EFFECTS OF OPERATIONS AND INNOVATION STRATEGY FIT ON COMPANY PERFORMANCE

by

JAMES EDWARD BROWN

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"Every problem has a solution. You may not see the path to your goal, but there is a path. Like climbing mountains… it's about staying focused on the summit. No one ever climbs a mountain to get to the middle. You don't focus on the difficulties; you take it one step at a time knowing you're going to get to the top," Jim Koch, co-founder and chairman of the Boston Beer Company.

This PhD program has been a long road filled with disappointments, sadness, but now finally joy. The list of thanks is long, but first glory and thanks goes to God, for his continued blessing in school, work, and life. All good things come from God, and through my faith in Him, I am finally at the end of this journey. God has sent people into my life that offered encouragement and direction. The first of these is my wife Teri. Without her, my life would be empty and without direction. She has always been my inspiration, my rock, my biggest supporter, and she always helped me see the big picture and focus on our dreams we sent in motion long ago. Many times when I have wanted to quit, she encouraged me to try one more time to get past whatever roadblock it was that seemed insurmountable. Her gentle (and sometimes not so gentle) words would get me back on track and focused on the end goal. Although I tried my best to balance her needs with school and work, I know that she has not had all of the time and attention that she deserves. The chores she picked up, the times we didn't go out, and the vacations we missed while going through this has left a debt that I hope to one day repay.

I have lost many close to me that I hope are looking down on me and sharing in my joy at this accomplishment. I miss them all and thank them for their support in this life and beyond. You are always in my heart and in my prayers.

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Abstract

EFFECTS OF OPERATIONS AND INNOVATION STRATEGY FIT ON

COMPANY PERFORMANCE

James Edward Brown, PhD

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Supervising Professor: Edmund Prater

For a company to survive long-term, it must be able to innovate and develop new products and services. There are two types of broad innovation classifications: exploration and exploitation. These two types of innovation require different resources, have different risks, and have different time horizons for the company to receive the benefits. Operations strategies impact the type and quantity of resources available. The concept of fit has been used to match operations strategy and corporate strategy. This dissertation will extend this concept to the relationship between innovation strategy and operations strategy.

Building on The Resource Based View and Punctuated Equilibrium, hypotheses were developed and tested using cluster analysis, ANOVA, and linear regression with data from companies in the disposable medical device industry. Results were mixed with some hypotheses not having any support and some hypotheses having very strong statistical significance. The results suggest there is a minimum threshold of innovation mix and efficiency and takes the form of an efficiency frontier instead of a narrow band of fit as hypothesized. Also, the results show that the size of the company affects the relationship between fit and company performance.

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Chapter 1

Introduction

Given that innovation, new product development, and entrepreneurship are critical components of success for companies and the economy as a whole, how does a company use and integrate these issues in their daily operations in order to succeed? Innovation and development of new products and services are critical for the company's long-term survival (Cash, Earl, and Morison, 2008); for long-term competitiveness, companies in capitalist economies must have innovation portfolios that build on its existing technical trajectory offering improved products or opening new markets to their existing products (Abernathy and Clark, 1985; Eisenhardt and Tabrizi, 1995; Teece and Pisano, 1994; Tushman and O'Reilly, 1997; Tushman, et. al. 2002; Zander and Kogut, 1995)

The topics of new product development and innovation have traditionally been researched in the management, marketing, and strategy literature but have not received as much attention in the operations management literature. A search for several key word combinations such as innovation, exploration, and exploitation in operations journals shows the lack of research attention in the top Operations Management journals (Figure 1-1) with a peak in research in 2007 and 2008 of 14 and 15 articles respectively. While from a practical perspective the field of Operations Management is where innovation becomes a viable market offering through conversion of a company's resources, it has not given innovation and new product development the attention that other academic disciplines have provided. The goal of this thesis is to begin to outline how the decisions made in operations of a company affect the success of the innovation program.

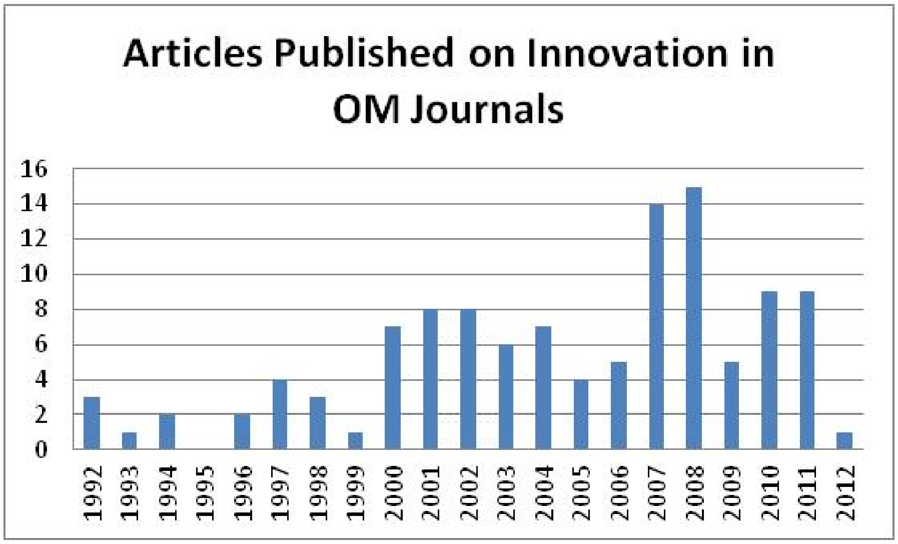

Figure 1-1 Innovation Research in Operations

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In the business function of operations management, companies have many operational strategy decisions to make so that the operations strategy aligns with the overall corporate strategy and the conversion of resources to product and services create the greatest competitive advantage. Operations strategy decisions fall into two major categories. One is the "bricks and mortar" decisions and the other is the infrastructure and organization (Hayes and Wheelwright, 1984). Some examples of bricks and mortar decisions are determining plant size and location, plant layout, and equipment selections (Hayes and Wheelwright, 1984). Decisions on the management side include, among others, vendor relations that are either market based (i.e., transactional or one-off relationships) or partnerships, quality programs, which process management techniques to use, product development, and workforce development (Swink, Narasimhan, and Kim, 2005). Traditionally, the primary drivers of these decisions are financial, service levels, and risk tolerance.

As with many functional decisions, the decisions made in operations strategy directly affect other areas of the organization. Large expenditures on capital equipment can reduce the flexibility of the company to pursue other opportunities by either tying up the needed capital or forcing the company to only look at products that can be made utilizing the current and expensive assets (Christensen, Kaufman, and Shih, 2008).

Research into new product development and innovation suggest that the need for slack resources (Ahuja and Lahiri, 2006), identification of a market need, and a perceived shortcoming between the desired performance in the market and actual performance are primary drivers of the innovation process. Many of the strategies that are popular in operations management focus on either reducing slack in the systems or changing how companies interact with the markets, suppliers, and customers. Also of importance is what happens to the company if there is a radical shift in the market: i.e. how does the operations strategy decision affect the company's ability to react to changes in the competitive environment? Asset specificity, process optimization, and supplier relationships can set the stage for how the company will react to a market disruption. For example these decisions affect how fast the company identifies the shift and the options it has to react to that shift. Many operations strategies are made for steady state long-term production focusing on reducing variation, costs, and wastes. Unfortunately the punctuated equilibrium model predicts relative steady state calm periods where there are minor changes leading up to a radical shift due to a major change in the environment. In a business view, this relates to incremental improvement in products and services that continue along a trajectory until a disruptive technology or business model emerges that dramatically changes the industry (Gersick, 1991).

The innovation literature classifies innovations into three categories These are classified as exploration and exploitation (March, 1991) or ambidexterity (Duncan, 1976;

Tushman and O’Reilly, 1997; O’Reillly and Tushman, 2008). “Exploitation is about efficiency, increasing productivity, control, certainty, and variance reduction. Exploration is about search, discovery, autonomy, innovation and embracing variation. Exploitative innovation is the incremental improvement of current products and services. In the punctuated equilibrium model, this relates to the equilibrium phase of evolution. Exploratory innovation is the radical change from existing products and services that is not closely related to anything currently existing. This disruptive technology is the event that breaks the industry out of the steady state and causes extinction of existing organisms as in the punctuated equilibrium model. Ambidexterity is about doing both. In March’s terms, this is the fundamental tension at the heart of an enterprise’s long-run survival,” (O'Reilly and Tushman, 2008).

