components and materials, incorporated software, user friendliness, or other functional characteristics (OECD, 2005).

A study by Becheikh et al. (2006) "consists of a systematic review of empirical articles published in scholarly reviews between 1993 and 2003 on the topic of technological innovations in the manufacturing sector." More specifically, only technological product and process innovations were reviewed. Of the articles, 37% looked at product innovation, 43% examined both, and only 1% looked at process innovation.

Observations from the study drew remarks from the literature. "In spite of the strategic importance for firms of process innovations—process innovations often lead to improved productivity" (Heygate, 1996), they were of relatively little interest to researchers. The study of Linder et al. (2003), conducted with forty managers, revealed that these managers had the same attitude with respect to process innovations. Indeed, the majority of executives in the study indicated they thought primarily about new products when considering innovation and much less often about processes. However, other studies (Martinez-Ros, 1999) found that product and process innovations are interdependent and closely linked. Neglecting process innovations could thus weaken a firm's capacity to develop new products and undermine the innovation process entirely.

Though it is true that a close link exists between product and process innovations, several studies (Freel, 2003; Gopalakrichnan et al., 1999; Lager & Hörte, 2002; Michie & Sheehan, 2003; Papadakis & Bourantas, 1998; Sternberg & Arndt, 2001) have shown that product and process innovation follow different processes and do not necessarily have the same determinants. Moreover, while using the same database, Michie and Sheehan (2003) found the determinants of innovation and their effect (positive or negative) differ according

to whether one considers only the product innovations, the process innovations, or both. "It is thus strongly recommended for future research not only to consider more process innovations, but also to consider them separately" (Becheikh et al., 2006).

Within the product function, a firm makes specific changes in an operation that changes the business's method of work. The literature distinguishes several of the operations shown in Figure 1: product performance, service, and supply chain.

Product Performance: Superior product performance does not necessarily ensure commercial success. In many industries, firms seek competitive advantage primarily through product innovation. Competition in such markets is based on performance superiority. However, unless a firm can clearly establish the superiority of its products in its customers' minds, a differentiation strategy based on relative product performance is likely to be ineffective. This is particularly true in markets characterized by numerous product introductions from many competitors.

Improving product performance in some industries is the main form of competition in claiming technical superiority (Freeman, 1982; Foster, 1985; Utterbach, 1975; von Hippel, 1976). An important factor for product innovation success is creating a product that is superior in the market (Cochran, 1964; Cooper, 1993, 1981, 1979).

Research by Friar (1995) found:

> "Studies list several dimensions from which product superiority can arise but most often consider product superiority to mean having a better performance to cost ratio. However, studies have also found that product innovation success is inversely related to the rate of product introduction and/or the intensity of competition in a market (Cochran, 1964; Cooper, 1981; Lilien, 1989; Link, 1987; Maidique, 1984; Myers, 1978; Yoon, 1985)."

Service: A service innovation is a service product or service process that is based on some technology or systemic method. In services, however, the innovation does not necessarily relate to the technology itself but often lies in the non-technological areas. Service innovations can, for instance, be new solutions in the customer interface, new distribution methods, and novel application of technology in the service process, new forms or operation with the supply chain or new ways to organize and manage services.

Research by Alam (2006) found:

> "New Product Development (NPD) has made a substantial contribution to our understanding of the overall innovation process. However, the relatively narrow focus on tangible products has largely failed to account for the intricacies of the innovation process as it applies to new services. In essence, the NPD literature makes the assumption that the development process for both tangible products and service are the same, although four unique characteristics—intangibility, perishability, inseparability, and heterogeneity—differentiate services from goods (Berry, 1980; Lovelock, 1983; Zeithaml & Bitner, 2000)."

Booz and Hamilton (1982) developed six categories of new tangible products. Based on this taxonomy, other researchers have devised different typologies of new products that can be placed on a continuum from pioneering to incremental or discontinuous innovation (Ali, 1994; Atuahene-Gima, 1995; Chandy & Tellis, 2000; Crawford & Di Benedetto, 2002; Kleinschmidt & Cooper, 1991; Miles & Snow, 1978; Storey & Kelly, 2001; Veryzer, 1998).

However, in a service context only, few such categorizations are available in the literature: major innovations through style changes (Lovelock, 1984); four types of service innovation (Gadrey et al., 1995); breakthrough/platform/derivative projects (Debackere et al., 1998).

More recently, Avlontis et al. (2001) "captured six varying levels of service innovation:

1. new-to-the-market service including new-to-the-world services;
2. new-to-the-company service, service that are new to the firm, but not new to the market;

3. new delivery process consisting of lines new to a firm, but not new to the world;
4. service modifications, major improvement or modifications of an existing service;
5. service line extension, additions to a firm's existing lines; and
6. service repositioning, i.e. repositioning of an existing service."

Supply Chain: A supply chain that responds to customer needs may look quite different from the supply chains of the past. For one thing, it maintains a close relationship with marketers and product developers at the very beginning of the product life cycle. For another, it addresses the question of what happens to a product after launch—in other words, the supply chain strategy helps sustain the product's success in the marketplace.

Firms are embracing supply chain management because it focuses on action along the entire value chain (Bechtel & Jayaram, 1997; Childerhouse et al., 2002; Tan, 2001; Vonderenbse, 2002).

The supply chain integrates manufacturers, distributors, suppliers, and customers through information technology to meet customer expectations efficiently and effectively (Ansari & Modarress, 1990; Childerhouse & Towill, 2002; Choi & Hong, 2002; Huang et al., 2003; Quinn, 1997; Rich & Hines, 1997; Thomas & Griffin, 1996).

Vonderembse et al. (2006) describes "a topology for designing supply chains that work in harmony to design, produce, and deliver products with different characteristics and customer expectations."

Researchers are investigating the factors needed to design and build effective supply chains (Childerhouse et al., 2002; Cooper & Ellram, 1993; Mabert & Venkataramanan, 1998; Narasimhan & Jayaram, 1998; Pagh & Cooper, 1998; Persson & Olhager, 2002; Walker et al., 1999, 2000). The research discusses strategies and methodologies for designing supply chains that meet specific customer expectations, reflecting the product's characteristics and the expectations of the final customer (Calantone et al., 2002; Fisher,

1997; Reiner & Trcka, 2004; Singhal & Singhal, 2002). The research examines three types of products: standard, innovative, and hybrid, and describes the supply chain characteristics of each.

Other research has deepened the understanding of the impact of the structure of supply chains on business success. Ganeshaw and Harrison (1995) deal with basic issues in supply chain management including definition, strategic and operating issues, and key decision areas. Beamon (1998) focuses on supply chain design and analysis. Nolan (1998) defines five characteristics that help managers reap the full benefits of the supply chain management approach. Ragatz et al. (1996) examine issues related to lean and agile supply chains. Dowlatchahi (1996) focuses on the early involvement of logistics in product design. Hoffman and Mehrz (1996) examine the relationship between concurrent engineering and risk management. Gunasekaran (1999 a, b) focuses solely on the agile manufacturing paradigm. Yusuf et al. (1999) provide information about the concepts, drivers, and attributes of agile manufacturing. Sharifi and Zhang (1999) focus on agile manufacturing systems and develop a conceptual model for achieving agility. Naylor et al. (1999) proposes the combined use of a lean and agile supply chain.

MARKETING PATHWAY

The third pathway of marketing innovation, depicted in Figure 1, is the implementation of a marketing or distribution method not previously used by the firm.

Marketing/Delivery Function: A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion, or pricing (OECD, 2005).

"Despite innovation's pervasiveness throughout marketing, formal acknowledgement of innovation as a concept essential to marketing is noticeable by its virtual absence from marketing theory" (Simmonds, 1986). Drucker (1954) and Levitt (1960a) separated innovation and marketing, but Alderson (1965 a, b) made the link by claiming innovation as the driving force and core for marketing. This was in contrast to Rogers' (1962, 1983) earlier work, *Diffusion of Innovation*, in which innovation was separated almost entirely from the marketing process. Simmonds (1986) contends:

> "There are essentially four main bodies of theory addressing marketing and innovation. The innovation diffusion literature examined a great deal of tested theory about innovation within external markets. There is also an extensive range of research findings about innovation views as scientific discovery and research and development (Carter & Williams, 1958; Mansfield & Wagner, 1975; Schmookler, 1966). This literature has much to say about how market influences are recognized and acted upon within firms. The third body of theory falls within the economics field. While not so extensive, it is concerned with the effect of market structure on innovation (Scherer, 1965, 1967; Turner & Williamson, 1972). Finally, the fourth body of research deals with organizations and innovation (Aiken & Hage, 1971; Argyris, 1965; Baldridge & Burnham, 1975; Corwin, 1972; Hage & Aiken, 1967; Moch & Morse, 1977; Wilson, 1966; Zaltman & Stiff, 1973). This literature has implications for marketing in viewing organizations as both customers to be influenced and as the home organization of the marketer which must be stimulated to change as market conditions change."

The question of how marketing innovation may impact technological innovation is an important issue as it changes factors determining technological innovation that may be a key to a firm's performance. The focus is usually on R&D investment. However, not all firms are R&D intensive, even in the biotechnology sector (Hall & Bagchi-Sen, 2007). Firms with a relatively lower R&D intensity attribute their innovation performance to strategies that focus on competitiveness, marketing, or distribution channels (Hall & Bagchi-Sen, 2007), i.e., on marketing innovation. In extending the recent interdisciplinary research showing that customer and technological skills have a direct, unconditional effect on a firm's innovative performance, Lokshin et al. (2008) consider the effect of organizational skills. If they do not

directly improve innovative performance, the firms that successfully combine customer, technological, and organizational skills will bring more innovations to the market (Mothe & Thi, 2010).

Within the marketing function, a firm can make specific changes in an operation that changes the business's method of opening up new markets, addressing customer needs, or positioning its product on the market with the object of increasing the firm's sales. The literature distinguishes two of the operations shown in Figure 1: packaging and customer experience.

Packaging: Most commercial packaging services consist of two basic functions: protecting the product from damage during shipping and promoting the product to the ultimate, or end, consumer. Innovation in industrial organization, production processes, and advertising media evolved synergistically with innovations in packaging technologies and processes.

The selection and design of a packaging system is affected heavily by trends and developments in the micro, ambient, and macro environment, as well as by material technological developments. Sonneveld (2000) contends that:

> "In principle, the trends affecting packaging development and use can be divided into four main areas. First, business dynamics with the main affecting factors of business acquisitions and mergers, chain integration and globalization. Second, distribution trends with multinational retailers, market diversification, new ways of selling and value added logistics. Third, trends in consumption with domestic/export, demographics, social environments, and consumption habits. Fourth, legislative frames in health and safety, environment and trade barriers."

Customer Experience: Beyond what customers want, however, is what firms can create effectively, with consideration given to costs and the delivery of the product. There has been extensive discussion in recent years about successful strategies for continuous

innovation, particularly the value of outside-in vs. inside-out innovation. Inside-out innovation assumes that the best sources of new product or service ideas are your own employees—particularly research and development specialists (R&D), whose job it is to develop ideas that will wow the marketplace. Proponents of outside-in innovation, in contrast, believe that successful innovation requires input from sources outside the organization—especially from the customers who ultimately will consume these new products and services and receive increased value from the innovation. These innovations can include new delivery systems, the connection between the sales experience, product, and brand, or it can be about the way the consumer interacts either with the product or the way the product is produced or service is delivered. Affecting the customer's product experiences can be done with far less risk and cost than inventing or marketing a totally new product. But care must be taken because the experience reflects the brand in a fundamental way. If the brand is a promise to the customer, then the purchasing experience and the experience provided through interacting with the product is the execution of that promise.

It is possible to foresee an alignment—consumers seeking more engagement and "meaning" in their product relationships and acquisitions while firms seek to sustain innovation with lower costs and less risk. Selden and MacMillan (2006) argue:

> "No matter how hard companies try, their approaches to innovation often don't grow the top line in the sustained, profitable way investors expect. For many companies, there's a huge difference between what's in their business plans and the market expectations for growth (as reflected in firms' share prices, market capitalizations, and P/E ratios). This growth gap springs from the fact that companies are pouring money into their insular R&D labs instead of working to understand what the customer wants and using that understanding to drive innovation. As a result, even companies that spend the most on R&D remain starved for both customer innovation and market-capitalization growth."

This is an inside-out innovation strategy.

Selden and MacMillan also spell out the systematic approach to innovation that continuously fuels sustained, profitable growth. They call this approach customer-centric innovation, or CCI, and state:

> "At the heart of CCI is a rigorous customer R&D process that helps companies to continually improve their understanding of who their customers are and what they need. By so doing, they consistently create or improve their customer value proposition. Customer R&D also focuses on better ways of communicating value propositions and delivering the complete experience to real customers. Since so much of the learning about customers and so much of the experimentation with different segmentations, value propositions, and delivery mechanisms involve the people who regularly deal with customers, it is absolutely essential for frontline employees to be at the center of CCI process. Simply put, customer R&D propels the innovation effort away from headquarters and the traditional R&D lab out to those closest to the customer."

This is an outside-in innovation strategy.

As innovation occurs through business functions and operations there is an outcome or impact on the market. This market impact draws its importance from the diffusion rate of innovation occurring within the firm. Diffusion is the way in which innovations spread, through market or non-market channels, from their very first implementation to different industries/markets and firms, to different regions and countries. Without diffusion, innovation will have no economic impact.

1.4 DISCUSSION AND IMPLICATION

The discussion of innovation is very complex and the process of moving an idea into a product is not well defined. The literature contributes a fragmented approach to improving the understanding of innovation and does not provide a well-accepted conceptual framework for the study of innovation. Terms used in the discussion of innovation by academics and

practitioners are often used interchangeably to describe different events and actions, which leads to confusion in its application and to the formation of public policy.

The first step in clarifying the study of innovation is to undertake a literature review that examines the meanings that innovation takes on in the real economy, in businesses, and of its impact on regions. The purpose of the review is to improve thinking, communication, practice, and public policy that stimulate innovation and to provide a well-accepted conceptual framework for the study of innovation.

The typology developed by this research adds to the existing knowledge of how innovation works in organizations by describing the relationship of business pathways, functions, and operations in a firm's internal innovation process and the market impact that innovation has in a regional economy. Meaningful business innovation can take place in the way in which a business is organized and managed; implements technological advances through product development and deployment or through its operating process; or through its marketing and distribution. For the sake of clarity, each of these is referred to as a pathway in Figure 1. Within each pathway, the innovation is applied or takes place in a specific business function. Within each function, a firm makes specific changes in an operation of the business. That is, the innovation either changes the business's method of work, its use of factors of production, or the type of product or service provided to its customers.

The typology is enhanced by the different threads of literature—innovation, technology, organization, and management. The integrated approach allows academics and practitioners to understand how and where innovation occurs in firms and lays the foundation for robust metrics of the behavioral relationship between variables under study. The result is a set of assessment tools that permits diagnostics of the firm, industry, market, and region.

This is an important step toward developing a comprehensive strategy for a regional economy.

Imagine a future in which academic/practitioner discussions and relationships might enrich research and practice by helping academic researchers and management practitioners enter into each others' world without the need to cast aside their own world. Imagine how a scholarly integration might help create an exciting and productive future relationship between academics and practitioners.

Imagine a bridge being broad and secure enough to carry many people back and forth between research and practice. The purpose of this research is to expand and build that bridge by the clarity and logic of argument and its supporting evidence. The typology of business innovation provides a platform for academic and practitioner discussions.

The platform brings together the relatively simple and intuitive models of managers and business consultants with the theoretical and analytical tools of academics. The integrated model presents a new framework for understanding firm and market dynamics as it relates to innovation. The ability to determine the scale of innovation activities, the characteristics of innovative firms, and the internal and systemic factors that can influence innovation is a perquisite for the pursuit and analysis of policies aimed at fostering innovation.

1.5 CONCLUSION AND FUTURE RESEARCH

Conclusion

Typologies frame both theory and empirical research. This research provides a typology for classifying innovations based upon the extant literature that includes both technological and non-technological activities. It brings together the early literature that focused on technological innovations of new or improved products and processes with the more recent literature that confirms the importance of non-technological innovations in organizations, management, and marketing. Business managers are able to see where innovation can take place within a business. Innovation is broader than most public policies envision and it is more than technology. This typology is a method for classifying technological and non-technological innovations so practitioners and academics can talk with a common understanding of how a specific innovation type is identified and how the innovation process may be unique for that particular innovation type. This type of discussion leads to better business decisions and public policies aimed at fostering innovation. What is unclear in the literature today, however, is the effect that non-technological organizational and marketing innovation has on technological innovation or the interaction between them on firms' performance.

Future Research

Limited research and empirical studies have been done on the effect of non-technological innovation on technological innovation. Business managers should be aware of the various effects in order to efficiently adopt non-technological innovation so that firms can benefits from its full potential. Future research could analyze the impact of non-technological innovation on product and process innovation and on firm performance.

ESSAY 2

IDENTIFYING EMERGING TECHNOLOGIES, THE FIRM'S INVESTMENT STRUCTURE, AND SPECIALIZED TYPES OF FINANCING: IS OHIO DIFFERENT FROM THE U.S.?

2.1 INTRODUCTION

This essay examines the relationship between emerging technologies, the business firm's investment structure, and specialized types of financing of U.S. and Ohio investors. The essay begins with a discussion of Ohio's technology landscape; innovation, technology and finance; and the role and formula for venture capital investment. The three types of innovation identified create nine possible interactions between innovation and the economy. The second section discusses methodology and measures. The third section discusses the data analysis for identifying emerging technologies and the firm's investment structure and specialized financing. The fourth section identifies emerging technologies from the investor's view along with new industries/transformational technological applications. The fifth section develops and tests a series of hypotheses for a firm's investment structure and financial types of specialized private equity. The essay concludes with a summary of the emerging technologies and investment findings.

2.2 EMERGING TECHNOLOGY INVESTMENT

OHIO'S TECHNOLOGY LANDSCAPE: BUILDING FROM STRENGTH

The Ohio Department of Development (ODOD) and Ohio's 3rd Frontier have constructed an economic development strategy around six core technology and research strengths in the state based on research by the Battelle Memorial Institute's Technology Partnership Practice. These strengths exist in universities, hospital-affiliated research institutes, federal laboratories, and private sector research institutions. These core areas are clustered in advanced materials, biosciences, instruments, controls and electronics, information technology, and power and propulsion (Battelle, 2002; ODOD, 2004). Each of these areas of research strength is associated with demonstrated intellectual and human capital depth. As a number of commercial investment opportunities have emerged, private companies have organized to build on the flow of research and development dollars invested within the state.