Exploration is the cutting edge, new technologies that are often disruptive and greatly surpass current products. Exploitative products are often innovated by an iterative process where new products are based on existing products, but offer different features or have improvements that allow it to be made more inexpensively or to improve its quality. Other modes of exploitative research is to apply existing technology in new fields, new markets, or new applications. Over the long-term, companies need to have both types of innovation either created in-house or licensed or purchased from another company. Companies can approach innovation and new product development from two different strategies. The development can be done in-house with full control of the company or the company can acquire innovations from outside the company by buying other company’s patents, acquisitions of external companies and associated product lines and technology, or by contracting the design and development to a 3rd party design firm. This dissertation is looking at the concept of fit between operations strategy and innovation strategy, therefore to test the effects of that fit this dissertation will focus on only the in-house development of innovations. Some firms excel at both types of innovations, some excel at one or the other, and some do neither well. There has been much debate on whether the two extremes of innovation, exploration and exploitation, are mutually exclusive, or if there is a mix that gives the best of both worlds.

For a company to be successful financially in the long term, the decisions made by management at multiple levels must be aligned to an overarching strategy set forward by the executive leadership team (ELT). Figure 1-2 shows the flow of strategic decisions and influences of these decisions on other parts of the firm and demonstrates how decisions made affect later decisions. The long-term strategic decision of the company as a whole influences what will be the primary innovation mode. Depending on how well the strategic fit is between the various drivers (ex. innovation strategy, the resources of the company, the operations strategy, corporate learning ability, and the match between operations and innovations) strategy will determine if the company performs better financially.

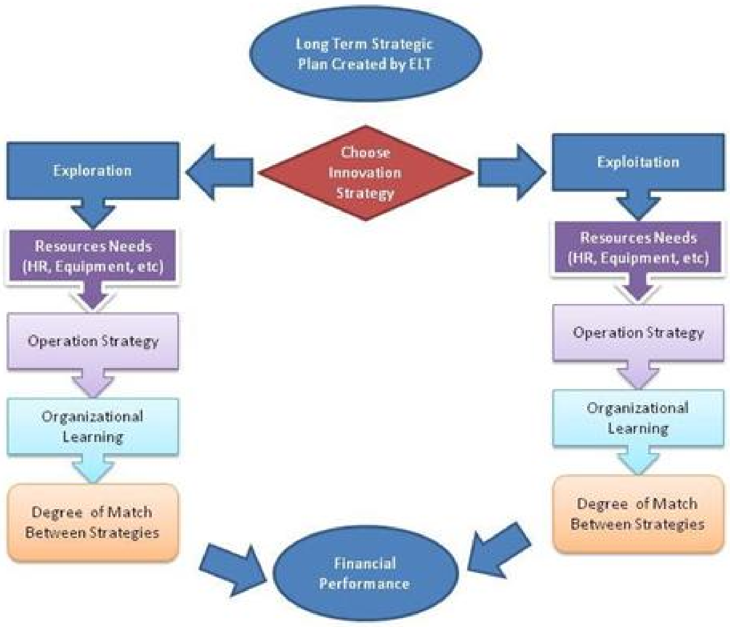

Figure 1-2 Strategic Decision Relationship

How can operations contribute to the successful development of innovation, new product development and new entrepreneurial ventures? This dissertation will examine the existing literature on these subjects from strategic management and operations to develop a model for operations strategy decisions that will positively affect the innovation process and ultimately successful financial outcome of the firm. It will be hypothesized that operations decisions affect the long-term success of a firm's innovation and that the decisions of innovation create a path dependency that affects the future success of innovations.

A review of existing literature on innovation has found several weaknesses in current understanding of innovation. There is also a surprising lack of research in the relationship between innovation and operations strategy. The concept of fit between operations and other disciplines such as finance and marketing have been researched, but few on innovation and operations. One of the main issues found by other researchers is the lack of longitudinal studies. Gupta, Smith, and Shalley (2006) identified the lack of longitudinal studies on how companies balance exploitation and exploration over the long term and if the market conditions and environment dictate the choice of innovation strategy. Raisch, Birkinshaw, Probst, and Tushman (2009) followed up the work of Gupta, Smith, and Shalley to examine innovation ambidexterity and still found a lack of longitudinal studies on ambidexterity success. Menora, Mohan, and Samsonc (2002) called for more empirical work investigating the development process of exploration, exploitation, and ambidexterity. Finally, there are still gaps in how manufacturing and operations strategy affect firm performance over time (Bozarth and McDermott, 1998; Kathuria and Porth, 2003; Kroes & Ghosh, 2010). This dissertation will attempt to fill in some of these gaps. First, the contribution of this dissertation to the operations strategy literature is to lay out how innovation strategies decisions can impact the success the innovation strategy decisions of the company. This dissertation proposes a testable construct of innovations-operations fit that seeks to determine if the alignment between these two strategies affect company performance. In contribution to the innovation literature, this dissertation looks at over 30 years of data from the disposable medical device industry to investigate the success of exploration, exploitation, and ambidexterity over different economic conditions and levels of market uncertainty.

The remainder of the dissertation is structured as follows. Chapter 2 will review literature from the fields of corporate strategy, innovation, organizational learning, the Resourced Based View of the firm, opearations strategy, and process management. Chapter 3 develops the research model based on literature and develop hypotheses. Chapter 4 presents the methodology and results from the analysis. Chapter 5 discusses the results of the analysis and finally chapter 6 presents recommendations, conclusions of the analysis, and suggestions for future research.

Chapter 2

Literature Review

This dissertation builds on several literature streams. It progresses from a discussion of the fundamental theory of company and industry structures and strategy development by presenting the punctuated equilibrium model (that explains why and how industries and companies change over time) and the resource based view of the firm (that develops corporate strategy from an inside-out point of view that is a contrast from Michael Porter's external orientation of strategy). The literature then focuses on more tactical implications of corporate strategy, innovation, organizational learning, operations strategy, and process management using the punctuated equilibrium model and RBV as a basis of understanding. Finally, the concept of fit is reviewed and how fit can influence the success of companies in both stable and turbulent environments.

2.1 Punctuated Equilibrium

The Punctuated Equilibrium theory is a model that has its origins in the field of biology as a challenge to Darwin's theory of evolution. Darwin's theory of Natural Selection describes the changes in an organism as a cumulative effect of minor incremental changes in species to explain the evolution of species over time. Small variations and mutations develop in species and if the variation is beneficial, it is incorporated in future generations. If the mutation is not beneficial, the mutation is not passed on and the mutation dies in that generation. Eldredge and Gould (1972) challenged the Darwinian evolution model when they proposed the punctuated equilibrium model. The punctuated equilibrium model adds another mechanism for evolution that was not included in Darwinian evolution. While it is possible that the species evolves slowly over time, they added a new effect of radical change occurring in a short time frame that then allowed natural selection to choose between the older species or the new upstart. Gersick (1991) further developed the punctuated equilibrium model by building on work from Kuhn (1970) in philosophy of science, Abernathy and Utterback (1982) work in industry, Miller and Friesen (1984) focus on organizational adaptation, and the Nobel Prize winning work on self-organizing and dissipative structures by Prigogine (1977).

The core of the punctuated equilibrium model is the observation that long periods of stability (equilibrium) are broken by periods of dramatic upheaval (revolution). Gersick (1991) describes the characteristics of each phase and how the two phases interact and what causes the system to stay in one phase or switch over to the other. The key to the model is the size of change. A system can handle small and intermediate changes with ease and can sometimes resist the change. This resistance to the change can actually cause the change to die out due to inertia resisting change. There is a point where the change cannot be easily absorbed and changes to the system must occur to adapt to the change.

The punctuated equilibrium model has three concepts that predict how the system will react to change. These three components are deep structure, equilibrium periods, and revolutionary periods (Wake, Roth, and Wake, 1983; Gersick, 1991). Deep Structure is a complex concept that refers to the characteristics of the system that form the foundation and organization of the system. The deep structure reinforces the system and early decisions carry the most weight as it creates path dependence as in a decision tree (Gersick, 1991). During the equilibrium period, the system can make minor changes without major changes in the deep structure of the system (Wake, Roth, and Wake, 1983; Gersick, 1991). "If deep structure may be thought of as the design of the playing field and the rules of the game, then equilibrium periods might be compared loosely to a game in play," (Gersick, 1991) The deep structure has been described as a "menu of choices about how they will organize and run themselves," (Gersick 1991). "While [deep structure] may or may not be explicit, it can be described by [five facets]: (1) core beliefs and values regarding the organization, its employees and its environment; (2) products, markets, technology and competitive timing; (3) the distribution of power; (4) the organization's structure; and (5) the nature, type and pervasiveness of control systems," (Tushman and Romanelli, 1985). In an industry setting, deep structure can take on various forms like industry standards, labor relations, vendor relations, government regulations, or shared views of how companies should work. For example, the role of telephone customer support was long viewed as an expense to be minimized. Industries found ways to reduce costs by automation, off-shoring, and outsourcing the role. This was the dominant mindset of many industries until the customer began to stop using companies with off-shore call centers and switched to companies with United States based call centers.