A brief picture of the technological strengths of the state's economy drives home a central finding: the state's economy is composed of a portfolio of products that form a wide array of industries located within a portfolio of regional economies. A deeper view finds that the state's regional industrial bases contain a portfolio of technologies, both established and emerging. The recession of 2001 hit Ohio disproportionately hard. Ohio slid into recession before the nation as a whole and stayed there longer, with recovery only becoming apparent in the labor market in 2003. Since that time, employment growth has remained sluggish. Political and business leaders have recognized a need to chart a new economic course for Ohio's future (Deloitte, 2005).

In fall 2004, the Ohio Department of Development commissioned a study by Deloitte Consulting and Cleveland State University (CSU) to access growth opportunities and emerging technologies that have economically meaningful prospects for the state of Ohio. Business leaders from Ohio's six economic regions participated in a series of expert panels held throughout the state. Most of the expert panelists expressed interest in sustaining process and technology pull innovations. These participants were typically managers highly focused on cost containment and competitive threats to their business's existence. Many were manufacturers, but managers of service sector firms, such as back-office operations and health care organizations, also expressed interest in cost-containing or cost-reducing process innovations. While these expert panels indicate a substantial need for sustaining innovations, innovation can also be a disruptive force in the economy.

Based on the expert panels and a survey of Ohio and North American venture capitalists, a potential technology portfolio for the state was identified. These are emerging technologies and products that are viewed as being particularly competitive in Ohio: polymers; medical equipment; fuel cells; nanotechnologies; information technology; and micro-electrical mechanical systems (MEMS). The full portfolio of technologies and their relationship to product markets are given in Table 1 and discussed in the Innovation, Technology, and Finance section.

Table 1: Emerging Technologies – Promising Investment Areas

Emerging Technologies – Promising Investment Areas

Technology	Market Impact	Innovation Type: Process	Innovation Type: Product	Technology Infusion
Polymers	Sustaining	✓	✓	Pull
Biocompatable	Disruptive		✓	Push
Photonic	Unkown		✓	Push
Electronic	Disruptive		✓	Push
Conductive	Disruptive		✓	Push
Liquid crystal displays (next generation)			✓	Push
Medical equipment	Both	✓	✓	Pull/Push
Fuel cells			✓	Push
HVAC	Disruptive		✓	Push
Electric power generation	Disruptive		✓	Push
Automotive	Disruptive		✓	Push
Nanotechnology			✓	Push
Materials	Disruptive		✓	Push
Remote sensing	Sustaining		✓	Push
Biological applications	Disruptive		✓	Push
Chemical applications	Disruptive		✓	Push
Nano-polymers	Disruptive		✓	Push
Information technology		✓		
Medical industry applications	Sustaining		✓	Pull
Finance industry applications	Sustaining		✓	Pull
Industry-specifc solutions	Both	✓	✓	Pull
Micro-Electrical Mechanical Systems (MEMS)			✓	Push
MEMS machines	Disruptive		✓	Push
Automotive applications	Sustaining		✓	Push
Basic chemistry	Formative			Pull

Defining Attributes

- Clear linkage to existing state drivers
- Research strength and localized intellectual capital
- Significant Ohio venture-capital interest

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INNOVATION, TECHNOLOGY, AND FINANCE

Matching the types of innovation research requires many science and technology innovations, different sources of funding, and different performance metrics. Three types of innovation are identified—process, product, and technology—that serve to sustain, disrupt, or form products, creating nine possible interactions between innovation and the economy. Shelton et al., (2010 working paper), argue that evidence could be found to support only seven of the nine possible interactions (Table 2), as formative technology is closer to pure science than to technology-based economic development.

Table 2: Innovation Matrix

Relation to Product	Type of Innovation		
	Process	Product	Technology
Sustaining	X	X	pull
Disruptive	X	X	push
Formative			X

For this analysis, an innovation is defined as any change that results in a product that is either new or fundamentally different in its design, function, purpose, quality, or cost. A process innovation is the implementation of a new or significantly improved production or delivery method. Some innovations are sustaining: they maintain the position of the product in the marketplace and reinforce a firm's existing competitive advantage. Sustaining innovations frequently affect production processes (meaning they enable products to be made better or cheaper) and can include engineering or management innovations. Other sustaining innovations fundamentally change the nature and quality of the product or are a product extension. Sustaining product innovations typically affect use or design. A specific form of sustaining product innovation is a platform innovation in which new technology is infused, or pulled, into a product to change its function and competitive characteristics. Sustaining innovation reinforces or revitalizes existing products or firms but not necessarily regional economies (Shelton et al., 2010 working paper). Christensen (2004) argues "the odds overwhelmingly favor the incumbent leaders of the industry in battles of sustaining innovation—whether they are simple, incremental innovation or breakthroughs."

Disruptive innovation is any change in product, process, or business model that results in the death of existing products, firms, or competitive business models.[2] A disruptive innovation that has been on people's minds recently is the threat that low-cost airlines pose to

[2] The discussion of innovation is heavily influenced by Clayton Christensen and his *The Innovators Dilemma* (Harvard Business School Press, 1997).

the established major carriers. Another example can be found in the auto industry. Ohio's auto parts industry is still experiencing the after effects of the disruption stemming from lean manufacturing systems and business practices of the "new" domestic automotive sector. The new domestics' lean practices, coupled with the absence of legacy costs to retirees, have resulted in a competitive advantage in operating margin, product investment, and, frequently, product quality. Disruptive innovations are embodied in technologies that exist and are close to becoming products. The challenge for the operating company or the entrepreneur is to find an initial market for these products and then begin to move the product up the value chain. This is the history and experience of steel minimills and of public warehousing operations.

Disruptive innovations are frequently based on technology pushes: A new technology exists, and entrepreneurs or managers search for market applications for it. In this sense, technology pushes out products and applications. Venture capital investors tend to be interested in disruptive technologies that can push a wide platform of products. Investment risk lies in the scope of the potential market and the time it will take products to find meaningful markets. Nanotechnologies are currently in this stage of development (Shelton et al., 2010 working paper).

Formative technologies are closer to pure science than to technology-based economic development. The only characteristic that differentiates formative technological development from pure science is the existence of intellectual property rights protection, meaning that access to portions of the knowledge created can be legally excluded. Time to market is most often too distant for venture capitalists to participate in investing in formative innovations. Investing in formative technologies requires patient money, and it is the role of government if the knowledge remains a public good. Otherwise, formative innovation is the province of

risk-taking angel investors who may channel public funds or philanthropic sources of funding (Shelton & Hill, 2010 working paper).

THE ROLE AND FORMULA FOR VENTURE CAPITAL INVESTMENT

Shelton et al., (2010 working paper), argue the role and formula for successful venture capital investment. Venture capitalists have a fairly simple rule of thumb to guide their investment: if the investment in a company can be turned over and cashed out in three to five years, then the investment is a success. If the investment takes seven years to be sold, then, after the opportunity cost of capital is considered, the fund expects roughly to break even. If it takes 10 years or more to sell the investment, then the fund has lost money. Venture capitalists use knowledge and experience to focus their investments and to minimize risk. Among the best firms, some 10% to 30% of investments do not work out. The keys to success are having access to a large volume of credible business plans, having specialized knowledge in an area of technology, and being able to bring the skills required to manage fast-growing companies to the startup through the venture capitalists' position on its board of directors. One venture capitalist reported to the research team: "I want to pitch my tent at the crossroads of technology and the market and see what comes by." The trick is in knowing which technology road to camp on. In today's venture capital market, the best technology street is not evident to the crowd. Many venture capital firms are moving into leveraged buyouts as a way to generate returns while the technology picture becomes clearer. In 2004, Stanford University moved from a portfolio that was 66% invested in venture startups and 33% invested in leveraged buyouts to a 50-50 portfolio split. The fund planed to continue to shift toward buyouts as 2005 proceeded (Grimes, 2004).

Experienced venture capital investors are changing the way they invest, pulling money out of venture startups and diversifying into leveraged buyout financing of existing businesses. Meanwhile, the amount of money available for new ventures is actually expanding because newcomers to the marketplace are filling the pipelines of financial supply. *The Wall Street Journal* reported that the venture market is bifurcating. Venture capitalists raised $21.8 billion in 2004, $29.9 billion in 2007, and $18.6 billion in 2009. At the same time, established venture investors were reducing their risk exposure to the venture capital market. Harvard, Princeton, Stanford, and Boston Universities were reported to be joining the Ohio Public Employees Retirement System in cutting their venture capital investment targets. One university money manager told a *Wall Street Journal* reporter that "the smart money is rotating out, and the dumb money is rotating in" (Pettypiece, 2004). One fear among investors is that too much money may be going after too few quality deals. Thomson Venture Economics reported that venture funds lost 17% from 2004 to 2009. The flow of money into the venture market by new investors has resulted in funds being able to increase both their fees and their cut in any future profits. This has encouraged experienced investors to pursue other investment options.

The volume of venture investments picked up in 2004 after declining since 2001 (National Venture Capital Association, 2004). Thomson Venture Economics reported 3,141 deals in 2004, 4,018 in 2007, and 2,893 in 2009. The National Venture Capital Association reported that 663 of the 2,893 deals booked in 2009 were for software development projects. Biotechnology had 423, medical devices and equipment had 315, media and entertainment had 258, industrial/energy had 230, and information technology services had 215. On average, the largest investment amounts were in biotechnology and software at over $3

billion each, followed by medical devices/equipment and industrial/energy at over $2 billion each.

The Economist asked, "Has the venture-capital industry learnt its lesson?" *The Economist*'s reporters echoed the *Wall Street Journal*: "Many experienced venture capitalists think it [the amount of venture capital in the market] is still too high." Many venture capitalists in Europe have been moving into latter-stage, near-market investing. *The Economist* also noted that venture firms were returning to older practices, moving away from portfolio-like incubators and resuming their value-adding, time-tested practice of coaching firms they invest in from seats on the boards of directors (*The Economist*, 2004).

The key to good venture investing is what it traditionally has been—deep knowledge of an industry or of a product set. In the venture investment market, two strategies are apparent. Large, experienced institutional funds are looking globally but are specializing in markets and technologies in which they have experience. Yet even these firms try to establish a geographic basis for their practice because technology-based development blossoms in geographically concentrated clusters. Smaller venture pools have a much tighter geographic focus, with disciplined concentration on specific technologies or industries. A small but growing number of venture firms now provide seed-level funding—thousands rather than millions—to promising young start-ups. The approach differs from the usual venture capital model, in which investors take equity at the outset and demand board seats and input in day-to-day operations. But these smaller deals make particular sense in today's marketplace, the investors say. After all, tech firms now can be launched for much less investment. Thanks to declining costs for servers, more powerful coding languages, and the prevalence of free open-source software tools, brand-new start-ups can attract sizable audiences for next to nothing. And with the market awash in private equity, competition among investors for promising companies

and concepts is more heated than ever. As a result, the number of seed-level deals increased almost 50 percent in 2006, according to PricewaterhouseCoopers, the National Venture Capital Association, and Thomson Financial (NYSE:TOC).

Venture capital investing is taking different paths. Experienced institutional money managers are shortening time horizons in recessionary times and blending leveraged buyout investing with their venture funds. Additionally, national and global funds are concentrating on latter-stage investing. Newer and geographically targeted funds are focusing on areas that have been overlooked in the past; more money will be going into smaller, early-seed and preseed investing. In all cases, the size of investments will be smaller. Pittsburgh venture capital watchers reported that the typical deal size in that region would range from $1 million to $2 million (Pittsburgh TEQ, 2004).

As of 2004-2005, between 60 and 80 private equity firms were located in Ohio. Although a large pool of private equity funds has long been managed by Ohio firms, these funds have most frequently been invested out of state. Ohio's private equity firms also have tended to specialize in leveraged buyout finance and in reinvigorating firms that are well-established. These tendencies have resulted in a perceived financing gap.[3]

There is an ongoing debate over the reason for the perceived slow flow of early stage investment money into Ohio. Established venture fund operators claim that there are sufficient funds available in the region but that demand for funds, generated by a low density

[3] *Crain's Cleveland Business* reported that John Huston, a founder of Ohio Tech Angels Fund LLC, said there were more than 60 sources of private equity and venture capital in the state. The study team identified nearly 70. (Pettypiece, Shannon, February 21, 2005, "Huston pushes organizations to up support of fledgling entrepreneurs," *Crain's Cleveland Business*). Another story in *Crain's* that day reported that Northeast Ohio companies received $67 million in early-stage investing in 2003, firms in the Columbus region received $35 million, and Cincinnati-area firms had $16 million invested. These figures were compared to long-established technology hot spots: Austin, at $513 million; Research Triangle, at $296 million; and $218 million in the Twin Cities of Minneapolis-St. Paul. The study was commissioned by the Greater Columbus Chamber of Commerce, and the research was performed by Mark Butterworth of SciTech. No historical data were contained in the news report. (Pettypiece, Shannon, February 21, 2005, "Cleveland leads state, trails nation in venture capital investments," *Crain's Cleveland Business*.)

of quality deals, is weak. New entrants in the market claim that there is a shortage of funds. The study has concluded that the perception of a mismatch between supply and demand may not lie in the actual supply or demand for venture funds, but in the quality of information about potential investments. Economic development advocates are paying attention and are building intermediary organizations capable of closing the information gap between investors and borrowers and encouraging investment based on deep industry and technology-specific knowledge. Ohio's private equity investors are also moving toward making smaller investments at earlier stages of a product's and industry's life cycle.

The Ohio Bioscience Growth Report of 2007-08 reported that since 2004, over 130 investment groups have invested more than $968 million into 104 Ohio bioscience and health care-related companies. The data show that deals located in Ohio have newly found acceptance among venture capital investors. Small, early investment in medical equipment and technologies is the formula now followed by BioEnterprise, a Cleveland-based intermediary that introduces potential companies to the venture capital community. BioEnterprise has reported that the number of venture capital firms investing in bioscience has more than doubled over the past five years; 18 firms are now active in the state, with 11 of those starting operations since 2000. This count does not include angel investors or public purpose funds (Mezger, 2005).

2.3 METHODOLOGY

BUILDING THE FRAMEWORK

Both qualitative and quantitative methodologies were used for this study. The qualitative approach was used to gather information for categorizing data into patterns as the primary basis for organizing and reporting results. The sets of literature relevant to building this research conceptual framework were examined and the data gathered from peer-reviewed journal articles and discussions with academics and practitioners. From the analysis of documents, materials, and interviews, a conceptual framework was inductively developed that looks at the impact of emerging technologies on firms' financial investment in a regional economy. From this framework, a series of hypotheses were derived that were tested quantitatively.

IDENTIFYING EMERGING TECHNOLOGIES

Data were collected by a Deloitte Consulting and Cleveland State University Venture Capital Survey in 2004-05. A sample of nearly 2,400 venture capital firms across North America was surveyed to determine the technologies and industries where they were investing and to ascertain their opinion of Ohio's technology specializations. A list of 88 emerging technologies or products was developed from Ohio-based venture capital experts. This list was supplemented with material from *Technology Review* and from *the Economist* magazine's quarterly technology roundup and industry interviews. The full list is shown in Appendix A.

The survey was emailed to 466 venture capitalists and members of private equity firms. All private equity firms listed in *Crain's Cleveland Business* were surveyed. The *Crain's* statewide list for Ohio was supplemented with angel, preseed, and venture capital

funds associated with the technology division of the Ohio Department of Development. Every venture capital firm was contacted that was listed in *VCGate,* a comprehensive electronic directory of North American venture capital firms, which had a Sand Hill Road address in Menlo Park, California. Sand Hill Road is a road in Menlo Park, California, notable for the concentration of venture capital companies there. Its significance as a symbol of private equity in the United States may be compared to that of Wall Street in the stock market. Connecting El Camino Real and Interstate 280, the road provides easy access to Stanford University and Silicon Valley. Despite the development of other high-tech economic centers throughout the United States and the world, Silicon Valley continues to be the leading hub for high-tech innovation and development, accounting for one third of all of the venture capital investment in the United States (Price Waterhouse Cooper). The remainder of the mailing list was a random sample of North American venture firms included in *VCGate*. The research team received 57 responses, for a response rate of 12%.

TABLE 3: Survey Response

	Respondents Total	**Respondents Ohio**	**Respondents U. S.**
Venture Capital Firms	57	36	21
Response Rate (%)	12	63	37

Respondents were asked to rate Ohio and the United States as sources for investment opportunities for each technology or product. They were then asked to judge the number of years before the technology or product would be ready to go to market.

TESTING FIRMS' FINANCIAL INVESTMENTS

A quantitative research method was chosen for testing the series of hypotheses for firms' financial investment in a regional economy. From the survey results, a database was established to test the differences in financial investment by investing firms using cross tabulations and Chi-Square Tests of Independence.

MEASURES

Respondents to the survey were asked to identify predominate market structure investment, investment types of specialized finance, industry/technology niches, and geographical markets of investment. The variables of interest are the firms' investment structure, or the stage of business development of start-ups, middle markets, and large corporations. Start-ups are early stage firms that need funding for expenses associated with marketing and product development. Middle market firms are larger than SME (Small Medium Enterprises) but smaller than more formal corporations.

Within these structures or stages of business development, the finance specializations of interest are the angel/early stage, mezzanine finance, corporate turnaround, venture capital, leverage buyout, and investment banking/initial public offerings (IPO). Shelton et al., (2010 working paper), argue that investors that predominately invest in startups have a stronger investment interest in venture capital and angel/early stage. Seed money, often called angel investors, is the low-level financing needed to prove a new idea or fund early sales and manufacturing. Mezzanine financing is expansion money for a newly profitable firm. Corporate turnaround is funds used for corporate renewal and a return to solvency. Venture capital funds are for high growth potential. Leverage buyout occurs when a financial sponsor acquires a controlling interest in a company's equity and a significant percentage of the

purchase price is financed through leverage (borrowing). Investment banking raises funds in the capital market. An initial public offering (IPO), also called bridge financing, is intended to finance the "going public" process.

2.4 DATA ANALYSIS

IDENTIFYING EMERGING TECHNOLOGIES

There are many possible ways to score and report the survey results. Respondents were asked to rate each technology or product on a scale in which 1 was "avoid investing in this technology in Ohio," 2 was "not a desirable investment in Ohio," 3 signified "neutral in Ohio," 4 was "desirable investment in Ohio," and 5 depicted "very desirable investment in Ohio." Two weighting schemes were used to analyze the data, which is reported in Tables 4 and 5.