The second aspect of the punctuated equilibrium model is the equilibrium period. This period is the stable state of the system where the rules and deep structures are not changing and where small incremental changes can be made without fundamental changes to the deep structure of the system. Industries and companies can absorb almost any change as long as it is incrementally small enough and over time, these small changes can add up to a big change for the industry as a whole. Companies can slowly adjust to changes over time without much pain. The revolutionary period comes about when a system is faced with a large, rapid change is hard to absorb and creates a dramatic shift. (Gould, 1989: Gersick, 1991). It is like the metaphor of the frog and boiling water where a frog will jump out if thrown in a pot of boiling water, but will stay in the pot of cold water that is slowly heated to boiling since the frog will not notice the small changes over time and adjusts to it.

There must be an externality or switching cost and some uncertainty in the capabilities of the new technology for punctuated equilibrium to happen (Loch and Huberman, 1999). A major aspect of the equilibrium phase that comes out of the punctuated equilibrium model is that of inertia. The stronger the deep structure, the stronger the inertia. In human systems, the three barriers to radical change are cognition, motivation, and obligation (Tushman and Romanelli 1985). Cognition is the ability of a system to detect changes, the mental framework that the system uses to view the world, and willingness to see the need for change. It can also limit the company's ability to see that there are alternative paths for them to follow.

The motivation of a company's management can cause it to maintain the status quo and maintain its inertia. People have a natural resistance to change. In business, these take the form of sunk costs, loss of control, and fear of the unknown and they contribute to the resistance to change (Gersick, 1991). Sunk costs are when a company is not willing to abandon a course of action, strategy or project due to the costs, time, and energy that has been dedicated already to the past decisions. Management might not want to admit that they made a mistake or that what has been successful for so long is no longer working. A Harvard Business Review article describes how financial measures can also lock the company into living in the past. Discounted cash flows (DCF) and Net Present Value (NPV) are common methods for evaluating new opportunities. Unfortunately, these methods value current fixed costs and sunk costs in a way that reduces existing companies' ability to approve new projects and provides an advantage to new firms (Christensen, Kaufman, and Shih, 2008). Other sources of inertia due to motivation are the fear of new and uncertain tasks and change in responsibilities that may affect a person's power in the organization. Companies can choose to follow old routines even though they know they are no longer working because they are unwilling to risk trying a new approach. An error in judgment is the belief that the status quo is a viable option for future success (Christensen, Kaufman, and Shih, 2008).

The revolutionary period of the punctuated equilibrium model is the time of great and fundamental changes to the system. The revolutionary period is the phase when the rules change and the system faces major change (Gersick, 1991) and when the deep structure of the system is altered. The alteration of the deep structure creates a disorganized and chaotic state where the rules of the game are changed and each player is seeking to understand what the new state will be and how to reach that new state with least pain. Industries stay in static forms (equilibrium) the majority of the time but suddenly a new technology or company creates a rapid change (punctuation) that cause companies to adapt or die (Gersick, 1991).

The disruption that can cause a need for a shift from equilibrium state to revolutionary phase can come from either internal changes or environmental changes. Some examples of internal changes can be changes in management, changes in business model, and changes in strategy. Examples of external changes could be regulatory changes, disruptive technologies, natural disasters, and new entrants to the market. Although a need for revolutionary change is created, it is not certain that a revolution would materialize. The inertia of the deep structure can prevent the change even when the need exists.

During the revolutionary phase, the system and companies feel uneasy and the new path forward is untested. The true value of the new path cannot be fully understood until the deep structure is realigned and a new period of equilibrium is entered. This makes the motivation for getting through the revolutionary phase quickly extremely important, but it is also important take time to understand the choices available and make decisions that push the organization toward the new paradigm without falling into the old way of doing things. This often takes advice from people from outside the organization. Access to trusted outsiders is an important resource to the company and should be developed during the equilibrium phases so that the company does not panic and take advice from someone not fully trusted by company.

As change begins to happen in a system, the inertia of the system will resist. The nucleus of change that is necessary to effect lasting change has to be larger the more integrated the system is and the better the communication is between various parts of the system. Systems that are highly interconnected, that have rigid structure, and a great deal of relationships have larger inertia and resists changes, more than systems that have a more lax control system and connectivity. Why do revolutions occur at all? The same deep structure that creates the inertia can also create the revolution. The mutual interdependence and how the system gets resources from the environment forces major changes when the system can no longer get resources from the environment and when the parts (companies) are no longer aligned (Gersick, 1991).

Technology diffusion follows the punctuated equilibrium model for five reasons presented by Loch and Huberman, (1999). These five reasons are: “1. A radical innovation creates uncertainty (for producers as well as users), which needs to be resolved before widespread adoption can occur. 2. The new characteristics of the technology may destroy existing firm competences, which contributes to inertia within firms. 3. A new technology may be incompatible technically with other components of complex systems of which it is a part. 4. It may also upset the balance of cooperations and interests in the business network that has evolved around the old technology and its complements. 5. Finally, it may encounter resistance in society at large," (Loch and Huberman, 1999)

In summary of the punctuated equilibrium model, there exist two phases, which are the equilibrium phase i.e. steady state, and the revolution phase where the deep structure is modified. The deep structure is the source of inertia of the equilibrium phase. The deep structure comes from the predominant system structure, beliefs, norms, and processes. The stronger the deep structure is, the longer the system will stay in equilibrium and the stronger the resistance to change or even can cause firms to not see or accept that there is change going on. Organizations that are able to radically and quickly change their processes and structures in response to external changes perform better long term than those who just change incrementally (Miller and Friesen 1982, 1984; Virany, Tushman, and Romanelli 1992; Romanelli and Tushman, 1994). Punctuated equilibrium is tied to organizational learning that created tensions between the drive stability and change, (Lant and Mezias, 1992; Romanelli and Tushman, 1994).

2.2 Resource Based View and Dynamic Capabilities

In order for companies to succeed, earn economic rents over the long term, and produce supernormal returns compared to its competitors, they must be able to perform better than another company in some area. The Resource Based View (RBV) of the firm is a theory of the firm that seeks to match the strategy of the organization to its internal resources (Grant R. M., 1991). The RBV forms the foundation for understanding the how the company can develop competitive advantages and earn profits. The RBV assumes firms are profit-maximizing entities directed by bounded rational managers in markets that are to a reasonable extent predictable and moving towards equilibrium (Bromiley and

Papenhausen, 2003; Leiblein, 2003; Kraaijenbrink, Spender, and Groen, 2010; Rugman and Verbeke, 2002). The RBV links the company's capabilities with the industry and market dynamics (Collis and Montgomery, 1995). Grant develops an integrated framework of capabilities at multiple levels of the company and there are complex interactions between different strategy levels (Grant R. M., 1991; Kor and Leblebici, 2005; Kraaijenbrink, Spender, and Groen, 2010)

The Resource Based View seeks to explain the competitive advantages of the company by looking at the resources a company has and how it uses them and that resources are heterogeneous across companies (Barney, 1991; Grant, 1991; Schroeder, Bates, and Junttila, 2002; Knott, Bryce, and Posen, 2003; Rugman 2002). Resources that firms have are different and the differences can persist long-term, despite the system's attempt to reach equilibrium (Barney, 1991; Rumelt, 1984; Wernerfelt, 1984; Chuang, 2004). Prahalad and Hamel (1990) discuss how the core competencies develop from the knowledge and are enhanced as they are applied inside a company. "The resource-based model is fundamentally concerned with the internal accumulation of assets, with asset specificity, and, less directly, with transactions costs" (Peteraf, 1993). Figure 2-1, below from Grant (1991), shows the input of the firm's resources and how that flows into corporate strategy formation. Figure 2-1 also shows that using the RBV, strategy should be selected based on the resources that the firm has and builds on what it uniquely has that other firms do not.