The first gave a value of 1 for the "neutral" response, 2 for the "desirable" response, and 3 for a response of "very desirable." The responses were then added together and divided by the number rating the technology neutral to very desirable. (In this weighting scheme, there is a bias in favor of positive responses.) The second method again gave weights of 1 for a "neutral" response, 2 for "desirable," and 3 for "very desirable," but the total was divided by the number of responses related to the technology in question. (This is a neutral method.) Technologies in Tables 4 and 5 were those in the top 25 under both weighting methods.

TESTING FIRMS' FINANCIAL INVESTMENTS

A conceptual framework was developed for financial investment and a set of hypotheses tested for investment differences between Ohio and U.S. firms. Cross tabulation and Chi-Square Tests of Independence were used to test the differences in firms' financial

investments in a regional economy. The analysis tested the influence of investment market structure and finance types of specialized private equity in technology-based regional economies.

2.5 IDENTIFYING EMERGING TECHNOLOGIES – THE INVESTOR'S VIEW

Investors rated U.S. and Ohio technology strengths, new industries, and technology opportunities in Ohio based on expert panel comments and the venture capital survey.

- Emerging U.S. Technology Strengths -Table 4
- Emerging Ohio Technology Strengths - Table 5
- New Industries/Transformational Applications in Ohio (5 to 10 years) -Table 6
- Emerging Technology Opportunities in Ohio

EMERGING U.S. TECHNOLOGY STRENGTHS

Respondents were asked to rate emerging technology strengths in the nation as a whole. The national findings are shown in **Table 4**.

Venture Capitalists Rate Emerging U.S. Technology Strengths

Top 25 Weighted Average: Assigning 1 for "neutral," 2 for "desirable," 3 for "very desirable" and then dividing by number of "neutral" through "very desirable" responses	**Top 25 Weighted Average Using All Ratings:** Assigning 1 for "neutral," 2 for "desirable," 3 for "very desirable" and then dividing by number of total responses
Power-grid hardware	Genetically modified pest control
Security: Chemical sensing and monitoring	Medical equipment
Regenerative medicine (stem-cell research)	Medical instruments
Genetically modified pest control	RFID software
Nanobio (biomedical applications)	Security: Informational databases/data mining
Security: Water-quality monitoring	Power-grid control
Medical equipment	RFID hardware
Medical instruments	Fuel cells: Off-grid civilian applications
RFID software	Artificial intelligence/fuzzy logic
Data mining and database management	Regenerative medicine (stem-cell research)
Systems biology and bioinformatics	Security: Chemical sensing and monitoring
Security: Informational databases/data mining	Security: Remote sensing
Power-grid control	MEMs: Biological applications
Space technology	Fuel cells: Building power and HVAC
RFID hardware	Fuel cells: Off-grid military applications
Fuel cells: Vehicle propulsion	Biocompatible polymers
Genetics	Data mining and database management
Security: Smart/robotic weapons	Systems biology and bioinformatics
Fuel cells: Off-grid civilian applications	Power-grid hardware
Artificial intelligence/fuzzy logic	Nanobio (biomedical applications)
Distributed storage	Security: Water-quality monitoring
Solar energy	Fuel cells: Vehicle propulsion
Genetically modified foods	Genetics
Security: Remote sensing	Distributed storage
Security: Identification technology	Wireless technologies

EMERGING OHIO TECHNOLOGY STRENGTHS

The responses about Ohio varied from those rating emerging strengths in the nation as a whole. This indicates that respondents were sensitive to geographic differences in research strengths.

The top 25 technology strengths of Ohio are displayed in Table 5. These are technologies and emerging products that are viewed as being particularly competitive in Ohio: medical

equipment and instruments; fuel cells, with off-grid civilian applications being favored; three nanotechnologies (nanomaterial, nanochemical, and nanobiological applications); general polymer technologies as well as photonic and electronic polymers; MEMS applications in micromachining and automotive applications; security database and data-mining applications as well as industry-specific applications of information technology; and liquid crystal displays.

Table 5:

Venture Capitalists Rate Emerging Ohio Technology Strengths*

Top 25 Weighted Average Dividing by "Neutral" to "Very Desirable" Responses: Assigning 1 for "neutral," 2 for"desirable," 3 for "very desirable" and then dividing by number of "neutral" through "very desirable" responses	**Top 25 Weighted Average Using Total Number Responding to Question:** Assigning 1 for "neutral," 2 for "desirable," 3 for "very desirable" and then dividing by number of total responses
Solar energy	Security: Informational databases and data mining
Security: Informational databases and data mining	Medical equipment
General polymers	Fuel cells: Off-grid civilian applications
Genetically modified pest control	Nanomaterial (material science)
Medical equipment	Nanosensing (chemical sensing and monitoring)
Fuel cells: Off-grid civilian applications	Nano-enhanced polymers
Nanomaterial (material science)	Composite materials
Nanosensing (chemical sensing and monitoring)	Medical instruments
Nano-enhanced polymers	Biocompatible polymers
RFID software	Nanochem (chemical applications)
Systems biology and bioinformatics	Photonic polymers
Composite materials	Security: Remote sensing
Medical instruments	General polymers
Biocompatible polymers	Electronic polymers
Genetically modified agriculture-drug production	Liquid crystals
Automotive: Energy storage/battery	MEMs: Automotive applications
Nanobio (biomedical applications)	Fuel cells: Off-grid military applications
Nanochem (chemical applications)	Fuel cells: Building power and HVAC
Photonic polymers	Conductive polymers
Security: Remote sensing	RFID software
Automotive: Control software	Security: Chemical sensing and monitoring
Electronic polymers	Automotive: Energy storage/battery
Liquid crystals	Remote sensing
MEMs: Micromachining	Data mining and database management
MEMs: Automotive applications	MEMs: Micromachining

* Blue highlights show where Ohio emerging strengths overlapped national strengths.

NEW INDUSTRIES/TRANSFORMATIONAL TECHNOLOGICAL APPLICATIONS

Both Ohio and U. S. investors identified new industries or transformational technological applications, shown in Table 6, where Ohio is likely to be a significant location of investment in the next five to ten years. Investors identified Ohio's future significant investments as advanced materials/polymers/chemicals; medical devices; information technology/software/business analytics/data mining; biotechnology; RFID/wireless/ distribution/logistics/packaging; nanotechnology; healthcare/medical services/regenerative medicine; fuel cells; advanced manufacturing/industrial automation.

Table 6: Ohio's Future Significant Investments in 5 to 10 Years

New Industries/ Transformational Technical Applications	% of Total	Stronger Investment Interest	Investment Interest Ratio
Advanced Materials/Polymers/ Chemicals	18.3	Ohio	14.3
Medical Devices	15.9	Ohio	15.9
Information Technology/Software/Business Analytics/Data mining	13.4	Ohio	4.6
Biotechnology	11.0	Ohio	8.2
RFID/Wireless/Distribution/ Logistics/Packaging	7.3	Ohio	7.3
Nanotechnology	6.1	Ohio	4.1
Healthcare/Medical Services/ Regenerative Medicine	6.1	Ohio	6.1
Fuel Cells	4.9	Ohio	4.9
Advanced Manufacturing/ Industrial Automation	4.9	Ohio	3.1

EMERGING TECHNOLOGY OPPORTUNITIES IN OHIO

Business leaders from Ohio's six economic regions participated in a series of expert panels held throughout the state in 2004 to get a business and qualitative perspective on

where technological and industrial innovation will emerge in Ohio. Comments from the expert panels have been organized by technology area and aligned with the results from the venture capital survey. The following is a summary of the expert panel input and the research performed by the study team.

1. Process Improvements—A Critical Basis of the Near-Term Portion of the Innovation Portfolio. In the great majority of cases, the panel participants were highly focused on the day-to-day challenges of running their businesses in the face of global competition and intense cost pressures. Manufacturers were extremely interested in productivity-enhancing process innovations and infusions of machinery that would hold costs down and increase productivity while improving quality. Employers in service industries, especially health care, were focused on process improvements that would cut the cost of paperwork and also improve health outcomes.

2. Information Technology—A Crosscutting Platform Set of Technologies. A theme emerged throughout the expert panels about the business prospects for the information technology (IT) industry. This theme usually was built around process improvements. Participants agreed with the study team's observation that computer systems design, data warehousing, and information technology represent growth opportunities throughout the state. Their comments indicated that success in the IT industry will come from "narrowcasting"—developing and marketing industry-specific solutions. The state's advantage in this narrowcasting strategy is that Ohio has a dense and broad array of customers. Process improvements both in the service sector and in manufacturing, coupled with data warehousing, are leverage points for the information technology industry in Ohio.

IT, instrument, and controls. There is an emerging area of expertise in instruments and controls equipment (ICE) that is hard to distinguish from IT products. National recognition of the state's competency in ICE and IT has been slow to come because Ohio's firms are focused on applications, especially factory automation, not basic research. This work is coming from the instruments and controls industry and process engineering, not from computer science. This is clearly an area of technology that is private sector-led, not university-led. Innovations in ICE allow companies to improve how they interpret, react to, and access data about what is happening on factory floors, one panelist noted. A second area of growth in ICE will be in the deployment of sensors to improve quality during the manufacturing process and in the integration of sensors into automated processing.

IT, RFID, and self-serve technology. Pointing to ubiquitous ATMs and scanners, one West Central panelist predicted that more innovation was to come through data mining and other technologies, such as radio frequency identification (RFID). RFID, he predicted, will further automate manufacturing processes, in much the same way self-scanners have transformed the transaction process in retail checkout lines. "We've only scratched the surface in the area of self-serve technology."

Venture capitalists on Ohio and IT. The venture capital survey indicated two areas in which Ohio may have a competitive edge in information technology: data mining and database management in general and database mining with security applications. Venture capitalists also saw strength in the development of RFID software, bioinformatics, and systems biology.

3. Chemistry—A Foundation of the Economy of the Future Incorporating a Critical Crosscutting Area of Science, Polymer Chemistry, and Nanotechnology. Those who

participated in the venture capital survey responded strongly to both nanotechnologies and polymer science. This response led the study team to hypothesize that the intersection of these two sets of intellectual activities is a particular strength of the state. General polymer science was highly rated by the venture capital community, as were more specific polymer chemistry applications: biocompatible polymers, photonic polymers, and electronic and conductive polymers.

Nanotechnology. The science of all things small is of growing interest to investors in Ohio, and it is a crosscutting set of technologies that will disrupt many existing product lines and companies. Despite *Business Week* declaring that nanotech is a set of technologies ready to emerge from the lab and go to the market, area venture capitalists noted that the technologies have yet to find substantial market penetration.

Nanotechnologies were not mentioned in-depth during the expert panels, but they were very well represented in the venture capital survey, both locally and nationally. Nanomaterials were identified as a strength of the state, as was the intersection of nanotechnologies and polymer science. "We're trying to figure out how to make it benefit us," said one Northeast Ohio manufacturer. "We're looking into novel ways to create material."

Nanosensing was another application that interested investors, given the demand for remote-sensing security applications. Other applications of interest were in the areas of nanobiology, nano-enhanced polymers, nanochemistry, and nanocoatings.

Liquid crystal research. Liquid crystals were viewed as a growing area in Ohio and were ranked among the top 25 technologies by both of the methodologies used to analyze the

venture capital survey. This research was not viewed as being a competitive area of investment elsewhere in the nation.

Micro-electro-mechanical systems (MEMS). The two applications in which venture capitalists considered Ohio to be strong were MEMS machining and automotive MEMS applications. However, MEMS research is beginning to merge with chemistry and the borderline between MEMS and nano-scale chemistry is beginning to blur.

4. Agriculture and Biotechnology. The expert panel in Columbus noted a connection between research and agriculture. "Ohio is on the cutting edge of technology," said one Central region manufacturer, citing increases in genetic engineering as an example. "But I don't see a lot of research and development around it." Another participant considered genetic engineering of plant materials to be a natural bridge linking Ohio's agricultural history to a technology-rich future. Respondents to the venture capital survey saw genetically engineered pest control as a likely area of investment nationally and locally, but the national ranking was higher. The Ohio venture capital survey also ranked genetically modified drug production as a potential area of investment.

5. Fuel Cells. Despite the interest and optimism about fuel cells as an emerging technology, the applications and market are still distant. Fuel cells are a decade or more away from widespread application, predicted one Northeast Ohio manufacturer. Although expert panelists noted the potential that fuel cells have for changing the world economy, one Northeast Ohio manufacturer who has been involved with the industry since 1998 predicted that applications for fuel cells would emerge faster in developing countries because "they don't have the infrastructure that we do. You have to have hydrogen fueling stations develop first before you can see fuel cells develop."

Other opportunities now lie in bridge technologies: hybrid fuel uses that combine batteries, fuel cells, and electric motors with petroleum-based fuel sources. Some expert panel members viewed bridge technologies as intermediate steps that could take consumers from current technology to a fuel cell hydrogen economy of the future.

Fuel cells were viewed as an opportunity area for Ohio-based venture investing. The embryonic technology is rooted in the state, and industries that can ride down the application curve, which is measured by the cost per kilowatt hour, are also located in Ohio. However, the mass application to automobiles remains in the future. Respondents to the venture survey agreed with members of the expert panel: the immediate target market consists of civilian applications that are off the electric grid. One of the weighting schemes also brought out off-grid military applications and heating, ventilation, and air-conditioning as top 25 technology areas. All three fuel cell uses were ranked by the venture capitalists nationally. However, fuel cells for automobile use appeared on the national list and was absent from the Ohio list.

6. Medical Devices. "As much as we want to be biotech here, I don't think it will happen here," said a representative of a Northeast Ohio medical technology incubator. Instead, the region's best prospects lie in leveraging its clinical knowledge and its manufacturing base to develop and produce medical devices and equipment. "I think we will be on par with Minneapolis within a few years." But such a goal requires nurturing small to mid-sized businesses, she said.

The venture capital survey was in agreement with the panelist's comments. Medical equipment and instruments were highly ranked in Ohio, receiving higher marks in the state than in the nation as a whole. Biocompatible polymers were also highly ranked as a potential area of investment in Ohio. This technology was missing from the national list. Biological

applications of nanotechnology were ranked as a potential Ohio specialization under one of the analytic methodologies.

7. Automotive. A number of emerging technologies relate to automobiles. None was identified as being of interest to the venture capital community. When these results were discussed with private equity investors, they indicated that these technologies will disrupt the automobile market when they come. However, the timing is distant, and these technologies will most likely be the province of large, established businesses because of the amount of money required to place them in the cars of the future.

Energy and battery systems. This was seen as technology in which Ohio is competitive in producing hybrid propulsion systems and in providing way stations for an alternative fuel source to the hydrocarbon engine. However, the respondents to the venture capital survey disagreed, indicating that hybrid systems are being developed by global automotive OEMs or Tier 1 suppliers.

Vehicle control software. This technology was viewed as the province of automotive systems integrators and Tier 1 suppliers. Therefore, Ohio firms are not expected to make a contribution in this area.

Drive-by-wire. Airplanes have migrated from mechanical flight controls to electronic, or fly-by-wire, controls. In the process, aircraft original equipment manufacturers replaced a number of mechanical parts and lightened the weight of planes and airframes. The same advancements are expected to occur in automobiles, with electronics replacing much of the steering, braking, and control systems. Industry experts also have noted that, if the gasoline engine is replaced with smaller electronic propulsion systems, the entire drive train can be changed. The venture capitalists who responded to these technologies showed little interest.

Two reasons were given: First, technologies connected to the drive train were considered dependent on electric propulsion systems, which were viewed as being distant. Second, for those technologies that are imminent, such as anti-lock braking and skid-control systems, the capital and system integration requirements make this an area in which existing automotive supply companies with knowledge of automotive electronics will dominate. Tier 3 and 4 suppliers of mechanical subassemblies will most likely lose business from these technological innovations.

Advanced modeling and simulation. Testing automobiles is a costly endeavor, said one Central region supplier for the automotive industry. Efforts are under way to build computer simulation models for testing components such as tires. "It cuts down on testing," he said. "It takes some of the risk and money out of it." Finite element analysis is one application of mathematics and IT that could be the core of industry-based simulation opportunities. Other forms of applied mathematics, statistical analysis, and computer modeling could also be important to this area of product development and testing.

8. Alternative Energy Sources. Alternative energy sources generate much interest on the part of environmentalists and futurists. In the northwestern corner of Ohio, agricultural researchers consider biomass a fuel source.[4] They join wind-power advocates in seeing such technologies, including clean coal, as ways of fueling Ohio's future. However, other than fuel cell technology, the surveyed venture capitalists did not put power at the top of their lists of technologies in which the state has a current competitive advantage.

[4] Biomass is any organic matter that is available on a renewable or recurring basis, including trees, plants, and associated residues; plant fiber; poultry litter and other animal wastes; industrial waste; and the paper component of municipal solid waste. Most biomass is derived from cellulose, which is a polymer, and combinations of lignin, which is the glue that holds the cellulose polymer chain together.

Clean coal is an active area of research funded by the state, with a decision forthcoming on the location of a pilot plant. However, this technology was not viewed as an area for venture capital investing. Respondents deemed solar power an area in which Ohio could be technologically competitive. Wind power technology was viewed as largely established; survey participants considered going to market with these technologies to be a matter of relative energy costs. Demand for electric power has decreased in recent years due to the recession and in response to higher prices. There is no easy solution for energy cost increases. Respondents noted that government deregulation would probably make things worse, not better. A number of adverse developments have brought into question the industry's future. These include financial restatements, federal investigations into trading activities, and extremely depressed wholesale power prices, which have resulted from weak demand and excess power capacity.

2.6 IDENTIFYING FIRMS' FINANCIAL INVESTMENT STRUCTURE AND SPECIALIZED FINANCE: HYPOTHESIS AND FINDINGS

Venture capital investment in regional economies is important because it is early-stage investment in business. It isn't essential to start-ups—76% of American firms are financed by the founders themselves and 23% by their friends and family. In fact, only one start-up in one thousand receives venture capital. In 2000, venture-backed firms had a failure rate of less than 1%, compared with the 46% failure rate for all start-ups. *One percent compared to forty-six percent.* Investors in early-stage companies are very selective: for every 100 business plans they evaluate, on average, they fund only one. So a firm that receives venture financing has been highlighted by experts as a likely winner, and still, only

10-15% of them will grow enough to meet their investors' goals (Intelligent Community Forum, 2008).

Hypothesis testing and findings give insight to and comparison of Ohio and U.S. investment interest and patterns. A summary of hypotheses to be tested are shown below.

- H1: Investment in Firm Structure (Stage of Business Development) – Table 7
- H2: Investment Types of Specialized Finance – Table 8
- H3: Types of Specialized Finance in a Firm's Structure – Table 9, 10
- H4: Industry/Technology Niche Investment – Table 11
- H5: Industry/Technology Niche Types of Specialized Finance – Table 12
- H6: Geographic Investment Markets – Table 13, 14, 15, 16

HYPOTHESIS 1: INVESTMENT IN A FIRM'S STRUCTURE

There is limited literature on national and state patterns for emerging technology investment in firm structures or stages of business development (start-up, middle market, large-corporate) and the types of specialized finance used (angel/early stage, venture capital, mezzanine finance, leverage buyout, corporate turnaround, investment banking/initial public offering-IPO).

The literature on entrepreneurial finance (Denis, 2004) argues that debt is a quite unsuitable source of financing for new technology-based firms. Chittenden et al. (1996) examine 3,480 small firms in the United Kingdom and found that small firms rely more on internal funds. Jordan et al. (1998), surveying small firms in England, found that small firms tend to use retained earnings first, then turn to debt when retained earnings are consumed, and then go to external equity when borrowing limits are reached. Previous research suggests that the amount of initial financial capital invested in firms is positively related to new venture survival and growth (Cooper et al., 1994; O'Neill & Duker, 1986).

In principle, outside equity capital provided by venture capitalists, other firms, or angel investors enjoys several advantages over debt. These investors, while specializing in early stage financing of high tech firms, develop superior capabilities in coping with adverse selection and moral hazard problems that allegedly deter other investors (Gompers & Lerner, 2001; Sahlman, 1990).

Shelton et al., (2010 working paper), argue that the national pattern for equity capital investment indicate twice as many investment firms invest in start-ups as in middle markets. The research question for hypothesis 1 centers on whether Ohio investors follow the same national pattern when investing equity capital in a firm's structure.

Hypothesis 1 (Ho): Investment in a firm's structure is the same for Ohio and the U.S.
Hypothesis 1 (Ha): Investment in a firm's structure is not the same for Ohio and the U.S.

Finding: The data in Table 7 indicate nearly 60% of firms invest in start-ups. The U.S. (71.4%) has a stronger investment interest than Ohio (48.6%) by a 1.5 to 1 ratio. Nearly 30% of firms invest in middle markets. Ohio (37.1%) has a stronger investment interest than the U.S. (14.3%) by a 2.6 to 1 ratio. Large-corporate and others represent less than 15% of investments.

Conclusion: A Chi-square test of independence indicates that investors in Ohio and the rest of the U.S. view the same investment opportunity differently. The χ^2 test rejects the null hypotheses that Ohio and U.S. investors have the same investment interest in a firm's structure or stage of development. The difference between Ohio and U.S. investors is significant. χ^2 (3, N = 56) = 8.044, $p < .05$. This means that Ohio investors tend to favor middle market investments, while investors in the rest of the nation prefer start-up investments.

Table 7: Investment Structure (Stage of Business Development)

Firms Predominately Invests in	% of Total	% within firm location Ohio	% within firm location U.S.	Stronger Investment Interest Ratio for Ohio	Stronger Investment Interest Ratio for U.S.
Start-ups	57.1	48.6	71.4		1.5
Middle markets	28.6	37.1	14.3	2.6	
Large-corporate	3.6	0	9.5		
Others	10.7	14.3	4.8		

Chi-Square = 8.044 Reject Ho: 8.044 exceed 7.815, significant at $p < .05$

HYPOTHESIS 2: INVESTMENT TYPE OF SPECIALIZED FINANCE

Carter and Van Auken (1990) argue there is little information to guide business founders in the development of an appropriate financial package at start-up. Shelton et al., (2010 working paper), argue that the national pattern for types of specialized finance used by investors indicate twice as many investment firms use venture capital than angel/early stage or leverage buyout financing. The research question for hypothesis 2 centers on whether Ohio follows the same national pattern for specialized types of finance.

> **Hypothesis 2** (Ho): Ohio and U.S. investors use the same type of specialized finance.
> Hypothesis 2 (Ha): Ohio and U.S. investors do not use the same type of specialized finance.

Finding: The data in Table 8 indicate nearly 50% of firms use venture capital financing. The U.S. (57.1%) has a stronger investment interest than Ohio (41.7%) by a 1.4 to 1 ratio.

Nearly 25% of firms use angel/early stage financing. The U.S. (28.6%) has a stronger investment interest than Ohio (22.2%) by a 1.3 to 1 ratio.

More than 20% of firms use leverage buyout financing. Ohio (27.8%) has a stronger investment interest than the U.S. (9.5%) in leverage buyout financing by a 3 to 1 ratio.

Mezzanine finance, corporate turnaround, and investment banking/initial public offering (IPO) represent less than 8%.

Conclusion: A Chi-square test of independence indicates that investors in Ohio and the rest of the U.S. view the same investment opportunity much the same. The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors use the same types of specialized finance. The difference between Ohio and U.S. investors is not significant. χ^2 (5, N = 57) = 4.303, $p < .05$. This means that Ohio and U.S. investors tend to favor using the same types of specialized financing.

Table 8: Investment Types of Specialized Finance

Firms Investment Specialization	% of Total	% within firm location Ohio	% within firm location U.S.	Stronger Investment Interest Ratio for Ohio	Stronger Investment Interest Ratio for U.S.
Angel/early stage	24.6	22.2	28.6		1.3
Venture capital	47.4	41.7	57.1		1.4
Mezzanine finance	3.5	2.8	4.8		
Leverage buyout	21.1	27.8	9.5	3.0	
Corporate turnaround	1.8	2.8	0		
Investment banking/IPO	1.8	2.8	0		

Chi-Square = 4.303 Do not reject Ho: 4.303 does not exceed 11.070, not significant at $p < .05$

HYPOTHESIS 3: TYPES OF SPECIALIZED FINANCE IN A FIRM'S STRUCTURE

There is limited information on what types of specialized financial capital investors use when investing in a firm's structure. In addition to industry differences in demand for financial capital, researchers have recognized that financial capital is only one of the necessary resources for start-up firms. Thus the human capital provided by founders is an

important contributor to the success of the firm (Cooper et al., 1994). Some researchers (Timmons, 1990) suggest that founders with good business opportunities find ways to acquire the necessary capital. Indeed, economic theory (Nicholson, 1989) suggests that there may be some degree of substitutability between human and financial capital. Hence firms with relatively higher levels of human capital may require relatively lower levels of initial financial capital (Chandler & Hanks, 1998).

Van Auken and Carter (1989) found that initial equity comes from a variety of sources, including savings, mortgages on homes and personal property, partners, friends and relatives, and outside investors. They found that "initial debt typically comes from lending institutions. Although in larger firms a clear distinction is made between debt and equity, in start-up firms the time-honored line tends to blur. Equity from external sources is often structured more like debt than equity. Shares are not easily traded and there is often the expectation that equity plus a return on the investment will be repaid at some point in the future. Thus it is more practical to classify the initial capital structure as *internal capital* provided by the founder or founding team and *outside capital* provided by investors or lending institutions." This categorization has been used by several researchers and has precedent in the literature (Carter & Van Auken, 1990; Cooley & Edwards, 1982; Downes & Heinkel, 1982).

Shelton et al., (2010 working paper), argue that investors use different types of specialized finance when investing in a firm's structure. The data in Table 9 indicate investors that predominately invest in startups have a stronger investment interest in venture capital (30.4%) and angel/early stage (25%). Middle market investments are leverage

buyouts (17.9%) by a 5 to 1 ratio over venture capital (3.6%). Large corporate turnaround and others represent less than 15%.

Table 9: Types of Specialized Finance in a Firm's Structure

	Types of Specialized Finance		
Firm's Structure	% of Total Angel/early Stage	% of Total Venture Capital	% of Total Leverage Buyout
Start-ups	25.0	30.4	1.8
Middle markets	0	3.6	17.9
Large-corporate	0	1.8	1.8
Others	0	10.7	0
Total	25.0	46.4	21.4

Chi-Square = 48.136 Reject Ho: 48.136 exceed 24.996, significant at $p < .05$

The research question for hypothesis 3 centers on whether Ohio and the U.S. use the same types of specialized finance when investing in a firm's structure.

Hypothesis 3 (Ho): Ohio and U.S. investors use the same types of specialized finance in a firm's structure.
Hypothesis 3 (Ha): Ohio and U.S. investors do not use the same types of specialized finance in a firm's structure

Finding: The data in Table 10 indicate Ohio investors (47.1%) have a stronger investment interest than the U.S. (40%) in start-ups using angel/early stage specialization by a 1.2 to 1 ratio. Ohio investors (69.2%) have a 2 to 1 stronger investment interest than the U.S. (33.3%) in middle markets using leverage buyout.

U.S. investors (60%) show a stronger investment interest than Ohio (47.1%) in start-ups using venture capital specialization by a 1.3 to 1 ratio.

Conclusion: A Chi-square test of independence indicates that investors in Ohio and the rest of the U.S. view the same investment opportunity much the same. The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors use the same types of specialized

finance in a firm's stage of development. The difference between Ohio and U.S. investors is not significant. For start-ups, χ^2 (2, N = 32) = 1.224, $p < .05$. For middle markets, χ^2 4, N = 16) = 3.528, $p < .05$. This means that Ohio and U.S. investors tend to favor using the same types of specialized finance in a firm's stage of development.

Table 10: Ohio and U.S. Firms' Investment Interest

Firm's Structure	Types of Specialized Finance	% within Firm Location Ohio	% within Firm Location U.S.	Stronger Investment Interest Ratio for Ohio	Stronger Investment Interest Ratio for U.S.
Start-ups	Angel/early stage	47.1	40.0	1.2	
	Venture Capital	47.1	60.0		1.3
Middle markets	Leverage Buyout	69.2	33.3	2.1	

Start-ups-Chi-Square = 1.224 Do not reject Ho: 1.224 does not exceed 5.991, not significant at $p < .05$

Middle markets- Chi-Square = 3.528 Do not reject Ho: 3.528 does not exceed 9.488, not significant at $p < .05$

HYPOTHESIS 4: INDUSTRY/TECHNOLOGY NICHE INVESTMENT

There should be differences between industries groups in the total amount of capital required to start a firm (Porter, 1980). In a start-up firm, the skills and abilities founders bring to the business constitute an important resource (Chandler & Jansen, 1992). The relationship between founders' human capital and financial capital is not clearly understood, yet the concept of substitutable resources is documented in the economics literature by the development of production functions discussed extensively in basic microeconomics and taught in basic courses (Nicholson, 1989).

There is limited literature on national and state interest and patterns for investment in industry/technology niches and the specialized types of finance used. The research question for hypothesis 4 centers on whether Ohio and the U.S. invest in the same industry/technology niches.

> **Hypothesis 4** (Ho): Ohio and the U.S. invest in the same industry/technology niches.
> Hypothesis 4 (Ha): Ohio and the U.S. do not invest in the same industry/technology niches.

Finding: The data in Table 11 indicate Ohio and U.S. firms' relative positions in the top industry/technology niches according to current portfolios that exceeded 20% of firms' investments. Ohio has a stronger investment interest than the U.S. in information technology/specialized software (50%/47.6% for a 1.1 to 1 ratio), advanced materials (27.8%/19% for a 1.5 to 1 ratio), and micro electric-mechanical systems—MEMS (22.2%/19% for a 1.2 to 1 ratio).

The U.S. has a stronger investment interest than Ohio in biotechnology (42.9%/35.1% for a 1.2 to 1 ratio), telecommunications (38.1%/33.3% for a 1.1 to 1 ratio), healthcare information systems (33.3%/16.7% for a 2 to 1 ratio), nanotechnology (23.8%/22.2% for a 1.1 to 1 ratio), and security technology (28.6%/19.4% for a 1.5 to 1 ratio).

Conclusion: A Chi-square test of independence indicates that investors in Ohio and the rest of the U.S. view the same investment opportunity much the same. The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors invest in the same industry/technology niches. The difference between Ohio and U.S. investors is not significant. χ^2 (1, N = 57) = 0.030 (Information); 0.255 (Biotechnology); 0.132 (Telecommunications); 0.546 (Advanced Materials); 2.093 (Healthcare); 0.019 (Nanotechnology); 0.628 (Security Technology); 0.080

(MEMS), $p < .05$. This means that Ohio and U.S. investors tend to favor investing in the same industry/technology niches.

Table 11: Industry/Technology Niche (> 20% of Investments)

Industry/ Technology Niche	% Of Total	% within Firm Location Ohio	% within Firm Location U.S.	Stronger Investment Interest Ratio for Ohio	Stronger Investment Interest Ratio for U.S.
Information technology/specialized software	49.1	50.0	47.6	1.1	
Biotechnology	38.6	35.1	42.9		1.2
Telecommunications	35.1	33.3	38.1		1.1
Advanced materials	24.6	27.8	19.0	1.5	
Healthcare information systems	22.8	16.7	33.3		2.0
Nanotechnology	22.8	22.2	23.8		1.1
Security technology	22.8	19.4	28.6		1.5
Micro electric-mechanical systems—MEMS	21.1	22.2	19.0	1.2	

Do not reject Ho: Chi-Square for each niche does not exceed 3.841, not significant at $p < .05$

HYPOTHESIS 5: INDUSTRY/TECHNOLOGY NICHE TYPES OF SPECIALIZED FINANCE

The research question for hypothesis 5 centers on whether Ohio and the U.S. use the same types of specialized finance for industry/technology niches.

Hypothesis 5 (Ho): Ohio and U.S. investors use the same types of specialized finance in industry/technology niches.
Hypothesis 5 (Ha): Ohio and U.S. investors do not use the same types of specialized finance in industry/technology niches.

Finding: The data in Table 12 indicate that within the top industry/technology niches, U. S. firms show a stronger specialization than Ohio in *angel/early stage investment* for

information technology/specialized software (50%/27.8% for a 1.8 to 1 ratio), biotechnology (55.6%/46.2% for a 1.2 to 1 ratio), telecommunications (37.5%/25% for a 1.5 to 1 ratio), advanced materials (75%/40% for a 1.8 to 1 ratio), health care information systems (57.1%/33.3% for a 1.7 to 1 ratio), nanotechnology (60%/50% for a 1.2 to 1 ratio), and security technology (50%/42.9% for a 1.2 to 1 ratio). U.S. and Ohio firms have the same interest in MEMS (50%/50%).

Ohio firms show a stronger interest than the U.S. in *venture capital investment* for information technology/specialized software (61.1%/50% for a 1.2 to 1 ratio), telecommunications (66.7%/62.5% for a 1.1 to 1 ratio), advanced materials (50%/25% for a 2 to 1 ratio), health care information systems (50%/42.9% for a 1.2 to 1 ratio), nanotechnology (50%/40% for a 1.3 to 1 ratio), and security technology (57.1%/50% for a 1.1 to 1 ratio). Ohio and U.S. firms have the same interest in MEMS (50%/50%). Ohio firms (38.5%) have less interest in biotechnology than U.S. firms (44.4%).

Ohio firms show a stronger interest than the U.S. in *leverage buyout investment* for information technology/specialized software (11.1%/0% for a 11.1 to 1 ratio), biotechnology (15.4%/0% for a 15.4 to 1 ratio), telecommunications (8.3%/0% for a 8.3 to 1 ratio), advanced materials (10%/0% for a 10 to 1 ratio), and health care information systems (16.7%/0% for a 16.7 to 1 ratio). Both Ohio and U.S. firms show no interest in nanotechnology, security technology, and MEMS.

Conclusion: A Chi-square test of independence indicates that investors in Ohio and the rest of the U.S. view the same investment opportunity much the same. The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors use the same types of specialized finance when investing in industry/technology niches. The difference between Ohio and U.S.

investors is not significant. *For Ohio:* χ^2 (5, N = 36) = 10.367 (Information); 8.115 (Biotechnology); 6.713 (Telecommunications); 4.929 (Advanced Materials); 1.440 (Healthcare); 7.457 (Nanotechnology); 5.302 (Security Technology); 7.457 (MEMS), $p < .05$. *For the U.S.:* χ^2 (3, N = 21) = 5.966 (Information); 6.708 (Biotechnology); 2.272 (Telecommunications); 5.327 (Advanced Materials); 4.875 (Healthcare); 3.544 (Nanotechnology); 2.625 (Security Technology); 1.544 (MEMS), $p < .05$. This means that Ohio and U.S. investors tend to favor using the same types of specialized finance when investing in industry/technology niches.

Table 12: Industry/Technology Niche Types of Specialized Finance

	Types of Specialized Finance					
	Angel/Early Stage		**Venture Capital**		**Leverage Buyout**	
Industry/ Technology Niche	% within Firm Niche		% within Firm Niche		% within Firm Niche	
	Ohio	U.S.	Ohio	U.S.	Ohio	U.S.
Information technology/specialized software	27.8	50.0	61.1	50.0	11.1	0
Biotechnology	46.2	55.6	38.5	44.4	15.4	0
Telecommunications	25.0	37.5	66.7	62.5	8.3	0
Advanced materials	40.0	75.0	50.0	25.0	10.0	0
Healthcare information systems	33.3	57.1	50.0	42.9	16.7	0
Nanotechnology	50.0	60.0	50.0	40.0	0	0
Security technology	42.9	50.0	57.1	50.0	0	0
Micro electric-mechanical systems—MEMS	50.0	50.0	50.0	50.0	0	0

Do not reject Ho: Ohio, Chi-Square for each niche does not exceed 11.070, not significant at $p < .05$

Do not reject Ho: U.S., Chi-Square for each niche does not exceed 7.815, not significant at $p < .05$

HYPOTHESIS 6: GEOGRAPHIC INVESTMENT MARKETS

Institutional theory suggests that industries are likely to develop different financing practices. It also is likely that the supply of financial capital influences initial capital structure (Mizruchi & Stearns, 1994). Human capital theory (Becker, 1975) is used in the economics literature to predict income differences based on differences in individual education and experience characteristics. A theory proposed by Leland and Pyle (1977), and partially tested by Carter and Van Auken (1990), states that when founders perceive the probability of a successful and lucrative venture to be greater, they are more likely to provide a greater proportion of the initial investment. A need for autonomy has been identified by many researchers as an important dimension in the personality of many entrepreneurs (Collins et al., 1964; Smith, 1967).

Localized knowledge and capital investment in firms drives innovation. Successful innovation drives competitive advantage and in turn economic growth. Economic growth drives wealth and prosperity for both firms and regional economies. Successful regional economies are those that foster the capability to innovate.

The research question for hypothesis 6 centers on whether Ohio and the U.S. have the same geographic market investment interest. The research centers on whether the investment interest is the same for the national, state, and metropolitan level.

> **Hypothesis 6** (Ho): Ohio and U.S. investors have the same investment interest in geographic markets.
> Hypothesis 6 (Ha): Ohio and U.S. investors do not have the same investment interest in geographic markets.