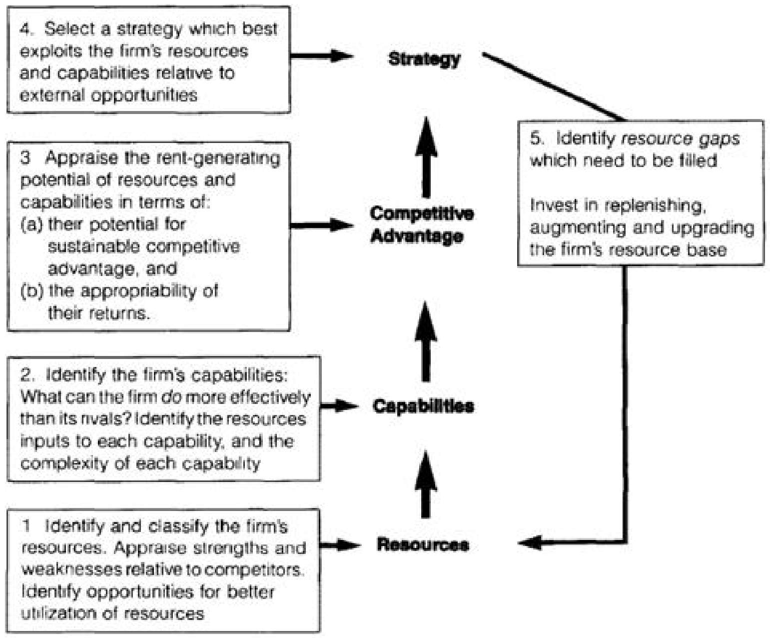

Figure 2-1 Resource Based View (Grant, R. M., 1991)

While Michael Porter's work focuses on the industry (external) strategic orientation, the long term strategy that is more likely to succeed is one that is built upon what the company does well that provides value in the marketplace and to not focus the strategy externally (Peteraf M. , 1993; Grant R. M., 1991). Each company has resources that are acquired over time and is path-dependent. This path-dependency creates value to the firm as it may be more difficult for another firm to acquire the resources or if another company must follow the same path, the first company would have a time advantage.

There are six major categories of resources upon which capabilities are made. These are classified as financial, physical, human, technological, reputation, and organizational (Grant R. M., 1991). Financial resources are the availability and cost of capital, tax structure, and leverage of the firm. Physical resources refer to the raw materials, costs of energy, location, and plant and equipment. Human resources are the talents and skills inherent in the workforce. This could be access to lower labor costs, higher education, or specialized employee skills. Technological resources are the knowledge and equipment that the company has at its disposal. Technological resources can be patented processes and technology, off the shelf equipment, or a utility resource such as bandwidth. Reputation is powerful resource that is developed over time and can have great affect on the ability of a company to gain and apply resources. The reputation of the firm can provide an advantage in accessing markets, building market share, gaining favor with government organizations, and can make it easier to acquire resources, especially human resources. Organizational resources are the management and operations processes that allow the company to best use recourses and spot opportunities.

Resources are the building blocks of profitability in a company, but almost any company can acquire resources. The next step to earning economic rents is developing the capabilities that are made from resources. It is not necessarily the resources themselves, but the ability of management to mobilize, organize and integrate the resources that gives a company a competitive advantage (Grant R. M., 1996) (Kraaijenbrink and Wijnhoven, 2008) (Kraaijenbrink, Spender, and Groen, 2010). Capabilities are the organizational routines that combine and coordinate the use of various resources in the company (Grant R. M., 1991). Six factors affect the ability of a company to achieve economic rents from its resources and capabilities. These factors are sustainability, durability, transparency, transferability, inimitability, and appropriability (Collis and Montgomery, 1995; Grant R. M., 1991).

Sustainability is the ability of a company to maintain competitive advantage from both the sustainability of the resources and the capability and advantage derived from them. Durability is the characteristic of the resource to degrade or become obsolete over time. Durability is affected by the rate of change of technology in an industry. Transparency is how obvious is the source of the competitive advantage and how hard it would be to obtain all the resources necessary to duplicate the advantage. Transferability is how easy it is to switch the resource from one firm to another. Transferability is made up of geographic immobility, imperfect information, firm specific resources and immobility of capabilities. Inimitability is the degree to which the knowledge upon which a competitive advantage is tacit or codified and how difficult it is to recreate the capabilities in-house in another organization. Appropriability is the ability of a company to earn economic rents on an asset when ownership is in question. An example is the skills of an employee. Is their skill property of the company or of the person?

Prahalad and Hamel (1990) discuss how the core competencies develop from the knowledge and are enhanced as they are applied inside a company. “The resource-based model is fundamentally concerned with the internal accumulation of assets, with asset specificity, and, less directly, with transactions costs” (Peteraf, 1993). The competitive advantages of companies are not static and can change over time (Helfat, Peteraf 2003). “…a resource with the potential to create competitive advantage must meet a number of criteria, including value, rarity, imitability and organization. Resources and capabilities are considered valuable if they allow an organization to exploit opportunities and counter threats in the business environment,” (McIvor, 2009).

Core competencies enable product innovation but can actually impede product innovation when those core competencies become part of the deep structure of the firm, (Leonard-Barton, 1992; Danneels, 2002).

While the RBV has many supporters, it does have some detractors and critiques. In order to succeed long-term, companies must be able to compete in existing and change to compete in new markets. Dynamic capabilities allow company leaders to reorganize and mobilize the capabilities in new ways once threats and opportunities are identified (Teece, 2006; O'Reilly and Tushman, 2008) Competitive advantage and disadvantage are developed over time and are not constant (Helefat and Peteraf, 2003). In fact, in order for a resource to have the potential of delivering a competitive advantage, it must be rare and hard to duplicate or imitate (Barney, 1991).

The company must exploit current capabilities and build new ones (Stieglitz and Heine, 2007). The RBV is a snap shot in time and does not take into account how the resources or competitive advantages change over time (Kraaijenbrink, Spender, and Groen, 2010). RBV as originally proposed is applies as long as the deep structure in an industry remain relatively fixed. In unpredictable environments, in which new technologies and/or new markets emerge and the value of resources can drastically change, we need to go beyond the RBV to explain a firm's sustainable competitive advantage (Barney, 2002; Kraaijenbrink, Spender, and Groen, 2010). The RBV has trouble dealing with issues that change over time such as boundaries, timing, innovation, and entrepreneurship (Kraaijenbrink, Spender, and Groen, 2010).

In response to this critique, the idea of dynamic capability was developed. Dynamic capabilities take the static resources, capabilities, and completive advantages and add a temporal aspect that allows for their variation over time, (Tushman, Smith, Wood, Westerman, and O’Reilly, 2002). Adding a dynamic element to the economy and resource allocation allows for entrepreneurs to develop in a classical economic model. (Arend, 1999; Langlois, 2007; Sarasvathy and Dew, 2005; Teece, 2007; Kraaijenbrink, Spender, and Groen, 2010).

The static theories of strategy made popular by (Barnett, Greve and Park, 1994; Porter, 1980; Rumelt, 1984) are being replaced by dynamic theories that focus on the ability of the firm to change so that it matches its resources and structure to match new competitive environments (Eisenhardt and Martin, 2000; Helfat, 1999; Lavie, 2006; Teece, Pisano and Shuen, 1997; Teece, 2006; O'Reilly and Tushman, 2008). Dynamic capabilities enhance the company's ability to exploit and explore at the same time (March, 1991; McGrath, 1999; Tushman, Smith, Wood, Westerman, and O'Reilly, 2002)

The RBV was initially devised as in intra-firm framework, but Dyer and Singh 1998 looked at moving beyond the company and into its network for resources that contribute to its competitive advantage are sometimes outside the firm's boundaries. Previous research suggests that firms occupying central network positions with greater network ties have superior access to information and, thus, are more likely to increase the number of their alliances in the future (Gulati, l995a; Mitchell and Singh, 1996; Walker et al., 1997). When a firm is well positioned in networks, the firm has access to more reliable information about potential partners because of trusted informants within the network who may have direct experience with the potential partner (Burt, 1992; Chung, Singh, and Lee, in press; Granovetter, 1985; Nohria, 1992). An information-rich position within a network, therefore, provides a firm with additional information about the nature and degree of accessibility of the complementary resources of potential partners, (Dyer and Singh, 1988)

Process technologies that lead to cost advantage are results of making existing technology more efficient and optimized. These are exploitation activities and contribute to the deep structure of the company. Figure 2-2 illustrates how unique resources of a firm build to create value and competitive advantage in the company, but also illustrates how those same capabilities make the industry more or less attractive to competitors. It combines the internal and external aspects of corporate strategy.