Finding: The data in Table 13 indicate nearly 90% of firms have significant portfolio investments (at least 10 percent) in markets in the United States. Ohio has less focus on foreign investment and invests more in the United States (56.1%) than U.S. firms (31.6%) by

almost a 2 to 1 ratio. Nearly 10% of firms invest in Canada. The U.S. (5.3%) invests more than Ohio (1.8%) firms by a 3 to 1 ratio. Europe, Asia, and South America account for less than 4% of investment.

Conclusion: A Chi-square test of independence indicates that investors in Ohio and the rest of the U.S. view the same investment opportunity much the same. The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors invest in the same geographic markets. The difference between Ohio and U.S. investors is not significant. χ^2 (1, N = 57) = 0.124 (U.S.); 2.692 (Canada); 0.594 (Europe); 0.594 (China). This means that Ohio and U.S. investors tend to favor investing in the same geographic markets.

Table 13: Geographic Market Investment

	Firm Location		
Investment Market	% of Total Ohio	% of Total U.S.	% of Total
United States	56.1	31.6	87.7
Canada	1.8	5.3	7.0
Europe	1.8	0	1.8
China	1.8	0	1.8
Japan, South Korea, Southeast Asia, India, South America	0	0	0

Do not reject Ho: Chi-Square for each market does not exceed 3.841,not significant at $p < .05$

The data in Table 14 indicate Ohio and U. S. investors have nearly the same investment interest in the United States by 88.9% and 85.7%, respectively. U. S. investors, including seven California and four New York investing firms, show stronger interest than Ohio in Canada (14.3%/2.8% for a 5 to 1 ratio).

Table 14: Geographic Market Interest of Ohio and U.S. Firms

	Firm Location		
Market	% within firm location Ohio	% within firm location U.S.	% of Total
United States	88.9	85.7	87.7
Canada	2.8	14.3	7.0
Europe	2.8	0	1.8
China	2.8	0	1.8

The data in Table 15 identify states within the countries where firms have significant investments (at least 10 percent). From the 26 U.S. states and five Canadian provinces identified, the top eight states and one Canadian province that represent 63% of the total are shown with Ohio and U.S. firms' relative position. Ohio shows a stronger investment interest in six of the eight states (Ohio, California, Massachusetts, Illinois, Texas, and Pennsylvania). Ohio and U.S. have the same interest in Virginia. The U.S. shows a stronger investment interest in New York State and the Canadian province British Columbia.

Table 15: Geographic Market of States with Significant Investment

State	% of Total	Stronger Investment Interest	Investment Interest Ratio
Ohio	21.6	Ohio	26.0
California	8.8	Ohio	1.2
Massachusetts	7.2	Ohio	2.0
New York	6.4	US	3.0
Illinois	5.6	Ohio	2.5
Texas	4.0	Ohio	4.0
Pennsylvania	3.2	Ohio	3.0
Virginia	3.2	Ohio/US	1.0
British Columbia	3.2	US	3.0

The data in Table 16 identify urban/metropolitan areas of investment for each state. Although the sample size may skew the finding of stronger investment interest toward Ohio, the study would expect to see like findings if the survey were taken in other state markets.

Table 16: Urban/Metropolitan Areas of Investment

State	Urban/Metropolitan Areas of Investment
Ohio	Akron, Cincinnati, Cleveland, Columbus, Dayton, Northeast, Toledo
California	Palo Alto, San Francisco, Silicon Valley
Massachusetts	Boston
New York	Buffalo, Erie County, New York City Area
Illinois	Chicago
Texas	Dallas, Houston
Pennsylvania	Philadelphia, Pittsburgh
Virginia	Northern Virginia
British Columbia	Vancouver

2.7 SUMMARY

Emerging Technology Promising Investment Areas: Based on expert panels and a survey of Ohio and North American venture capitalists, a potential technology portfolio for the state of Ohio was identified. These are emerging technologies and products that are viewed as being particularly competitive in Ohio: medical equipment and instruments; fuel cells, with off-grid civilian applications being favored; three nanotechnologies (nanomaterial,

nanochemical, and nanobiological applications); general polymer technologies, as well as photonic and electronic polymers; MEMS applications in micromachining and automotive applications; security database and data-mining applications, as well as industry-specific applications of information technology; and liquid crystal displays.

Emerging U.S. and Ohio Technology Strengths: Venture capitalists rated Ohio and the U.S. as sources for investment opportunities for 88 technologies/products. The top 25 weighted average technology strengths are showed in Tables 4 and 5, respectively. The responses about Ohio varied from those rating emerging strengths in the nation as a whole. This indicates that respondents were sensitive to geographic differences in research strengths.

Emerging Technology Opportunities in Ohio: Expert panels convened throughout the state to get a business and qualitative perspective on where technological and industrial innovation will emerge in Ohio. Comments from the expert panels have been organized by technology area and aligned with the results from the venture capital survey. Eight areas of innovation are identified for Ohio:

1. Process improvement
2. Information technology (IT)
    - Instrument and control equipment (ICE)
    - Radio frequency identification (RFID)
3. Chemistry
    - Nanotechnology
    - Liquid crystal research
    - Micro-electro-mechanical systems
4. Agricultural and biotechnology
5. Fuel cells
6. Mechanical devices
7. Automotive
    - Energy and battery systems
    - Vehicle control software
    - Drive-by-wire
    - Advanced modeling and simulation
8. Alternative energy sources

New Industries/Transformational Technologies Applications: Both Ohio and U. S. investors identified new industries or transformational technological applications where Ohio is likely to be a significant location of investment in the next 5 to 10 years. Investors identified Ohio's future significant investments as advanced materials/polymers/chemicals; medical devices; information technology/software/business analytics/data mining; biotechnology; RFID/wireless/distribution/logistics/packaging; nanotechnology; healthcare/medical services/regenerative medicine; fuel cells; advanced manufacturing/industrial automation.

Investment in Firm Structure Conclusion: The χ^2 test rejects the null hypotheses that Ohio and U.S. investors have the same investment interest in a firm's structure, or stage of development. Nearly 60% of firms invest in start-ups. The U.S. has a stronger investment interest than Ohio by a 1.5 to 1 ratio. Nearly 30% of firms invest in middle markets. Ohio has a stronger investment interest than the U.S. by a 2.6 to 1 ratio. Large-corporate and others represent less than 15% of investments.

Investment Types of Specialized Finance Conclusion: The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors use the same types of specialized finance. Nearly 50% of firms use venture capital financing, and nearly 25% use angel/early stage financing. The U.S. has a stronger investment interest than Ohio in both venture capital (1.4) and angel/early stage (1.3) financing. More than 20% of firms use leverage buyout financing. Ohio has a stronger investment interest than the U.S. in leverage buyout financing by a 3 to 1 ratio. Mezzanine finance, corporate turnaround and investment banking/initial public offering (IPO) represent less than 8%.

Types of Specialized Finance in a Firm's Structure Conclusion: The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors use the same types of specialized finance in a firm's stage of development. Ohio investors have a stronger investment interest than the U.S. in start-ups using angel/early stage specialization (1.2). Ohio investors have a 2 to 1 stronger investment interest than the U.S. in middle markets using leverage buyout. U.S. investors show a stronger investment interest than Ohio in start-ups using venture capital specialization by a 1.3 to 1 ratio.

Industry/Technology Niche Investment Conclusion: The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors invest in the same industry/technology niches. Ohio has a stronger investment interest than the U.S. in information technology/specialized software (1.1), advanced materials (1.5), and micro electric-mechanical systems (MEMS) (1.2). The U.S. has a stronger investment interest than Ohio in biotechnology (1.2), telecommunications (1.1), health care information systems (2.0), nanotechnology (1.1), and security technology (1.5).

Industry/Technology Niche Types of Specialized Finance Conclusion: The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors use the same types of specialized finance when investing in industry/technology niches. Within the top industry/technology niches, U. S. firms show a stronger specialization than Ohio in angel/early stage investment for information technology/specialized software (1.8), biotechnology (1.2), telecommunications (1.5), advanced materials (1.8), health care information systems (1.7), nanotechnology (1.2), and security technology (1.2). Ohio firms show a stronger interest than the U.S. in venture capital investment for information technology/specialized software (1.2), telecommunications (1.1), advanced materials (2.0),

health care information systems (1.2), nanotechnology (1.3), and security technology (1.1). Ohio firms show a stronger interest than the U.S. in leverage buyout investment for information technology/specialized software (11.1), biotechnology (15.4), telecommunications (8.3), advanced materials (10.0), and health care information systems (16.7).

Geographic Investment Market Conclusion: The χ^2 test cannot reject the null hypotheses that Ohio and U.S. investors invest in the same geographic markets. Nearly 90% of firms have significant portfolio investments (at least 10 percent) in markets in the United States. Ohio invests more than U.S. firms by almost a 2 to 1 ratio. Nearly 10% of firms invest in Canada. The U.S. invests more than Ohio firms by a 3 to 1 ratio. Europe, Asia, and South America account for less than 4% of investment. Ohio and U. S. investors show nearly the same investment interest in the United States, but U. S. investors, including seven California and four New York investing firms, show stronger interest than Ohio in Canada by a 5 to 1 ratio.

Within the countries, firms with significant investments (at least 10 percent) identified urban/metropolitan areas within 26 U.S. states and five Canadian provinces. The top eight states and one Canadian province represent 63% of the total (Table 15). Ohio shows a stronger investment interest in six of the eight states (Ohio, California, Massachusetts, Illinois, Texas, Pennsylvania).The U.S. shows a stronger investment interest in New York State and the Canadian province British Columbia. The urban/metropolitan areas of investment for each state are shown in Table 16. Although the sample size may skew the finding of stronger investment interest toward Ohio, the study would expect to see like findings if the survey were taken in other state markets.

The key to good venture investing is what it traditionally has been—deep knowledge of an industry or of a product set. Large, experienced institutional funds are looking globally but are specializing in markets and technologies in which they have experience and comparative advantage. Yet even these firms try to establish a geographic basis for their practice because technology-based development blossoms in geographically concentrated clusters that have been fortified with localized knowledge. Smaller venture pools have a much tighter geographic focus, with disciplined concentration on specific technologies or industries.

2.8 RESEARCH CONCLUSION AND LIMITATION

CONCLUSION

"Following the money" is a useful exercise in understanding Ohio's most likely opportunities for future economic success. The venture capital community, which typically finances innovations, stakes its business success on identifying investment areas that represent the best opportunities for market success. Ohio has newly found acceptance among venture capitalists for the potential investment opportunities it provides because of its history of innovation. The technologies and products identified in the study were most likely selected as the best fit for Ohio because they are directly related to the state's key industrial and research strengths. A major concept of the study is that Ohio is a portfolio of distinct but interconnected regional economies, each with individual regional portfolios of driver industries. Regions can change their growth trajectory by making firm-level decisions for product investment that determine regional product mixes. The regional product mix should center on economic development strategies that represent a balanced portfolio of investments

that include product, platform, and technology development along with conceptual research and development.

When financing emerging technologies, Ohio takes a different investing approach than the national pattern when investing in the firm's structure, or stage of business development. However, Ohio and U.S. investors' investment interest are not significantly different for types of specialized finance used, types of specialized finance in a firm's structure, industry/technology niche investing, types of specialized finance in industry/technology niches, and geographic markets. The study shows Ohio's investment patterns are similar to national patterns on the use of specialized types of financing for emerging technologies and products. This allows Ohio's businesses access to a much larger national pool of capital equity investors, along with local investment, to develop a balanced portfolio of investments.

It is important to understand how Ohio's public policy and other general business issues affect businesses in the state. These factors are critical when businesses are making investment decisions. Ohio must be competitive with other locations in basic public policy issues to retain and attract investments. The study identified a number of gaps at the state and regional levels in the economic development performance of the state. Industry leaders in the state voiced similar concerns on major public policy issues such as the Ohio tax system, health care costs, workers' compensation, liability and torts, global competitiveness, and energy costs. They also listed workforce issues although these varied by region, industry, and job level.

Ohio's focus should be on ways in which the state can better align its economic development policies and programs to retain, support, and expand core industries and build

from that base to attract new investments, businesses, and industries. Ohio industries are continuing to innovate and incorporate new technologies to improve their productivity. For some, these are largely labor-saving measures, but other companies are embracing technology as growth opportunities. While it is important that economic development incentives be targeted toward attracting new businesses to the state, they also should be used to help retain and expand existing Ohio businesses. Often, these businesses may need help with productivity-enhancing investments and innovations. It is important to keep in mind that retention and expansion can be even more valuable to the state than attraction.

Ohio must be competitive. Public policy analysis in the study indicates that taxes (specifically the tangible personal property tax); environment regulation; and accessibility, transparency, and speed of economic development incentives are all concerns at some level for business leaders in Ohio and site selectors considering Ohio as an investment location. These are the basics that Ohio must fix to be competitive. Solving these issues will not solve all of the challenges facing Ohio's economy, but it is necessary for establishing competitiveness.

Implementing a cohesive approach to economic development in Ohio requires that state and regional entities collaborate on processes, incentives, and communication of goals and services. Economic development practitioners at the state and regional levels must work together through the stages of implementation to identify industries and technologies to support and prioritize those areas in which development assistance can have an optimal effect. They must choose whether the state or regions will take the lead and determine how best to support targeted industries and technologies. To accomplish this, Ohio must build an action plan.

Since the Ohio study of the relationship between emerging technologies and venture capital investments was completed in 2004-2005, the economic environment has changed. After nearly a decade of global competitive challenges and the negative impact of a recession beginning to ease, a new round of self-evaluation and assessment is needed. Recognizing this economic change, the state of Pennsylvania completed a new round of self-evaluation and assessment in 2011 that built upon a similar 2004 report. Ohio should follow the same approach and update the 2004-2005 study. First, to access if Ohio is still a portfolio economy made up of several distinct regional economies and driver industries. Second, to determine if capital investment for technologies and products remains the same or has changed for national and Ohio investors in 2011.

LIMITATION

The limitation of this study is twofold. First, the breadth and cost of the study took nearly a year to complete. The study occurred during 2004 and 2005, making the data somewhat dated. However, to date, no comparable study has been undertaken to update Ohio's economic strengths and opportunities or access where Ohio has embraced the study's recommendations to shift its economic development approach.

Second, the survey solicited 466 of approximately 2,400 venture capitalists and members of private equity firms and the response rate was 12%. A larger solicitation and response rate would provide a more robust data set for the findings on national and state investment patterns.

ESSAY 3

MEASURING THE REGIONAL ECONOMIC IMPACT OF INNOVATION IN SMALL TO MEDIUM-SIZED FIRMS

3.1 INTRODUCTION

The primary purpose of this study is to determine if innovative small to mid-sized firms have greater impacts on their regional economies then their non-innovative peers. A series of observations are made and hypotheses tested using data collected from two surveys conducted by a business intermediary located in the Cleveland metropolitan area called Entrepreneurs EDGE.

There is evidence in the literature that technological innovation in firms is one of the main sources of industrial competitiveness and national economic development (Cortright, 2001; Romer, 1986; Temple, 1999; Zaltman et al., 1973). Economic studies have concluded that technology innovation and its related capital and human investments contributes nearly half of a nation's productivity, economic growth, and standard of living (Milbergs & Vonortas, 2008). This argues for government and business leaders paying attention to the role of innovation in national and regional development.

The essay begins with a literature review of the role innovation plays in the financial performance of firms and then on their economic impact on their regional economies. The methods used for measuring and testing the economic impact of innovative firms on regional economies are presented in the second section. Also in this section is a discussion of the data, sample, and region that frame the study. Statistical observations as to why firms innovate, how they innovate, and more specifically, why they engage in product innovation are presented in the third section. A series of hypotheses about the differential performance on a number of output or activity measures of innovative firms compared to firms that did not innovate are developed in the fourth section. This section also contains a series of hypotheses about the differential performance on a number of output or activity measures of spinout firms compared to firms that were not spinout firms. The differential effects of innovative versus non-innovative firms and of spinout firms compared to non-spinout firms on a regional economy are the subject of the fifth section. The essay concludes with a summary of the findings.

3.2 LITERATURE REVIEW

Historically, the dominant system for measuring business performance has been solely financial. Chandler (1977) argues that innovations in measuring the financial performance of firms during the Industrial Revolution played a vital role in their successful growth. Innovations in financial measurement such as the return on investment (ROI), and operating and cash budgets were critical to the success of enterprises like DuPont and General Motors (Johnson & Kaplan, 1987). Traditional performance measures are largely derived from accounting systems. Return on assets (ROA), return on investment (ROI),

return on sales (ROS), sales per employee, purchase price variances, profit per production unit, and employee productivity are examples of these measures. Such measures, however, have limitations because they quantify performance and other improvement efforts solely in financial terms and over emphasize short-term returns.

Both the Harvard Business School Council on Competitiveness[5] and the American Institute of Certified Public Accountants (AICPA)[6] criticized the extensive, or even exclusive, use of financial measurements in business management in 1994.They contend that concentrating on achieving and maintaining short-term financial results can cause firms to over-invest in projects that generate short-term returns and to under-invest in long-term value creation. Another well-recognized challenge that exists with purely financial reporting is that it tends to be inconsistent with the concept of continuous improvement. (Drucker, 1990; Eccles, 1991; Fisher, 1992; Johnson & Kaplan, 1987; Kaplan, 1983; Kaplan, 1990; Maskell, 1992; McNair et al., 1989; Plossl, 1991; Skinner, 1986). An alternative is an integrated performance measurement system. Such systems build from financial measures taking a longer-term view of company success and specifically incorporate returns from innovation and processes that sustain innovation.

The measurement of innovation in the past several decades depended on measuring inputs to the innovation process (R&D expenditures, education expenditures, capital investment) and of intermediate outputs (publications, patents, workforce size and experience, innovative products), while ignoring the value of outcomes in terms of both new products and of improved production processes. Accordingly, innovation measurement tends

[5] Harvard Business School Council on Competitiveness in Special Committee on Financial Reporting--Studies in strategic performance measurement, 1994.

[6] AICPA Special Committee on Financial Reporting, *Improving Business Reporting—A Customer Focus: Meeting the Information Needs of Investors and Creditors, 1994.*

to be focused on technology outcomes and technology development and their related production systems (Milbergs & Vonortas, 2008). Innovation metrics must look beyond innovation inputs and incorporate outcomes as well as innovation processes.

Innovation is a complex, multidimensional activity that cannot be measured directly or with a single indicator. Milbergs and Vonortas (2008) argue "Innovation is a process through which the nation creates and transforms new knowledge and technologies into useful products and services and processes for national and global markets—leading to both value creation for stakeholders and higher standards of living."

Some recent studies provide limited evidence of the better performance of innovative firms. Liao and Rice (2010) identified the role of innovation as a driver of firm dynamics through improved sales growth and expected sales growth. Their study of 449 manufacturing firms indicates that a firm's innovation-related activities can only drive its competitive performance when accompanied by effective changes in the organization in response to market dynamics and customer demands.

Xin et al., (2010) found that technologically innovative products have a statistically significant positive effect on the operating performance of a firm. The study focuses on financial measures and indicates that the median increase in return on assets (ROA), return on sales (ROS), and sales over assets (SOA) for the168 manufacturing firms surveyed increased an average of 5% over a four-year period.

A study of various types of innovative firms by Schneider and Veugelers (2010) found that young, small, highly R&D-intensive firms have significantly higher average sales growth and employee growth than do other older and larger R&D-intensive innovators.

These studies indicate that firms producing new or improved products and services perform better than firms that do not.

Measuring whether or not firms with deep innovation resources and assets perform better than otherwise similar firms is perhaps the most direct measure of how the introduction of new technologies, processes, products, and services are associated with firm performance (Schramm et al., 2008). The research in this essay examines differences in the performance of firms that through innovation develop new products and services and firms that do not. The study utilizes variables that represent firms' financial performance (earnings before tax and interest and net sales), and their impact on their regional economy (compensation paid to employees, employee rate of growth, civic contributions, and payments to regional vendors).

3.3 METHODOLOGY AND DATA ANALYSIS

MEASURING THE IMPACT OF INNOVATIVE FIRMS

This study examines the reasons why firms invest in innovation and then tests the difference in the innovation behaviors of firms. Due to data limitations, multiple regression or other multivariate techniques could not be used. The data are examined in two ways.

First, descriptive analysis is performed on differences in the way firms engage in innovation, their preferred means of pursuing product innovation, and the reasons for engaging in product innovation.

Second, hypotheses are tested on the influence of innovation on firms' financial performance. This is followed by a series of tests on differences in the regional economic impact of innovative versus non-innovative firms and then a more limited examination of

spin-out versus non-spin-out firms. The tests are t-tests of the difference in means of the two subsets that are described below. Six dimensions of performance are tested.

Survey

Data were collected from two surveys conducted by Entrepreneurs EDGE[7] in 2007 and 2008. The same set of 1,000 middle market firms[8] with annual revenues of $10 to $500 million in the Northeast Ohio region[9] were solicited in each of the surveys. The original sample was stratified and random. The number responding to both of the questionnaires was 101 firms from 17 counties in the Northeast Ohio region. This is a 10.1 percent survey response rate.

First, difference in means tests is conducted on two subsets of respondents to the Entrepreneur's Edge Survey. The first subset is termed innovative firms, and the others are called non-innovative firms. The number of innovative firms in the sample was 55; the remaining 46 firms were non-innovative. Innovative firms were identified as firms that had created new product and service offerings during the years 2003 to 2006 that accounted for between 10 and 100 percent of total sales.

Second, formal hypotheses are tested about the influence of newly created (spin-out) firms' financial performance and contribution to a regional economy. Here again, difference in means tests are conducted and the universe is split into two subsets. One group of enterprises is termed spin-out firms and the other non-spin-out firms. The number of spin-out

[7] The Entrepreneurs EDGE (Economic Development through Growth and Entrepreneurship) is a nonprofit organization that works with middle-market firms in the 17-county region of Northeast Ohio helping them grow in value.

[8] For this study, Northeast Ohio's middle-market firms are defined as having annual revenues between $10 million to $500 million and are located within the 17 counties of Northeast Ohio. The firms must also have plans to sell outside of the 17 county regions or currently sell outside the region.

[9] The Northeast Ohio regional economy is comprised of 17 counties: Ashland, Ashtabula, Columbiana, Cuyahoga, Erie, Geauga, Huron, Lake, Lorain, Mahoning, Medina, Portage, Richland, Stark, Summit, Trumbull, and Wayne.

firms in the sample was 32; the remaining 69 firms were non-spin-out firms. The number of spin-out firms reporting earnings (EBIT), vendor purchases, and civic contributions were not adequate to reach statistical valid conclusions. These results are reported because they are illustrative rather than conclusive. Spin-out firms were identified as firms that left an existing entity to form an independent entity during the years 2003 to 2006.

VARIABLES

The business performance of firms is measured by the percentage change in earnings before interest and tax (EBIT) and percentage growth in net sales. Their impact on the region is measured by percentage change in compensation paid to employees in the region, percentage change in purchases from vendors located in the region, the percentage change in civic contributions made to organizations located in the region, and the percentage growth in the number of full-time employees in the region. All six variables are measured as a percentage change from 2003 to 2006. Compensation includes wages, bonuses, car/housing allowance, and stock options exercised in the current year, insurance and any other compensation that is taxed for all full and part-time employees. The vendors[10] or suppliers included must be located in the 17 county area of Northeast Ohio, but not necessarily headquartered there. Civic contributions are the total cash and value of employee time (valued in dollars) contributed by the firm to civic projects in Northeast Ohio.

Finally, all surveyed firms were asked how many spin-out businesses they created, how much money they invested in the spin-outs, the number of new businesses created, and how many innovations they had created over the past three years that contributed to the

[10] Vendor services include office supplies, computer services, raw materials, professional service firms, contracted services, plant and equipment, local outings, etc.

firm's sales.[11] Fifty-five firms indicated that they had an average of eight innovations over the past three years, which contributed an average of 27 percent of current year revenue. Twenty-seven firms indicated an average of two spin-out firms over the past three years. An analysis of spin-out firms' performance is included in the study.

3.4 EXPLORING THE ROLE OF INNOVATION

In this section, quantitative observations are made on three questions related to the behavior of these middle-market firms when it comes to innovation. 1) Why do these firms engage in innovation? 2) How do they actually innovate? 3) How do they measure the impact of these innovations?

OBSERVATION 1: ARE THERE DIFFERENCES IN WHY FIRMS ENGAGE IN INNOVATION?

Cooke and Memdovic (2003) argue: "There is a growing awareness among regional authorities that the economic growth and competitiveness of their regions depend largely on the capacity of indigenous firms to innovate. Offering the appropriate support to indigenous firms to become more competitive through innovation is a rising star on the regional policy agenda."

The research question for observation 1 centers on why firms engage in innovation. Table 1 displays the rank-order of six potential reasons as to why firms engage in innovation. The reasons are ranked 1 to 6 with 1 being the primary, 2 the secondary, etc. The most frequent responses are in bold.

[11] The Leading EDGE Awards Abridged Questionnaire is included as Appendix A to this chapter.

Table 1: Why Do Firms Engage in Innovation?

	Increase Market Share		Maintain Market Share		Lower Production Costs		Improve Profit Margins		Introduce New Products		Improve Production Process	
Ranked	Response	%	Response	%	Response	%	Response	%	Response	%	Response	%
1	**33**	**34.7**	1	1.1	2	2.1	**14**	**14.7**	**9**	**9.5**	4	4.2
2	**20**	**21.1**	8	8.4	7	7.4	**13**	**13.7**	**11**	**11.6**	2	2.1
3	5	5.3	2	2.1	8	8.4	**17**	**17.9**	**12**	**12.6**	6	6.3
4	1	1.1	1	1.1	5	5.3	3	3.2	2	2.1	9	9.5
5	0	-	1	1.1	6	6.3	2	2.1	0	-	1	1.1
6	0	-	3	3.2	0	-	0	-	1	1.1	2	2.1
selected unranked	10	10.5	0	-	3	3.2	9	9.5	6	6.3	5	5.3
did not select	26	27.4	79	83.2	64	67.4	37	38.9	54	56.8	66	69.5
Total	95	100	95	100	95	100	95	100	95	100	95	100

Finding: The data in Table 1 indicate that nearly 35% of firms rank "increase market share" as the primary reason they innovate. This is a 2.4 to 1 ratio over "improve profit margins" (34.7% to 14.7%); a 3.6 to 1 ratio over "introduce new products" (34.7% to 9.5%); and an 8.3 to 1 ratio over "improve production process" (34.7% to 4.2%).

Nearly 56% of firms rank "increase market share" as the primary or secondary reason they innovate over "maintain market share" (55.8% to 9.5% for a 5.9 to 1 ratio); "lower production costs" (55.8% to 9.5% for a 5.9 to 1 ratio); "improve profit margins" (55.8% to 28.4% for a 2 to 1 ratio); "introduce new products" (55.8% to 21.1% for a 2.6 to 1 ratio); and "improve production process" (55.8% to 6.3% for a 8.8 to 1 ratio).

Nearly 47% of firms rank "improve profit margins" as the first, second, or third reason why they innovate, while nearly 34% of firms rank "introduce new products" as the first, second, or third reason.

Conclusion: "Increase market share" is the primary reason why firms engage in innovation and "improving profit margins" was the secondary motivation. One in three firms rank "increase market share" as the primary reason why they innovate, while one in two firms rank it as the primary or secondary reason. One in seven firms rank "improve profit margins" as the primary reason why they innovate, while nearly one in three firms rank it as the primary or secondary reason.

OBSERVATION 2: ARE THERE PREFERRED MEANS OF PRODUCT INNOVATION?

Innovation is a vital component of a firm's internal business process. Innovation highlights the importance of identifying the characteristics of the market segments the organization wishes to satisfy with its future products and services, and then, designing and developing products and services that will satisfy those segments. This approach to the firms' business strategy enables the organization to put considerable weight on research, design, and development that yields new products, services, and markets (Kaplan & Norton, 1996). The literature is mixed on how this is accomplished.

A large number of recent works point to the networking capabilities of firms as a key way in which innovative products are created (Balconi et al., 2004; Benner, 2003; Cooke et al., 2000; Cowan & Jonard, 2003; Geenhuisen & Nijkamp, 2000; Ritter & Geműnden, 2003). Concurrently, a number of articles denounce the over-emphasis of the importance of inter-organizational links to the innovation process because models that include both internal and external resources explain the innovative performance better than do models in which only internal resources are included (Fritsch, 2004; Love & Roper, 2001; Oerlemans et al., 1998).

There is also disagreement among those who believe that networking is an important contributor to innovation as to the appropriate set of boundaries within which collaborative innovation takes place. Is inter-industry, intra-regional networking the critical set of relations or is it intra-industry, inter-regional networking? Some authors address innovation networks within sectoral systems (intra-industry, inter-regional), while others address innovation in regional systems (inter-industry, intra-regional). These authors may agree on the significant roles played by interactions between actors, where they disagree is on the spatial dimensions of those interactions (Malerba, 2002; Malerba & Orsenigo, 1993, 1995).

The innovation literature is inconclusive about how knowledge is transferred or diffused and how new products are developed. Some authors insist on the intrinsic advantages of spatial agglomeration (Malmberg & Maskell, 2002; Porter, 1998; Storper, 1995) while others (Zucker et al., 1998a,b), point to the need for interactions and the fact that deliberate cooperation is required to absorb knowledge generated by others (Ronde & Hussler, 2005)

The research question for the second observation centers on how innovation occurs within a firm. Table 2 displays six possible methods. The methods are ranked 1 to 6 with 1 being the primary, 2 the secondary, etc. The most frequent responses are in bold.

Table 2: How Does Innovation Occurs in a Firm?

	In-house R & D		Formal Product Development Process		Acquisition of Product or Technology		Formal Ideation Process		Work with Suppliers		Hire Consultants	
Ranked	Response	%	Response	%	Response	%	Response	%	Response	%	Response	%
1	**32**	**33.7**	**17**	**17.9**	7	7.4	3	3.2	4	4.2	1	1.1
2	**11**	**11.6**	**9**	**9.5**	8	8.4	5	5.3	17	17.9	5	5.3
3	7	7.4	4	4.2	2	2.1	5	5.3	4	4.2	7	7.4
4	0	-	1	1.1	1	1.1	1	1.1	3	3.2	3	3.2
5	0	-	0	-	2	2.1	2	2.1	0	-	2	2.1
6	0	-	0	-	0	-	0	-	2	2.1	0	-
selected unranked	10	10.5	6	6.3	5	5.3	1	1.1	4	4.2	2	2.1
did not select	35	36.8	58	61.1	70	73.7	78	82.1	61	64.2	75	78.9
Total	95	100	95	100	95	100	95	100	95	100	95	100

Finding: The data in Table 2 indicate that nearly 34% of firms rank "in-house R&D" as the primary way innovation occurs in the firm. This is a 1.9 to 1 ratio over "formal product development process" (33.7% to 17.9%) and a 4.5 to 1 ratio over "acquisition of product or technology" (33.7% to 7.4%).

Over 45% of firms rank "in-house R&D" as the primary or secondary way in which innovation occurs over "formal product development process" (45.3% to 27.4% for a 1.6 to 1 ratio); "acquisition of product or technology" (45.3% to 15.8% for a 2.9 to 1 ratio); formal ideation process" (45.3% to 8.5% for a 5.3 to 1 ratio); "work with suppliers" (45.3% to 22.1% for a 2 to 1 ratio); and "hire consultants" (45.3% to 6.4% for a 7.1 to 1 ratio).

Conclusion: "In-house R&D" is the preferred means of product innovation among the firms surveyed. Having a "formal product development process" was the secondary method. One in three firms ranked "in-house R&D" as the primary means of product innovation while

nearly one in two firms ranked it as the primary or secondary means. One in five firms rank a "formal product development process" as the primary means of product innovation while one in four firms rank it as the primary or secondary means.

OBSERVATION 3: WHY DO FIRMS ENGAGE IN PRODUCT INNOVATION?

The research question for observation 3 centers on the impact of product innovation as a specific type of innovation. Table 3 displays the rank-ordering of six possible impacts of innovation on the surveyed businesses. These are ranked 1 to 6 with 1 being the primary, 2 the secondary, etc. The most frequent responses are in bold.

Table 3: Why Do Firms Engage in Product Innovation?

	Improve Profit Margins		Sales Growth		Increase Employee Satisfaction		Improve Firm Reputation		Others	
Ranked	Response	%	Response	%	Response	%	Response	%	Response	%
1	**17**	**17.9**	**38**	**40.0**	2	2.1	3	3.2	4	4.2
2	**28**	**29.5**	**19**	**20.0**	4	4.2	8	8.4	1	1.1
3	8	8.4	3	3.2	11	11.6	**20**	**21.1**	0	-
4	3	3.2	0	-	9	9.5	4	4.2	0	-
5	0	-	0	-	0	-	0	-	0	-
6	0	-	0	-	0	-	0	-	0	-
selected unranked	8	8.4	10	10.5	4	4.2	5	5.3	0	-
did not select	31	32.6	25	26.3	65	68.4	55	57.9	90	94.7
Total	95	100	95	100	95	100	95	100	95	100

Finding: The data in Table 3 indicate that 40% of firms rank "sales growth" as the primary reason for engaging in product innovation. This is a 2.2 to 1 ratio over "improve profit margins" (40% to 17.9%).

Sixty percent of firms rank “sales growth” as the primary or secondary reason for engaging in product innovation over “improve profit margins” (60% to 47.4% for a 1.3 to 1 ratio); “increase employee satisfaction” (60% to 6.3% for a 9.5 to 1 ratio); and “improve firm reputation (60% to 11.6% for a 5.2 to 1 ratio).

Eighteen percent of firms rank “improve profit margins” as the primary reason for engaging in product innovation, and nearly 48% of firms rank it as the primary or secondary reason.

Conclusion: “Sales Growth” is the primary desired outcome for firms that engage in product innovation. ”Improving profit margins” was the second most popular outcome. Two in five firms rank “sales growth” as the primary reason for engaging in product innovation, while three in five firms rank it as the primary or secondary reason. One in five firms rank “improving profit margins” as the primary reason why they engage in product innovation while nearly one in two firms rank it as the primary or secondary reason.

SUMMARY OF OBSERVATIONS

Firms in this study indicated that the primary reason why they engage in innovation is to increase their market share. Firms also indicated they engage in product innovation to grow the top line of their income statement through an increase in sales. Their preferred means to accomplish the product innovation is to use in-house research and engineering.

The secondary motivation for engaging in innovation is to improve their profit margins. The respondents also indicated that they engage in product innovation to improve profit margins using a formal product development process. In the next section, formal hypotheses are tested about the influence of innovation on firms’ financial performance and

on the differential contributions made by innovative versus non-innovative firms on Northeast Ohio's regional economy.

3.5 HYPOTHESIS TESTING

MEASURING INNOVATIVE FIRMS' PERFORMANCE

HYPOTHESIS 1: MEASURING THE PERFORMANCE OF INNOVATIVE FIRMS

Over the last decade, there has been a growing interest in the role that regions and industrial districts play in fostering technical change and industrial innovation. For example, the interface between territory and technology development is the focus of Saxenian's (1994) book *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Route 128 is a ring highway outside of Boston). Saxenian points out the commonality of the two regions: both had excellent research universities with specializations in engineering and both were rich in firms that conducted military research. She also pointed out differences between the two regions. She characterized both during the early 1980s through the early 1990s.

Silicon Valley's industrial structure was described as being decentralized, consisting of network-based organizations that set a high premium on experimentation, collaboration, and collective learning among highly specialized and, hence, mutually dependent firms. Firms located along Massachusetts' Route 128 tended to be vertically integrated corporations that were both unable and unwilling to interact with others in the regional economy, with the result that their learning capacity was inferior to their West Coast rivals. While concentrating on the positive effort of inter-firm collaboration, Saxenian marshals a case as to why this was the real strength of Silicon Valley and why the lack of collaboration was the undoing of Route 128's economic base in the era studied (Saxenian, 1994).

Because of its freedom from established corporate structure, Silicon Valley became the headquarters of highly flexible startup organizations. Competition appeared not so much to be between firms as between technologies and the way in which those technologies were applied. The culture of Silicon Valley did not shun entrepreneurs who failed but only those who failed to try. Complementing this attitude was the deep pool of venture capital that located in the region and the influence that venture capitalists played on where the start-up firms located. The combination of the speed with which investment decisions could be made, the depth of talent familiar with running start-up technology companies, and the location of venture capital was and is the basis for deep regional competitive advantage.

The employment experience of venture capitalists in Silicon Valley also differed from the norm of investment bankers and institutional investors in the 1980s. They often had experience in electronics firms, rather than being former bankers or financial professionals, and could give technical as well as financial and managerial support to the firms in which they invested. Route 128 firms relied on the traditional financing mechanisms and commercial banks, institutions that favored lending over investing.