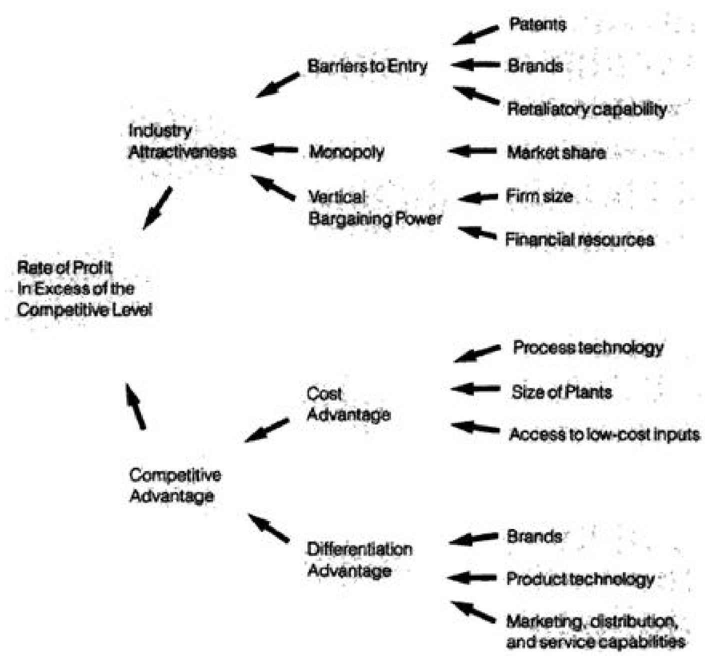

Figure 2-2 Unique Resources Build Competitive Advantage (Grant, R. M., 1991)

2.3 Efficient/Performance Frontiers

The Resource Based View of the firm describes imitable resources that can easily acquired by competitors and cannot be sources of competitive advantage due to the efficiency of an industry where companies . The Theory of Efficient Frontiers builds on this concept to describe the current state of the art in an industry and the mixture of resources that create an optimal curve of performance (Greve, 2003). Companies with finite resources and some technical situations require tradeoffs between competing variables and situations. These tradeoffs made by companies affect the performance of the firm and there exists a curve where there is an optimal mixture that creates maximum performance (Swink M. S., 2006). Companies that are far from the efficient frontier can improve by many changes to the mixture with high returns, but the closer a company is to the efficient frontier the more difficult it is for a company to improve its performance through diminishing returns (Swink M. S., 2006).

2.4 Corporate Strategy

One of the major roles of company executive management is to develop a strategy that will maximize shareholder value. Executive management makes decisions on the type of products, price points, service levels etc and how the company will use its resources to achieve the goals set out. Many tools exist for the executive strategy development from the industry and environmental factors with early pioneers such as Porter, Mintzberg, Prahalad and Hamel creating a strong tool kit for managers. This step has been researched greatly by those in the management strategy field and is outside the scope of this dissertation. Fort this dissertation, it is assumed that executives have developed a strategy and is actively moving forward in its implementation.

2.5 Modes of Innovation

2.5.1. What is Innovation?

"Innovation is doing new things that customers ultimately appreciate and value," (Cash, Earl, and Morison, 2008). Innovation is one of the most important things a company can do. Many quotes by respected business authors point this out. "The enterprise that does not innovate, ages and declines. And in a period of rapid change such as the present, the decline will be fast." Peter Drucker. "Innovate or die," Tom Peters. The importance of innovation in the survival of the company requires the company to continuously match the company's structure, organization, technology and practices to the needs of the market (Pavitt, 2004; Castellacci, Grodal, Mendonca, and Wibe, 2005). To continue and survive in a changing environment, a firm must be able to adapt (Eisenhardt and Martin, 2000; Teece, Pisano, and Shuen, 1997; Hoang and Rothaermel, 2010). Companies must have exploration and exploitation to survive long-term (Ancona, Goodman, Lawrence, and Tushman, 2001; Benner and Tushman, 2002; Dougherty, 1992; Eisenhardt and Martin, 2000; Feinberg and Gupta, 2004; Levinthal andMarch, 1993; March, 1991, 1996, 2006).

Companies have a strategic choice at the time of radical technological change. This choice has been researched in fields such as management of technology, organizational learning, and economics (Lee, Lee, and Lee, 2003). The firm must choose if they are going to exploit their current technology to ensure short-term survival or it can move to the new technology and hope for better long-term opportunities (Levinthal and March 1981, Nelson and Winter 1982; Lee, Lee, and Lee, 2003). Once management decides on the product mix and strategy, the executives must decide how new products will be developed in the future. RandD and innovation is an important factor in a firm's production and product offerings (Knott, Bryce, and Posen, 2003).

In the early formation of innovation theory, innovation was believed to exist on two opposed forms. March (1991) identified these two categories as Exploration and Exploitation. These are two distinctly separate ideas and were posed as mutually exclusive paths for innovation. More recently, research has shown that there is a hybrid between the Exploiters and Explorers. The group that occupies the middle ground is called ambidextrous organizations (Gupta, Smith, and Shalley, 2006). While there is some variations in definitions of exploration and exploitation (Nerkar, 2001; Vassolo, Anand, and Folta, 2004; Vermeulen and Barkema, 2001, Rosenkopf and Nerkar's, 2001; Benner and Tushman, 2003), the definitions below will be used for this paper. Exploitation innovation is focused on efficiency, productivity, and variance reduction while exploration is about wide search, new discovery, and embracing variation (O'Reilly and Tushman, 2008). Ambidexterity is about doing both (Duncan, 1976; Tushman and O'Reilly, 1997; O'Reilly and Tushman, 2008).

Research has identified three main reasons why a company would not be able to do both effectively at the same time. March, 1991 said that pursuit of one, makes you naturally do less of the other. Firms that try to do both have to select which to give more resources to and lack focus (Miller and Friesen, 1986). Finally, it should match its strategy to the business environment (Galbraith, 1973; Lawrence and Lorsch, 1967; Kyriakopoulos and Moorman, 2004)

"What is good in the long run is not always good in the short run," (March, 1991). While both types of innovation are needed in the long-term, there are competing demands of each and a company often moves towards exploitation since the positive feedback is often stronger (Benner and Tushman, 2002; Gupta, Smith and Shalley, 2006; Henderson and Clark, 1990; Levinthal and March, 1993; March, 2003; O'Reilly and Tushman, 2008).

2.5.2. Exploration

Exploration is the quest for new knowledge that is not based on pre-existing knowledge inside the firm or industry. Exploration is the quest for radical, game-changing, disruptive technologies that change the trajectory of technology development in an industry and opens new product markets (Benner and Tushman, 2003; He and Wong 2004). Returns from exploration are more uncertain and occur in much later time periods than exploitation (March, 1991). Radical innovations often require the support of the whole organization from creation of new assets and technology to new marketing, so having strategic direction to innovation is critical (Stieglitz and Heine, 2007).

Often called blue-sky or clean sheet research, this research has a large amount of uncertainty in its success from the point of view of being technically feasible and its success of these products in the market. Products developed from this research would become major market disrupters and could make existing products obsolete.

Exploratory innovation is the type of technologies that create the impetus for punctuated equilibrium to occur. Exploratory research can be classified as high risk, high reward research (Gupta, Smith, and Shalley, 2006). Many companies and researchers spend large amounts of money, time, and energy on developing technology that does not bear fruit in patents or saleable products. Exploratory innovation often requires new technology competency and marketing, so management structures must be in place to oversee and integrate (Stieglitz and Heine, 2007; Tushman and Anderson, 1986; O'Reilly and Tushman, 2008). For companies and researchers involved in this type of product development and knowledge creation, systems and machinery utilized would have general application. They are not tailored to a specific method of doing work, but instead offer flexibility and agility. The type of technology that has multiple applications tends to be more expensive since it has to provide a wide range of capabilities or alternatively, a company could spend a large amount on various machinery and technology that can be utilized in radical research. Exploration creates new competencies that facilitate further innovation and can result in increased performance in the long-term (Geroski, Machin, and Van Reenen, 1993), but these benefits are often offset by increased risk and delay in returns (Gupta, Smith, and Shalley, 2006; O'Reilly and Tushman, 2008).

2.5.3. Exploitation

Exploitative innovation refines and extends the existing product's price/performance ratio (Dosi, 1982; Rosenkopf and Nerkar, 2001; Tushman, Smith, Wood, Westerman, and O'Reilly, 2002) Exploitation makes existing products cheaper, faster and better (Nelson and Winter, 1982; O'Reilly and Tushman, 2008). "Successful exploitation provides a buffer from the shocks of exploration and entails less risk than exploration," (Gatignon, Tushman, Smith, and Anderson, 2002).

Exploitation is the application, refinement, optimization, and improvement of existing products and knowledge (March 1991). Exploitation continues the existing trajectory of technology and builds on the existing technology in that industry and improves existing product market domains (Benner and Tushman, 2003; He and Wong 2004). Exploitation insulates the firm from the shocks of exploration and usually is less risky than exploration (Gatignon, Tushman, Smith, and Anderson, 2002; Voss, Sirdeshmukh, and Voss, 2008). Positive local feedback such as profit and market share tends to cause companies (even ambidextrous ones) to lean toward exploitation (Benner and Tushman, 2002; Gupta, Smith and Shalley, 2006; Henderson and Clark, 1990; Levinthal and March, 1993; O'Reilly and Tushman, 2008). This is the steady state of the punctuated equilibrium model. In operations, this is characterized by efforts by companies and researchers investing money in creating economies of scale and scope, optimizing processes and implement best practices, holding kaizen events and six-sigma projects seeking to reduce variation. Exploitative research is the refinement and incremental improvement of existing products and technology. This research can increase product capabilities, reduce cost and complexity of existing products, or improve reliability or manufacturability. This type of research aids in the reduction of production cost seen in the phenomenon of the learning curve where production and costs decrease as more units are produced.