The research question for hypothesis 1 centers on whether there is a difference in the financial performance of innovative and non-innovative firms and then if there is a parallel difference in their impact on the Northeast Ohio economy. For this study, the financial performance of the firm is measured in two ways: the three-year percentage change in earnings (EBIT), and three-year percentage growth in net sales. The impact of the firm on the regional economy is captured through the four other variables displayed in the following tables: the three-year growth rate in the number of full-time employees in the region, three-year percentage growth in the compensation paid to employees in the region, three-year

growth rate in the purchases made from vendors located in the region, and the three-year growth rate in contributions made to civic organizations located in the region from 2003 to 2006.

The percentage change for earnings (EBIT), net sales, and full-time employees is expected to be higher for innovative firms because innovation is expected to result in the growth of the business (Asheim & Isak, 1997; Avlontis et al., 2001; Becheikh et al., 2006; Linder et al., 2003; Michie, 1998; Schumpeter, 1934). This expectation is reinforced by the expected position of the products of the innovative firms on the product cycle when compared to the position of the non-innovative firms. Innovative firms are expected to have products that are in the "take-off and super profit" position in the product cycle (Markusen, 1985; Vernon, 1966).

Innovative firms are also expected to pay higher financial compensation to attract and retain talent because their growth is expected to result in new hiring and, therefore, paying the marginal cost of labor while their competitors are expected to be paying the lower average cost.

Similarly innovative firms are expected to be more reliant on purchasing products and services from vendors located in the region. This is because they have, by definition, products in the early stage of the model or product cycle, with more frequent model changes, and are investing their capital in model development and sales. They are, therefore, more likely to be less vertically integrated than firms with more established products. This implies that they will be more reliant on external suppliers.

The last expectation is the expected impact of innovative firms on local philanthropy and civic involvement because innovative firms are experiencing greater growth than less

innovative firms and, as asserted earlier, higher EBIT. The existence of higher EBIT allows the firm to be more civically charitable.

No studies that examine these two aspects of the financial performance of firms and of the four impacts firms can have on their regional economies could be found to verify these expectations.

> **Hypothesis 1** (Ho): There is no difference in the performance between firms that innovate and firms that do not innovate.
> Hypothesis 1 (Ha): There is a positive difference in the performance between firms that innovate and firms that do not innovate.

Finding: The data in Table 4 indicate that innovative firms had a 7% greater change over three years than non-innovative firms in earnings before interest and taxes (EBIT) and a 377% three-year greater change in net sales. Innovative firms had a 25% greater regional impact over three years than non-innovative firms in the growth rate in the number of full-time employees and a 56% greater regional impact over three years in civic contributions in Northeast Ohio. Innovative firms had a 5% lower three year percentage change in compensation paid to employees in the region and a 7% lower three year percentage change in purchases from regional vendors.

Table 4: Performance of Innovating and Non-Innovating Firms

Variable	Firm Type	Percent Change 2003-2006	Percent Difference
EBIT Percentage Growth (Earnings before interest and taxes)	innovative non-innovative	265.6 258.6	7
Net Sales Percentage Growth	innovative non-innovative	480.7 103.8	377
Number Full-Time Employees Growth Rate	innovative non-innovative	47.2 22.2	25
Compensation Paid to Employees Growth Rate	innovative non-innovative	63.5 68.8	5
Regional Vendor Purchases Growth Rate	innovative non-innovative	81.6 88.8	7
Civic Contributions Growth Rate	innovative non-innovative	112.0 56.1	56

Statistical Finding: The data in Tables 5 indicate the descriptive statistics and Table 6 shows the results of independent-sample t-tests for the percentage change in the mean values between innovative and non-innovative firms. These are measured at the 90% confidence interval ($p < 0.10$). The t-tests indicate that the percentage change in the mean values for innovative and non-innovative firms is significantly different between the two groups of firms for net sales. However, the three-year percentage change in the mean values for innovative firms is not significantly different for earnings before interest and taxes (EBIT).

The results of the firms' regional impacts are mixed. The three-year percentage change in the mean values of the number of full-time employees is significantly different between innovative and non-innovative firms. The same holds true for the differences in their civic contributions. However, there is no significant difference for compensation paid to employees and purchases from regional vendors.

The results shown in Table 6 are the result of using two tests of significance: a t-test for the equality of means and the Levene test of homogeneity of variance. A t-test indicates whether there is a significant difference in the percentage change in the mean values for earnings (EBIT), net sales, the number of full-time employees, compensation paid to employees, civic contributions, and purchases from regional vendors between innovative and non-innovative firms. The Levene test of homogeneity of variance tests the variability of how much each respondent's score is different from the mean score. This tests whether the variability in one group is significantly different than the variability in another group and indicates which p-value to report.

Since the Levene test for equality of variances is significant for the percentage change for net sales (p = .058), the growth rate in the number of full-time employees (p = 020), and the growth rate in civic contributions (p = .057), equality of variance is not assumed. The t-test indicates the percentage change in the mean values for innovative and non-innovative firms is significantly different for net sales (p = .100), the number of full-time employees (p = .012), and civic contributions (p =.078) in the region. These are highlighted in bold text in Table 6.

Since the Levene test for equality of variance is not significant for the percentage change for earnings (EBIT / p = .647), compensation paid to employees (p = .221), and purchases from regional vendors (p = .989), equality of variances is assumed. The t-test indicates the percentage change in the mean values for innovative and non-innovative firms is not significantly different for earnings (EBIT / p = .479), compensation paid to employees (p = .409), and purchases from regional vendors (p = .396).

Table 5: Descriptive Statistics of Innovative and Non-innovative Firms

Variable	Firm Type	N	Mean	Standard Deviation	Standard Error Mean
EBIT Percentage Growth (Earnings before interest and taxes)	innovative	40	2.66	4.86	.77
	non-innovative	42	2.59	6.59	1.02
Net Sales Percentage Growth	innovative	52	4.81	21.07	2.92
	non-innovative	34	1.04	2.59	.44
Number Full-Time Employees Growth Rate	innovative	54	.47	.67	.09
	non-innovative	32	.22	.32	.06
Compensation Paid to Employees Growth Rate	innovative	40	.64	.87	.14
	non-innovative	42	.69	1.17	.18
Regional Vendor Purchases Growth Rate	innovative	38	.82	.99	.16
	non-innovative	19	.89	.90	.21
Civic Contributions Growth Rate	innovative	32	1.12	1.78	.32
	non-innovative	15	.56	.87	.22

Note: N is the number of observations

Table 6: t test for Equality of Means of Innovative and Non-innovative Firms

Variable		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (1-tailed)	Mean Difference	Standard Error Difference	90% Confidence Interval of the Difference	
									Lower	Upper
EBIT Percentage Growth (earnings before interest and taxes)	Equal variances assumed	.211	.647	.05	80	.479	.07	1.28	-2.07	2.21
	Equal variances not assumed			.05	75	.478	.07	1.27	-2.05	2.19
Net Sales Percentage Growth	Equal variances assumed	3.684	.058	1.04	84	.152	3.77	3.64	-2.28	9.82
	Equal variances not assumed			1.28	53	**0.100***	3.77	2.96	-1.18	8.72
Number Full-Time Employees Growth Rate	Equal variances assumed	5.647	.020	1.96	84	.026	.25	.13	.04	.46
	Equal variances not assumed			2.32	81	**0.012****	.25	.11	.07	.43
Compensation Paid to Employees Growth Rate	Equal variances assumed	1.524	.221	-.23	80	.409	-.05	.23	-.43	.33
	Equal variances not assumed			-.23	76	.408	-.05	.23	-.43	.33
Regional Vendor Purchases Growth Rate	Equal variances assumed	.000	.989	-.27	55	.396	-.07	.27	-.53	.38
	Equal variances not assumed			-.27	39	.393	-.07	.26	-.51	.37
Civic Contributions Growth Rate	Equal variances assumed	3.824	.057	1.15	45	.129	.56	.49	-.26	1.38
	Equal variances not assumed			1.44	45	**0.078***	.56	.39	-.09	1.21

***P < .01 **p < .05 * p < .10

Notes:
df = degrees of freedom
Sig. means significance level

Conclusion: The null hypothesis that innovative and non-innovative firms have the same performance in terms of three-year percentage growth in net sales is rejected. However, the null hypothesis that innovative and non-innovative firms have the same performance in terms of three-year percentage growth in earnings before interest and tax (EBIT) cannot be rejected. The t-test analysis indicates innovative firms have a 4.6 times higher mean three-year percentage change in net sales (4.81 to 1.04). The difference is significant at the 90% confidence interval ($p < .10$ level). This means that innovative firms are superior in performance to non-innovative firms in terms of net sales. The t-test analysis indicates that innovative and non-innovative firms have nearly the same mean percentage change in earnings before interest and tax (EBIT). The difference is not significant at the 90% confidence interval ($p < .10$ level). This means that innovative and non-innovative firms are nearly the same in performance in terms of earnings (EBIT). The mean percentage change in earnings (EBIT) for innovative firms is slightly higher than non-innovative firms by 7%. The initial expectation for the study was a significantly higher percentage change in earnings (EBIT) for innovative firms. However, observations of firms in this study indicated they engage in product innovation to grow the top line of their income statement predominately through sales growth.

The null hypothesis that innovative and non-innovative firms have the same regional impact in performance in terms of three-year percentage growth in civic contributions and in the number of full-time employees in the region is rejected. The t-test analysis indicates innovative firms have a two times higher mean three-year percentage change in civic contributions in the region (1.12 to 0.56) than non-innovative firms. The difference is significant at the 90% confidence interval ($p < .10$ level). Innovative firms also have a two

times greater three-year mean percent change in the growth rate in the number of full-time employees in the region (0.47 to 0.22) than non-innovative firms. The difference is significant at the 95% confidence interval ($p < .05$ level). This means that innovative firms are superior in performance than non-innovative firms in terms of the growth rate in civic contributions and in the number of full-time employees in the region.

The null hypotheses that innovative and non-innovative firms have the same regional impact in performance in terms of three-year percentage change in compensation paid to employees, and three-year percentage change in purchases from vendors located in the region cannot be rejected. The t-test analysis indicates that innovative and non-innovative firms have nearly the same mean percentage change in compensation and regional vendor purchases. The difference is not significant at the 90% confidence interval ($p < .10$ level). This means that innovative and non-innovative firms are nearly the same in performance in terms of compensation paid to employees and regional vendor purchases. The mean percentage change in compensation paid to employees by innovative firms is lower by 5% than the compensation paid by non-innovative firms. The mean percentage change in regional vendor purchases made by innovative firms is also lower than non-innovative firms by 7%. The initial expectation for the study was a higher percentage change in compensation paid to employees and regional vendor purchases by innovative firms. The compensation paid to employees by innovative firms shows that they are hiring at average cost or that average earnings and marginal earnings may be equal. Innovative firms in this study may also be more vertically integrated than expected and less reliant on external suppliers.

MEASURING THE PERFORAMNCE OF SPIN-OUT FIRMS: SUGGESTIVE RESULTS

HYPOTHESIS 2: MEASURING PERFORMANCE OF SPIN-OUT FIRMS

Innovation often leads to "spin-out" firms where a firm spins off sections of itself as a separate business. Spin-outs typically operate at arm's length from their parent organizations and have independent sources of financing, different products, services, and customers from their former parent organization. In some cases, the spin-out may license technology from the parent or supply the parent with products or services (Rohrbeck et al., 2007).

A common definition of a spin-out is when a division of a firm becomes an independent business. The "spin-out" firm takes the assets, intellectual property, technology, and/or existing products from the parent organization and uses them to establish a new corporate entity (Rohrbeck et al., 2007). A second definition of a spin-out is a firm formed when an employee or group of employees leaves an existing entity to form an independent, start-up firm.

A spin-out is distinct from a spin-off, which is created when a firm creates a new firm out of one of its existing divisions, subsidiaries, or subunits. In the case of a spin-off, the new firm is created as a deliberate act of the parent, and the owners of the parent are the original owners of the new firm (although these owners frequently sell their ownership stakes at market rates soon after the new entity is formed, especially if the spin-off is publicly traded). However, much of the academic and popular literature in business, economics, finance, and management uses the term "spin-off" when "spin-out" is the correct description of the entity being described. Spin-outs are important sources of technological diffusion in high technology industries (Rohrbeck et al., 2007).

Franco and Filson (1999) examine spin-outs as a source of technological diffusion in rapidly evolving high technology industries. Their analysis suggests that spin-outs play critical roles in the evolution of an industry. It is asserted in the literature that technologically advanced firms are more likely to generate spin-outs, and spin-outs that emerge from more advanced firms are more likely to survive, as long as the spin-outs succeed in learning and applying their parents' know-how. The fact that spin-outs are important in the evolution of high technology industries during the initial take-off stage of the product cycle challenges the previous conventional wisdom that progress and entry early on in the evolution of an industry is driven by forces outside the industry itself.

The research question for hypothesis 2 centers on whether there is a difference in the financial performance of spin-out and non-spin-out firms and if they have different economic impacts on their regional economy (Northeast Ohio). As was done earlier, the performance of the two groups of firms is measured by the three-year percent change in earnings before interest and taxes (EBIT) and the three-year growth rate in net sales. The hypothesized differential impact on the regional economy is measured through the three-year growth rate in employment, the three-year percentage change in compensation paid to employees located in the region, the three-year growth rate in purchases from vendors located within the region, and the three-year growth rate in civic contributions made in the region.

There is a statistical challenge to the dataset that limits the ability to draw strong conclusions about the difference in the performance and regional economic impact of spin-out versus non-spin-out firms. A number of respondents did not provide information on earnings (EBIT), vendor purchases, and civic contributions. Information is provided on earnings (EBIT) by 18 spin-out and 64 non-spin-out firms; vendor purchases by 15 spin-out

and 42 non-spin-out firms; and civic contributions by 12 spin-out and 35 non-spin-out firms.[12]

The sample size of spin-out firms was small. This led to concern that the sample may not be large enough to generate statistically valid results. Sample size is a critical factor in determining the statistical power of a test; the larger the sample size, the greater the statistical power (Lani, 2009, 2011). The power statistic was calculated for each of the t-tests in response to the surveys for these two types of firms. The power of a statistical test is the probability that the test will reject a false null hypothesis, or, in other words, that it will not make a Type II error. The higher the power, the greater the chance of obtaining a statistically significant result when the null hypothesis is false. Although there are no formal standards for the power of a test, most researchers assess their test using a standard for adequacy where the confidence level is 80% of not committing a Type II error (Cohen, 1988; Ellis, 2010).

The power statistic results indicate that the power of the study at the 90% confidence level is 15% for earnings (EBIT), 39% for regional vendor purchases, and 32% for civic contributions. All much lower than the 80% standard. The power statistics for the samples indicate that the returns are not adequate to reach statistical valid conclusions for these three under-sampled variables. However, the sample sizes for net sales, number of full-time employees, and compensation are adequate to reach statistical valid conclusions.

The study reports all results, keeping in mind that statistical valid conclusions can only be drawn for net sales, number of full-time employees, and compensation while the

[12] According to Neyman's sample size allocation methodology, the sample size for spin-out firms reporting earnings (EBIT), vendor purchases, and civic contributions were not adequate to reach statistical valid conclusions, given a fixed sample size and a stratified sample (Winkler, 2009).

reported results for earnings (EBIT), regional vendor purchases, and civic contributions are suggestive.

Additionally, as noted above, the small size of the sample does not allow for the sample to be subset into four mutually exclusive categories, i.e., innovative spin-out, non-innovative spin-out, innovative non-spin-out and non-innovative non-spin-out. Therefore, innovative firms in this sample can be either spin-out or non-spin-out firms and spin-out firms can be either innovative or non-innovative firms. Eighty percent of the spin-out firms in this sample (20 of 25) are also innovative firms. Correspondingly, *only* 36 percent of innovative firms (20 of 55) are spin-out firms. Therefore, the small sample is not considered robust and the p-value may be misleading. An adequate sample size is necessary to ensure the study has a good chance of detecting a statistically significant result if this is the true effect.

Because there are limited performance measurement studies in the literature that contrast spin-out and non-spin-out firms, there are no *a priori* expectations as to whether or not spin-out firms will have higher three-year growth rates in any of the variables than do non-spin-out firms. Based on the fact that 20 out of 25 spin-out firms were classified as being innovative, there is a reasonable expectation that the performance of spin-out firms will resemble that of non-spin-outs, with the understanding that the sample size is too small to draw statistically valid conclusions for the growth rate in EBIT, vendor purchases, and civic contributions.

Hypothesis 2 (Ho): There is no difference in the performance between spin-out firms and non-spin-out firms.

Hypothesis 2 (Ha): There is a positive difference in the performance between spin-out firms and non-spin-out firms.

Finding: The data in Table 7 indicate that spin-out firms had a 34% greater change than non-spin-out firms in earnings before interest and taxes (EBIT). Unfortunately, this result is just suggestive. The power statistic for earnings (EBIT) indicates that the return is not adequate to reach a statistically valid conclusion for this under-sampled variable.

Spin-out firms did have a 702% greater change in net sales. What is not clear is if this is due to the organizational form of the firm or the share of innovative firms in the subset.

In terms of regional economic impacts, spin-out firms had a 36% lower three-year percentage change in compensation paid to employees in the region; and a 3% lower change in the growth rate in the number of full-time employees in the region. The growth rate in civic contributions was higher and regional vendor purchases was lower but the results are not reliable due to the low response rate.

Table 7: Performance of Spin-out and Non-Spin-out Firms

Variable	Firm Type	Percent Change 2003-2006	Percent Difference
EBIT Percentage Growth (Earnings before interest and taxes)	spin-out	288.2	34
	non-spin-out	254.7	
Net Sales Percentage Growth	spin-out	853.8	702
	non-spin-out	152.2	
Number Full-Time Employees Growth Rate	spin-out	35.9	
	non-spin-out	38.7	3
Compensation Paid to Employees Growth Rate	spin-out	38.3	
	non-spin-out	74.2	36
Regional Vendor Purchases Growth Rate	spin-out	65.8	
	non-spin-out	90.5	25
Civic Contributions Growth Rate	spin-out	137.0	58
	non-spin-out	79.5	

Statistical Finding: The data in Table 8 indicate the descriptive statistics and Table 9 indicate the results of the independent sample t-tests for percentage change in the mean value for spin-out and non-spin-out firms. These are measured at the 90% confidence interval ($p < 0.10$). The t-tests indicate that the percentage change in the mean value for spin-out and non-spin-out firms are significantly different for the three-year growth rate in net sales and for the growth rate in compensation paid to employees in the region. There is no statistically significant difference in the three-year employment growth rate between these two subsets of firms. The results for the other variables, the percentage change in the mean value of earnings before interest and taxes (EBIT), vendor purchases in the region, and civic contributions in the region, are not statistically valid due to the combined problems of sample size and reporting on these questions.