2.5.4. Ambidexterity

Established companies must continue to invest in RandD to maintain or increase its status and competitiveness in the market (Cesaroni, Minin, and Piccaluga, 2005). Companies must stay up to date on the current state of the art of their industries and maintain collaborative relationships with partners (Cesaroni, Minin, and Piccaluga, 2005) The focus on exploitation will eventually lead to technological decline in competitive markets, (Lee and Ryu, 2002; Lee, Lee, and Lee, 2003). How can a company do both over the long term since each type of innovation "require different structures, processes, strategies, and capabilities and culture?" (He and Wong, 2004). Exploration and exploitation have been presented as mutually exclusive methodologies, but with weaknesses in each (Raisch, Birkinshaw, Probst, and Tushman, 2009). Many studies have suggested that the combination of exploration and exploitation is associated with longer survival (Cottrell and Nault, 2004), better financial performance (Govindarajan and Trimble, 2005; Markides and Charitou, 2004), and improved learning and innovation (Adler, et al., 1999; Holmqvist, 2004; Katila and Ahuja, 2002; McGrath, 2001; Rothaermel and Deeds, 2004; O'Reilly and Tushman, 2008)

While there has been a large debate on if exploitation and exploration can exist at the same time or if it follows a punctuated equilibrium model that causes a company to switch from exploit to explore, Tushman and O'Reilly (1996) were first to present a theory of organizational ambidexterity by building off work by Duncan (1976). They suggest that ambidextrous organization should have better performance and they described how to structure the RandD functions to allow for ambidextrous innovation (Raisch, Birkinshaw, Probst, and Tushman, 2009; Tothaermel and Alexandre, 2009). Ambidextrous innovation is when firms do both exploitative and exploratory research in the same timeframe. There is still some continued debate at what size of companies is ambidexterity possible. Being ambidextrous requires both skill sets that are required for exploration and exploitation. Research has shown that successful ambidextrous companies are larger due to need for more resources (Gupta, Smith, and Shalley, 2006).

Ambidextrous forms were more effective than other organizational design choices in creating non-incremental innovations long-term when new non-incremental products were phased in instead of immediately replaced (Tushman, Smith, Wood, Westerman, and O'Reilly, 2002). Ambidextrous innovation is more likely when the markets are highly competitive and unstable (Jansen, Van den Bosch and Volberda, 2005; O'Reilly and Tushman, 2008).

Can exploration and exploitation coexist? Many researchers have debated this topic. Many researchers cite the vast differences in research methodology, equipment, and mindset needed for each knowledge creation method are diametrically opposed and cannot coexist in companies and people, but rather are a binary/either-or scenario where companies seek to optimize and extract economic rents from the existing technology (Burgelman, 2002; Benner and Tushman, 2003; Siggelkow and Levinthal, 2003; Gupta, Smith, and Shalley, 2006; O'Reilly and Tushman, 2008; Andriopoulos and Lewis, 2009; Groysberg and Lee, 2009; Jansen et al., 2009; Mom et al., 2009; Taylor and Helfat, 2009). The organization configuration needed to follow exploration and exploitation are very different, but both are needed in a company if it is to succeed both over the short term and the long term, (O'Reilly and Tushman, 2008). If a company cannot balance both exploration and exploitation, a company can fall into either a “competency trap” where a company focuses on what it does well and exploits more than it explores or it can fall into a “failure trap” where the company fails on having a successful outcome of the exploration process and keeps searching without ever settling on something and exploitation is non-existent (Leonard-Barton, 1992; March, 2003; Siggelkow and Rivkin, 2006; O'Reilly and Tushman, 2008). Exploitative subunits are organized to be efficient, while exploratory subunits are organized to experiment and improvise. (Tushman, Smith, Wood, Westerman, and O’Reilly, 2002). Other researchers believe that both can coexist within an organization, but depends on the resources available to it. Siggleskow and Rivkin, (2006) identified that different levels of the organization can follow different forms of knowledge creation and that organic, decentralized firms often better explorers and adopted new technologies more quickly. On the other hand, centralized companies resisted new knowledge and were more prone to exploitation. Siggleskow and Rivkin created a model that demonstrated that lower level exploitation could actually limit the overall innovation of the firm. “The firm’s crucial task is to exploit its existing resources and capabilities while simultaneously developing new corporate assets for future business opportunities”, (Stieglitz and Heine, 2007).

“Ambidexterity refers to the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either exploration or exploitation,” (Gupta, Smith, and Shalley, 2006). The ambidexterity of the firm is not feasible at the group level due to the difference in expected outcome of tasks in exploration and exploitation, but can exist when the groups are separated (Gupta, Smith, and Shalley, 2006). Ambidextrous organizations have high level of differentiation with dedicated management and groups focused on each form of innovation with reporting structures that go to senior management, low integration and contact between groups, and top management support for both exploration and exploitation (Tushman, Smith, Wood, Westerman, and O'Reilly, 2002). Ebben and Johnson (2005) conducted a study of 300 small companies and found they did better when following a single strategy of either flexibility of efficiency instead of trying to do both. In support of a punctuated equilibrium model, some research has suggested following one strategy until it fails and either closing doors or then switching to a new strategy (Anand and Singh, 1997; Dew, Goldfarb and Sarasvathy, 2006; Knott and Posen, 2005; O'Reilly and Tushman, 2008). While there is a large amount of research on ambidextrous organizations, few studies have been done longitudinally to understand the long-term success of ambidextrous organizations (Raisch, Birkinshaw, Probst, and Tushman, 2009). Many companies do not have the resources or slack available to conduct exploration. For these companies, instead of following an ambidextrous approach, the exploration resources can be gained by alliances, licensing, joint ventures, and mergers and acquisitions.

The ability for a firm to survive long-term hinges on many different aspects that have been touched upon so far in this dissertation. The company must be able to spot opportunities and threats in the environment through boundary spanning activities, continue to produce new products that customers value through product innovation, have access to or develop resources and competitive advantages that allow the company to compete in its current environment, and have the flexibility to adapt operations after periods of revolution.

The supplier relationships discussed by (Swink, Narasimhan, and Kim, 2005) can have a big impact on the innovation of a firm. Research has shown that customer and supplier interaction can enhance the success of new products (Gruner and Homburg, 2000). Boundary spanning activities are important to identifying environmental risks and opportunities. The amount of vertical integration and the amount of cooperation and trust in the supply chain would impact the knowledge that the firm can get about the environment. Companies that are more vertically integrated would have fewer opportunities to interact with suppliers and competitors than a company that is more core competency and market focused. Contact with suppliers and customers at arm's length provides some information on market needs and disruption, however more integration and trust of the supply chain allows for more learning in the company and improves the chances that needs for innovation are identified. Once suppliers sign cooperation agreements and alliances, information on opportunities in the market, opportunities for improvement, and knowledge sharing will begin to increase. This increase in knowledge sharing allows for greater sensitivity to inputs in the market. The power and control of the vertically integrated companies would allow for more exploitative innovation as the opportunities for the company to implement process management processes over the whole value chain.

Radical exploration is the incorporation of knowledge from another technical domain and does not currently exist in the firm. Internal boundary spanning is incorporating knowledge that exists in other divisions of the same company and external boundary spanning is using current existing knowledge to blend with that knowledge acquired from outside sources (Rosenkopf and Nerkar, 2001). Local and internal boundary spanning contributes to path-dependency where a firm's RandD activity is closely related to its previous RandD activity (March and Simon, 1958; Nelson and Winter, 1982; Helfat, 1994; Rosenkopf and Nerkar, 2001).

2.5.5. Necessary and Sufficient Conditions for Innovation

Many researchers have looked into what are the inputs required for innovation. Research by (Nohria and Gulati, 1996; Sharfman, Wolf, Chase, and Tansik, 1988; Voss, Sirdeshmukh, and Voss, 2008) point out that to have innovation, a company or person must have slack resources to pursue innovation. Slack is one of the primary necessities for innovation. Slack is resources of time, capital, or capacity that are in excess of that quantity needed for production of goods and services performed by the company(Nohria and Gulati, 1996; Sharfman, Wolf, Chase, and Tansik, 1988; Voss, Sirdeshmukh, and Voss, 2008).. Slack can be measured in percentage of utilization of machinery, ratio of annual sales to PPE, or days of inventory (Hendricks et al 2009).