As was done earlier, the data shown in Table 9 are the result of using two tests of significance: a t-test for the equality of means and the Levene test of homogeneity of variance. The t-test indicates whether there is a significant difference in the percentage change in the mean values for earnings (EBIT), net sales, the number of full-time employees, compensation paid to employee, civic contributions, and purchases from regional vendors between spin-out and non-spin-out firms. The Levene test of homogeneity of variance tests the variability of how much each respondent's score differs from the mean score. This tests whether the variability in one group is significantly different than the variability in another group and indicates which p-value to report.

Since the Levene test for equality of variances is significant for the percentage change for net sales ($p = .001$), compensation paid to employees ($p = .057$), and civic contributions in the region ($p = .044$), equality of variances is not assumed. The t-test indicates the

percentage change in the mean values for spin-out and non-spin-out firms is significantly different for net sales (p = .106) and compensation paid to employees (p = .035). These are highlighted in bold text in Table 9.

Since the Levene test for equality of variances is not significant for the percentage change for earnings (EBIT/p = .968), the number of full-time employees (p = .192), and purchases from regional vendors (p = .416), equality of variances is assumed. The t-test indicates the percentage change in the mean values for spin-out and non-spin-out firms is not significantly different for earnings (EBIT/p = .415), the number of full-time employees (p = .421), purchases from regional vendors (p = .198), and civic contributions in the region (p = .214).

Table 8: Descriptive Statistics of Spin-out and Non-spin-out Firms

Variable	Firm Type	N	Mean	Standard Deviation	Standard Error Mean
EBIT Percentage Growth (Earnings before interest and taxes)	spin-out	18	2.88	4.87	1.15
	non-spin-out	64	2.55	6.04	.75
Net Sales Percentage Growth	spin-out	22	8.54	31.60	6.74
	non spin-out	64	1.52	4.68	.58
Number Full-Time Employees Growth Rate	spin-out	23	.36	.39	.08
	non-spin-out	63	.39	.64	.08
Compensation Paid to Employees Growth Rate	spin-out	18	.38	.57	.13
	non-spin-out	64	.74	1.12	.14
Regional Vendor Purchases Growth Rate	spin-out	15	.66	.74	.19
	non-spin-out	42	.91	1.02	.16
Civic Contributions Growth Rate	spin-out	12	1.37	2.33	.67
	non-spin-out	35	.80	1.21	.20

Note: N is the number of observations

Table 9: t test for Equality of Means Of Spin-out and Non-spin-out Firms

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (1-tailed)	Mean Difference	Standard Error Difference	90% Confidence Interval of the Difference	
Variable									Lower	Upper
EBIT Percentage Growth (earnings before interest and taxes)	Equal variances assumed	.002	.968	.22	80	.415	.33	1.55	-2.24	2.91
	Equal variances not assumed			.24	33	.404	.33	1.37	-1.99	2.66
Net Sales Percentage Growth	Equal variances assumed	12.220	.001	1.74	84	.043	7.02	4.03	.31	13.72
	Equal variances not assumed			1.04	21	**.106***	7.02	6.76	-4.61	18.64
Number Full-Time Employees Growth Rate	Equal variances assumed	1.731	.192	-.20	84	.421	-.03	.14	-.26	.21
	Equal variances not assumed			-.25	64	.403	-.03	.11	-.22	.16
Compensation Paid to Employees Growth Rate	Equal variances assumed	3.722	.057	-1.31	80	.096	-.36	.27	-.81	.10
	Equal variances not assumed			-1.85	56	**.035****	-.36	.19	-.68	-.03
Regional Vendor Purchases Growth Rate	Equal variances assumed	.673	.416	-.86	55	.198	-.25	.29	-.73	.24
	Equal variances not assumed			-1.00	34	.163	-.25	.25	-.67	.17
Civic Contributions Growth Rate	Equal variances assumed	4.310	.044	1.10	45	.138	.58	.52	-.30	1.45
	Equal variances not assumed			.82	13	.214	.58	.70	-.67	1.82

***p < .01 **p < .05 *p < .10

Notes:

df = degrees of freedom

Sig. means significance level

Due to low sample sizes only the results reported for net sales, compensation, and full time employees are statistically valid; the others are suggestive.

Conclusion: The t-test analysis indicates that spin-out firms have a 5.6 times higher mean percentage change in net sales (8.54 to 1.52) than non-spin-out firms. The difference is significant at the 90% confidence interval ($p < .10$ level). However, spin-out firms are not superior to non-spin-out firms in terms of compensation paid to employees. Non-spin-out firms have a two times higher mean percentage change in compensation paid to employees in the region (0.74 to 0.38) than spin-out firms. The difference is significant at the 95% confidence interval ($p < .05$ level). What cannot be determined is if the difference in sales performance is due to the organizational form of the company or the fact that so many are also innovators.

SUMMARY OF HYPOTHESES TESTING

INNOVATIVE FIRMS: The hypotheses testing confirmed the findings that innovative firms had a greater financial impact on their regional economy than non-innovative firms. Innovative firms had 377% higher net sales, 7% higher earnings before interest and taxes (EBIT), 56% higher civic contributions, and a 25% higher growth rate in the number of full-time employees in the region. However, innovative firms did pay slightly less in compensation by 5% and made 7% fewer regional vendor purchases.

The data in Table 10 indicate the performance differences between innovative and non-innovative firms and indicates which firms have the larger effect[13] in earnings before interest and taxes (EBIT), net sales, compensation paid to employees in the region, regional vendor purchases, civic contributions in the region, and the growth rate in the number of full-time employees in the region.

The innovative firms in this study demonstrated a greater positive percentage change over non-innovative firms in net sales by 377%, earnings before interest and taxes (EBIT) by

[13] "Yes" indicates a greater percentage increase in the performance measure

7%, civic contributions made in the region by 56%, and the growth rate in the number of full-time employees in the region by 25%. In addition, innovative firms had only a slightly lower percentage change than non-innovative firms in total compensation paid to regional employees by 5% and vendor purchases made to regional suppliers by 7%.

Table 10: Performance Differences of Innovative and Non-innovative Firms

Is There a Greater Percentage Increase in	Firm Type	
	Innovative	**Non-innovative**
EBIT (earnings before interest and taxes)	Yes (7%)	
Net Sales	Yes (377%)	
Full-Time Employees	Yes (25%)	
Compensation		Yes (5%)
Vendor Purchases		Yes (7%)
Civic Contributions	Yes (56%)	

Note: "Yes" indicates a greater percentage increase in the performance measure

SPIN-OUT FIRMS: The hypotheses testing confirmed the finding that spin-out firms out-performed non-spin-out firms in terms of the three-year growth rate in net sales by 702%. The testing also confirmed that spin-out firms did not have higher compensation growth rates than did non-spin-out firms. Spin-out firms had a 36% lower growth rate in compensation paid to employees and a 3% lower growth rate in the number of full-time employees in the region.

The results from the other hypotheses were not statistically valid due to reporting issues and inadequate sample size.

What remains unclear is if the results are due to the organizational form of the companies in question or due to the large number of innovators among the spin-out organizations.

3.6 SUMMARY

Why do firms engage in innovation? The primary reason why firms engage in innovation is to "increase market share." One in three firms rank "increase market share" as the primary reason why they innovate, while one in two firms rank it as the primary and secondary reason. The secondary motivation why firms engage in innovation is "improve profit margins". One in seven firms rank "improve profit margins" as the primary reason why they innovate, while nearly one in three firms rank it as the primary and secondary reason.

The preferred means of innovation in a firm: "In-house R&D" is the primary preferred means of product innovation in firms. One in three firms rank "in-house R&D" as the primary preferred means of product innovation while nearly one in two firms rank it as the primary and secondary preferred means. The secondary preferred means of product innovation in firms is having a "formal product development process." One in five firms rank a "formal product development process" as the primary means of product innovation while one in four firms rank it as the primary and secondary means.

Why do firms engage in product innovation? "Sales growth" is the primary desired impact for firms who engage in product innovation. Two of five firms rank "sales growth" the primary reason why they engage in product innovation, while three of five firms rank it as the primary and secondary reason. The secondary motivation for firms to engage in product innovation is "improving profit margins." One in five firms rank "improving profit margins"

as the primary reason why they engage in product innovation while nearly one in two firms rank it as the primary and secondary reason.

Financial performance of innovative firms: The data indicates that innovative firms had a 7% greater percentage change in earnings before interest and taxes (EBIT); and a 377% greater three-year percentage change in net sales than non-innovative firms.

Regional impact of innovative firms: Innovative firms had a 25% higher three-year regional employment growth rate. The three year growth rate in regional civic contributions made by innovative firms was 56% greater than non-innovative firms. Innovative firms also experienced slower growth rates in compensation paid to employees in the region (5%) and a 7% lower three year percentage change in vendor purchases from regional suppliers.

Differential effects of innovative and non-innovative firms: The differential effects of regional innovative firms in this study indicate a greater positive percentage change in earnings before interest and taxes (EBIT), net sales, civic contributions, and the growth rate in the number of full-time employees in the region than non-innovative firms. In addition, innovative firms had only a slightly lower percentage change than non-innovative firms in compensation paid to employees and regional vendor purchases.

3.7 MEANING AND IMPLICATION

This study confirms that innovative mid-sized firms have greater impacts on their regional economies than do their non-innovative peers. The findings of the study point to the fact that innovative firms are different in the way they impact the regional economy than non-innovative firms. They produce new products and services that translate into higher sales in the region and create more value for themselves in the form of higher earnings before

interest and taxes (EBIT). Innovative firms contribute more to a region's prosperity by having a higher employment growth rate and by having a higher growth rate in civic contributions in terms of money and value of the time spent on civically oriented projects in the region. This study has shown that innovative firms are superior in multiple performance measures then are non-innovative firms.

EPILOGUE

This research draws its significance from addressing three basic questions about innovation. First, where does innovation take place within a business? Second, what are the investment patterns of Ohio and national investors when investing in a business's stage of development and using different types of financing for innovation and emerging technologies? Third, what are the economic impacts of innovation on regional economies?

The research clearly shows that business innovation is broader than most public policies envision and it is more than technology. The typology of business innovation developed through the research indicates that meaningful business innovation can take place in the way in which a business is organized and managed; implements technological advances through product development and deployment or through its operating process; or through its marketing and distribution. The three pathways of organization, technology, and marketing are where innovation can occur in a firm's internal business cycle. The non-technological innovations in the organization and marketing activities of a firm can occur in their own right but can also have an influence on technological products and processes. Within each pathway, the innovation is applied or takes place in a specific business function. And within each function, a firm makes specific changes in an operation of the business. That is, the innovation either changes the business's method of work, its use of factors of production, or the type of product or service provided to its customers.

As innovation takes place and technologies emerge, the research identifies national and Ohio emerging technology strengths and compares the investment patterns of Ohio and national investors in a business's stage of development and the use of specialized types of financing for emerging technologies. The venture capital community stakes its business success on identifying investment areas that represent the best opportunities for market success. Ohio has newly found acceptance among venture capitalists for the potential investment opportunities it provides because of its history of innovation. The technologies and products identified in the study were most likely selected as the best fit for Ohio because they are directly related to the state's key industrial and research strengths. They are what Ohio does well, based on the state's current and historical strengths.

When financing emerging technologies, Ohio takes a different investing approach than the national pattern when investing in the firm's structure or stage of business development. Ohio investors tend to favor middle market investments, while the rest of the nation prefers start-up investments. However, Ohio and U.S. investors' investment interest are not significantly different for types of specialized finance used, types of specialized finance in a firm's stage of development, industry/technology niche investing, types of specialized finance in industry/technology niches, and geographic markets. The study shows Ohio's investment patterns are similar to national patterns in the use of specialized types of financing for emerging technologies and products. This allows Ohio's businesses access to a much larger national pool of capital equity investors, along with local investment, to develop a balanced portfolio of investments.

The research shows the importance of innovative firms in a regional economy. The study explores the role of innovation in business firms. Firms in this study indicated that the

primary reason why they engage in innovation is to increase their market share. Firms also indicated they engage in product innovation to grow the top line of their income statement through an increase in sales. Their preferred means of accomplishing product innovation is to use in-house research and engineering. As innovation occurs through business functions and operations, there is an outcome or impact to the market.

The regional impact of innovation is measured through the financial performance of firms and the economic impacts that firms make to the regional economy. This study confirms that innovative mid-sized firms have greater impacts on their regional economies than do their non-innovative peers. The findings of the study point to the fact that innovative firms are different in the way they impact the regional economy than non-innovative firms. They produce new products and services that translate into higher sales in the region and create more value for themselves in the form of higher earnings before interest and taxes (EBIT). Innovative firms contribute more to a region's prosperity by having a higher employment growth rate and by having a higher growth rate in civic contributions, in terms of money and value of the time spent on civically oriented projects in the region. This study has shown that innovative firms are superior in multiple performance measures then are non-innovative firms.

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Essay 2 Appendix A

Technologies or Products of the Future

Environmental clean-up
Environmental remediation
Automotive hybrid: Propulsion systems
Automotive hybrid: Energy storage/battery
Automotive hybrid: Propulsion software
Automotive hybrid: Drive train
Automotive hybrid: Control software
Automotive: Drive-by-wire, braking
Automotive: Drive-by-wire, safety
Automotive: Drive-by-wire, drive train/steering/controls
Automotive: Drive-by-wire, electrical (lights, visioning, entertainment)
Automotive: Drive-by-wire, system integration
Home robotics
Artificial intelligence/fuzzy logic
Predictive technologies, simulations (politics, stock market)
Remote sensing
Internet related semiconductors
Distributed computer data storage
RFID hardware
RFID software
Health care procurement software
Health care management software
Health care claims processing software
Universal language translation software
Automated network software
Data mining and database management
Wireless technologies
Internet-related telephones, VOIP, and PDAs
Advanced optical fibers (microfluids)
Photonics: Energy generation
Photonics: Communications
Photonics: Information processing
Photonics: Telecommunications
Photonics: Security
Medical equipment
Medical instruments
T-ray imaging
Regenerative medicine (stem cell research)
Genetics
RNAi therapy (RNA interference)
Systems biology and bioinformatics
Synthetic biology
Prosthetics
Genetically modified foods
Genetically modified agricultural products
Genetically modified pest control
Genetically modified agricultural -drug production
Fuel cells: Off-grid military applications
Fuel cells: Off-grid civilian applications
Fuel cells: Building power and HVAC
Fuel cells: Vehicle propulsion
Solar energy
Wind energy
Biomass energy
Clean-coal technologies
Power-grid control
Power-grid hardware
Nano-enhanced polymers
Biocompatible polymers
Electronic polymers
Conductive polymers
Photonic polymers
General polymers
Composite materials
Liquid crystals
Nanowires
Nanobio (biomedical applications)
Nanochemical (chemical applications)
Nanosensing (chemical sensing and monitoring)
Nano water quality monitoring
Micro-electro-mechanical systems (MEMS))
MEMS: Biological applications
MEMS: Chemistry applications
MEMS: Automotive applications
MEMS: Security applications
Security technology: Identification technology
Security: Chemical sensing and monitoring
Security: Water quality monitoring
Security: Remote sensing
Security: Informational databases/ data mining
Security: Smart/robotic weapons
Ultrahigh-speed rail travel: Magnetic levitation
Ultrahigh-speed rail travel: Electric propulsion
Ultrahigh-speed rail travel: Controls
Space travel
Small corporate jets

Essay 3 Appendix A

The Leading EDGE Awards Abridged Questionnaire CONFIDENTIAL

THE ENTREPRENEURS EDGE

The Entrepreneurs EDGE intends to identify, recognize and honor those companies that are generating the largest *value for the Northeast Ohio community.* This will be done by obtaining EBIT and adding total compensation for all employees in NEO, and then analyzing the absolute figure and growth rate figure over the past three years. All information will be held in the **strictest confidence**. No EBIT figure or total compensation figure will be shared with the public.

Please enter the following information with the most current year information first and note which fiscal cycle the figures represent in each column heading.

Company Fiscal Year End (month) _____

ANNUAL INFORMATION

	FY Ending _____	FY Ending _____	FY Ending _____
1. What is the amount of total compensation[2] paid to all employees residing in the 17 counties of NEO in your last 3 fiscal years?			
2. What were your EBIT (Earnings Before Interest and Taxes) figures in your last 3 fiscal years?			
3. Total EBIT and cash compensation (adding 1 & 2).* (It would be helpful for our research to have all requested information, but if you prefer to only provide the combined figure, answer question 3 only.)			

OPTIONAL QUESTIONS (But very important)

4. What were your total expenditures for all products or services supplied by vendors[3] located in the 17 counties of NEO? NEO zip code guide available at www.edgef.org/NEOZipCodes.pdf			
5. What were your annual net sales?			
6. What was the total cash and employee time (in dollars) contributed by the company to civic projects in NEO?			
7. How many full-time equivalent employees do you have working in NEO?			
8. What was the amount of money invested by your company in new NEO business creations (from outside the company) or in spin-outs (from inside the company)?			
9. Provide the number of spin-out businesses from your company that have been started in the past three years.			
10. Roughly, what percentage of annual earnings are being shared with employees?			
11. How many innovations (new/unique products or services) have you created in the past 3 years that are significantly contributing to sales in the most current year?			
12. Roughly, what percentage of revenue do you attribute to these innovations?			

INNOVATION MANAGEMENT STUDY (If multiple answers apply please rank as 1, 2, 3, etc.)

13. The reason my firm engages in innovation is :

_____ increase market share
_____ maintain market share
_____ lower production costs
_____ improve profit margins
_____ introduce new products
_____ improve production process
_____ n/a

14. How do you innovate in your firm?

_____ in-house R&D
_____ formal product development process
_____ acquisition of product or technology
_____ formal ideation process
_____ work with suppliers
_____ hire consultants

15. How do you measure the impact of innovation in your firm?

_____ improved profit margins
_____ sales growth
_____ increase in employee satisfaction
_____ improve firm reputation
_____ other _____

[2] Compensation includes: wages, bonuses, car/housing allowances, and stock options exercised in the current year, insurance and any other compensation that is taxed within the fiscal year for all full and part-time employees.

[3] Examples might include: computer services, office supplies, raw materials, professional service firms, contracted services, plant and equipment, local outings, etc. The vendor or supplier in which you receive your goods or services only needs to be located in the 17 county area, not necessarily headquartered here. A zip code list for all regions in NEO is available to help you answer this question.