There is contradiction on the role that slack plays in exploration innovation. Some research has shown a positive relationship (Nohria and Gulati, 1996; Singh, 1986; Kraatz and Zajac, 2001; Voss, Sirdeshmukh, and Voss, 2008) while other research has shown a negative relationship (Tan and Peng, 2003; Voss, Sirdeshmukh, and Voss, 2008). Slack financial resources can increase exploration due to financial freedom and a cushion against losses of unsuccessful exploration (Nohria and Gulati, 1996; O'Brien, 2003; Voss, Sirdeshmukh, and Voss, 2008) but the excess financial slack could be a signal of the company being risk adverse (Levinthal and March, 1993; Voss, Sirdeshmukh, and Voss, 2008). Slack resources are a necessary, but not sufficient condition. Slack resources must be met with the identification of a mismatch between current performance and expected performance or an identification of a current or future unmet market need.

Identification of market needs occurs during boundary spanning activities of a company. Boundary spanning occurs whenever there is interaction with customers, suppliers, or competitors. The boundary spanning activities can be formal and planned such as consumer or marketing research or they can be informal and spontaneous such as meeting people at conferences, impromptu contact with customers and suppliers, or even competitors.

Slack in Operations Management is often seen as the enemy of the efficient resource conversion. Lean manufacturing, JIT, and six sigma are all methodologies that seek to drive slack out of the system. Proponents of these methodologies push that in order to maximize the effect or sometimes even the success of implementing these programs, a corporate culture must shift and the whole organization must become committed to these philosophies.

If slack is a necessary condition for innovation, and lean, JIT, process improvement, and six sigma seek to drive slack out, do these philosophies limit innovation? It would actually depend on which innovation is looked at. Lean, six sigma, and JIT seek to reduce variability, produce higher quality products with fewer inputs. The methods utilized to implement each philosophy are very rigorous and investigates every part, process, and interaction to find ways to improve the current process.

2.5.6. Summary

Companies need both exploration and exploitation in the long-term. Exploitation following a successful exploration builds on the competencies gained and extracts value from the exploration (Gupta, Smith, and Shalley, 2006; O'Reilly and Tushman, 2008)

Innovation in highly competitive global markets requires companies to be able to learn even in the face of technological uncertainty. (Castellacci, Grodal, Mendonca, and Wibe, 2005). The natural tendency of a company experienced in one technology is to become fully integrated and either become locked in or to lose sight of new technological opportunities via a competency trap (Levitt and March, 1988) or learning myopia (Levinthal and March, 1993; Lee, Lee, and Lee, 2003).

It is important to point out that strategy only sets the stage of what the company wants to do and the necessary competencies need to be developed to develop those strategies (Rittera and Gemunden, 2004). As more companies use and accept a technology, its value grows (Shapiro and Varian 1999; Lee, Lee, and Lee, 2003) and this new technology becomes part of the deep structure of the industry.

The successful development and commercialization of innovative products depends on three factors (Luca and Atuahene-Gima, 2007). These factors were identified as “market knowledge (Atuahene-Gima 1995, 2005; Day 1994; Li and Calantone 1998), cross-functional collaboration (Griffin and Hauser 1996; Kahn and Mentzer 1998, Song and Parry 1997), and knowledge integration mechanisms (Madhavan and Grover 1998; Maltz and Kohli 2000; Ruekert and Walker 1987).” (Luca and Atuahene-Gima, 2007). These factors require separate structures and resources to allow for innovation. Operations strategy decisions as well as innovation strategy decisions affect each of these factors.

A broad knowledge base increases the opportunity of a company to identify new opportunities and recombine their resources to meet that opportunity (Kogut and Zander 1992). However, there is a point where have too wide of a knowledge breadth could limit the ability of the company to combine knowledge if it is too diverse (Galunic and Rodan 1998; DeLuca and Atuahene-Gima, 2007).

2.6 Organizational Learning

2.6.1. Internal Learning

Internal learning is the type of learning that happens inside the company or plant and builds knowledge that is unique to that company and is an important resource in RBV literature (Barney, 1991; Teece et al., 1997). Internal Learning includes cross training employees (Gerwin and Kolodny, 1992) and using employee feedback for process and product improvement (Hall, 1987). Good internal learning can create an adaptable organization (Gerwin and Kolodny, 1992).

Further, these practices are routine-changing routines suggestive of the path-dependent development of manufacturing processes (Nelson and Winter, 1982; March and Simon, 1958; Nelson and Winter, 1982; Helfat, 1994; Rosenkopf and Nerkar, 2001). The only real source of sustainable competitive advantage is internal learning (Prusak,1997; Schroeder, Bates, and Junttila, 2002) and includes “proprietary processes and equipment,” (Hayes and Wheelwright, 1984). Many operations management techniques improve the learning of an organization (Giffi, Roth, and Seal, 1990; Schonberger, 1996; Swink, Narasimhan, and Kim, 2005). The concept of learning curve is an internal learning methodology and creates and advantage for companies that are able to move down this curve faster than others (Yelle, 1979). The concept of absorptive capacity is another internal learning concept where a company’s ability to integrate new knowledge is related to past RandD (Cohen and Levinthal, 1990; Rosenkopf and Nerkar, 2001).

2.6.2. External Learning

External learning for a manufacturing company is accomplished through working with suppliers and customers to solve product problems (Schroeder, Bates, and Junttila, 2002). This external learning creates a non-imitable resource which is one of the key aspects of a resource in the RBV (Madhok and Tallman, 1998; Ward et al.,1995). Long-term relationships with suppliers and customers increase the external learning of a company (Gerwin, 1993; Schroeder, Bates, and Junttila, 2002). Many aspects of learning are affected by interaction of the company's structure, market orientation, and current competencies of the (Mahoney, 1995; Teece, 2007)). Also, there is a relationship between the type of learning (single-loop and double-loop learning (Argyris and Schön, 1978; Argyris and Schön, 1978; Lado, Boyd, Wright, and Kroll, 2006) and the type of innovation (Kraaijenbrink, Spender, and Groen, 2010). Single-loop learning enhances efficiency and resource exploitation, while double-loop learning enhances innovation and resource exploration (Kraaijenbrink, Spender, and Groen, 2010).

The type of innovation that the company will follow affects how the organization learns. Linkages between customers, suppliers, and internal groups will determine how well the organization can access and utilize knowledge inside the company. Exploration and exploitation have different requirements on the types of knowledge and rate of knowledge dissemination. Exploratory research requires more isolation and less linkage of the innovators to the rest of the company. If knowledge spreads too quickly, the creativity can be hampered and sub-optimal solutions are accepted without competing ideas.

Exploitative research requires intimate knowledge with current processes and products. Innovators learn from people involved the current process and develop iterative improvement often from direct input of customers and suppliers. This supports the idea that if you do not do your own manufacturing, you lose a large source of learning.

2.7 Operations Strategy

"Many of the exemplars of superior capabilities in the resource-based literature such as service excellence, innovation and rapid time-to-market cycles, are closely related to operations management," (McIvor, 2009). The study of manufacturing strategy as separate from corporate strategy began to come into focus in works like Skinner 1978, Hayes and Wheelwright 1984; Miller and Roth, 1994). Organizations seek to integrate the overall corporate strategy with the operations of the individual manufacturing facilities (Swink, Narasimhan, and Kim, 2005). How well this integration is achieved affects the profitability and long-term success of the firm (Ward and Duray, 2000).

There are two main elements to the operations strategy. First is what it must be able to do produce a competitive product such as efficiency goals, flexibility, costs and quality (Skinner, 1978; Giffi et al. 1990; Miller and Roth, 1994). The other is the set of decisions made to support manufacturing such a plant and equipment choices, vertical integration, quality procedures, etc. and these choices must match the product strategy (Hayes and Wheelwright 1984, Wheelwright 1984, Hayes et al. 1988, Hill 1989; Anderson et al. 1989, Buffa 1984, Cohen and Lee 1985, Fine and Hax 1985, Wheelwright 1978,1984,Hayes and Wheelwright 1984, Schroeder et al. 1986, Skinner 1969, 1978, 1985, Roth et al. 1989, Hill 1989, Roth and Miller 1990, Stobaugh and Telesio 1983, Swamidass and Newel1 1987; Miller and Roth, 1994)

The pattern of manufacturing choices that a company makes is one element of a manufacturing strategy (Hayes and Wheelwright 1984, Wheelwright 1984, Hayes et al. 1988, Hill 1989). Hayes and Wheelwright (1984) classify strategic manufacturing decisions as "bricks and mortar" decisions and infrastructure. "Bricks and mortar" decisions are decisions about facilities, technology, vertical integration, and capacity. Manufacturing infrastructure decisions relate to topics such as organization, quality management, workforce policies, and information systems architecture (Miller and Roth, 1994). "Achieving long-term success requires that firms possess not only the operational capabilities and competencies to compete in existing markets, but also the ability to recombine and reconfigure assets and organizational structures to adapt to emerging markets and technologies," (O'Reilly and Tushman, 2008). Therefore, manufacturing infrastructure decisions will be the focus of this paper and will be built primarily upon work done by (Swink, Narasimhan, and Kim, 2005) who looked at different operations strategies and (Benner and Tushman, 2003) who looked at innovation effects of process improvements methodologies and developed the research model that will be utilized for testing hypotheses.

Swink, Narasimhan, and Kim, (2005) focus on five major manufacturing practices: workforce development, process quality management, just-in-time (JIT) flow, supplier relationship management, and product-process development. Workforce development practices are improves workers' abilities through enhance worker control over their work and cross training (Giffi, Roth, and Seal, 1990; Schonberger, 1996). Process quality management practices make use of associated tools to promote the continuous improvement of process capabilities. Just-in-time flow practices have the primary goal of eliminating wastes such as unnecessary movement, work-in-process inventories, and queuing (Sugimori, Kusunoki, Cho, and Uchikawa, 1977). Supplier relationship management practices move the company from arms length transactions toward partnerships promote closer involvement with fewer, select suppliers by establishing long-term relationships, information sharing systems, certification and training, and joint investments (Kinni, 1997). These partnerships allow for more learning through problem solving with customers and suppliers and have been called external learning (Schroeder, Bates, and Junttila, 2002). One of the big advantages from a RBV and competitive advantage point of view is that relationships with customers and suppliers create tacit knowledge that is not easy to duplicate (Madhok and Tallman, 1998; Ward et al., 1995; Gerwin, 1993; Schroeder, Bates, and Junttila, 2002). Product process development practices facilitate collaboration between product and process designers as they seek to make the most effective use of manufacturing technologies (Swink, Narasimhan, and Kim, 2005). Figure 2-3 from Danneels, 2002, separates the knowledge necessary for new product development into Technological Competence and Customer Competence. Both of these knowledge streams are critical to the success of new products and as discussed previously, these competencies are affected by operations structure.

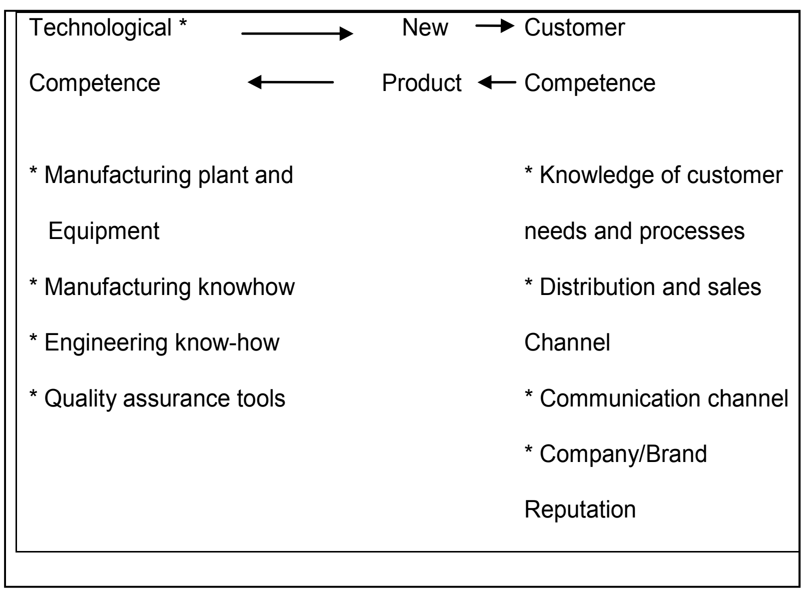

Figure 2-3 Technology and Customer Competencies (Danneels, 2002)

2.8 Process Management Effects on Innovation

Abernathy (1978) observed in the automobile industry that a firm's efficiency and productivity improvement efforts led to a decline in financial performance and he proposed that a company's ability to maintain financial success was related to both the efficiency improvement as well as innovation, (Abernathy, 1978: 173; Hayes and Abernathy, 1980) (Teece, Pisano, and Shuen, 1997; Benner and Tushman, 2003). What Abernathy (1978) saw would be the beginnings of the exploration and exploitation ideas presented by March (1991). Despite the observations of Abernathy, theory by March, and countless anecdotal evidence of the potential long-term damage to the firm, process improvement and process management movements took hold and thrived. On the manufacturing floor, process management and Japanese production concepts had success improving efficiency and reducing costs. As the success, support, and following of these methods grew, governments and customers started contractually requiring that process management programs be implemented (Harrington and Mathers, 1997; Westphal, Gulati, and Shortell, 1997; Benner and Tushman, 2003). The success on the factory floor led it to implementation in other areas of the firm (Brown and Duguid, 2000; Sitkin and Stickel, 1996; Benner and Tushman, 2003). Some firms are moving process management programs into RandD and product development groups. As this occurs, the "variation-decreasing and efficiency-oriented focus" can degrade the dynamic capabilities and core competences, (Benner and Tushman, 2003). This relates directly to the punctuated equilibrium concept of deep structure. As stated previously in this paper, deep structure is the part of the system that causes companies, people and processes to follow the norms set by the group and increases the inertia of the firm. The stronger the deep structures grow, the harder it is to overcome inertia, perceive new threats and opportunities, and change course once issues are identified. The spread of process management typifies the entrenchment of this deep structure.

Advocates of process management promote process management practices as "universally beneficial for organizations, spurring continuous innovation that results in efficiency improvements, cost reductions, improved customer satisfaction, and, ultimately, higher profits," (Benner and Tushman, 2003; Hammer and Stanton, 1999; Harry and Schroeder, 2000; ISO, 1999). Naturally with the focus on the financial benefits of process management by the advocates of the various methodologies, empirical research has been limited to assessing the financial performance implications from process management adoption and the results have been mixed (e.g., Ittner and Larcker, 1997; Powell, 1995; Samson and Terziovski, 1999; Benner and Tushman, 2003).

"Process management entails three main practices: mapping processes, improving processes, and adhering to the improved processes," (Benner and Tushman, 2003) and involves both individual work processes and the hand offs between individuals and functions (Garvin, 1995; Harry and Schroeder, 2000). The programs (especially ISO programs) demand following the mapped processes so that the organization can gain the cost and quality improvements and auditing is often part of the program, (Hackman and Wageman, 1995; Harrington and Mathers, 1997; Mukherjee, Lapré, and Van Wassenhove, 1998; Cole, 1998; Harrington and Mathers, 1997; Harry and Schroeder, 2000; Benner and Tushman, 2003).

The process management methodologies encourage exploitation along the current technological trajectory and current customers but the focus on reducing variation retards exploration and limits response to new customers and markets (Henderson et al., 1998; Sterman, Repenning, and Kofman, 1997; Benner and Tushman, 2003). Process management determines resource allocation and which projects get supported, (Christensen and Bower, 1996). The implementation of process management techniques requires process mapping where tacit knowledge is codified and improvement of the current process and this deep investigation inspires incremental (exploitation) innovation, (Winter, 1994; Brown and Duguid, 1991;Repenning, 1999; Anderson et al., 1994; Harry and Schroeder, 2000; Benner and Tushman, 2003).   Process management techniques also improve internal communication and affect the types of technological changes that are recognized and addressed, (Henderson and Clark, 1990; Benner and Tushman, 2003). From literature on innovation and learning , the more easily information flows between members of a firm or network, the faster the search process ends and limits the variation and experimentation.

Process improvement methodologies are typically carried out at lower levels of the organization. Employees at lower organizational levels have less access to the overall strategic plans and have limited boundary-spanning roles since the contacts at this level would be with current customers and suppliers. Spatial myopia develops where innovation begins to occur only near the innovator in terms of psychometric distance, (Levinthal and March, 1993). This is a result of the data available on the processes being improved are by nature those that are existing processes with existing customers and suppliers (Benner and Tushman, 2003).

From the literature on exploration discussed earlier, variation and slack are required for exploration. Process management seeks to limit variation and slack in the system, (Benner and Tushman, 2003). Also at work are the concepts of temporal learning myopia and learning traps, (Levinthal and March, 1993). Temporal learning myopia is the focus on short-term goals and in turn an innovator loses sight of the long-term goals. Learning traps are self-reinforcing loops where the rapid positive feedback encourages more of the same and in process management that would be exploitative research.

Boundary spanning activities are important for the company to spot new opportunities and threats. Process management drives the focus to existing processes and readily available data and those are related to existing customers. The learning traps and deep structure of the firm encourage building on successes and may limit the firm's willingness to take risk or discount opportunities where the data is not available for analysis.

The ambidextrous organization is a firm level decision that attempts to create structure that allows both exploration and exploitation by isolating the exploration RandD groups from the exploitative current production groups. The ambidextrous organization literature points to structures that limit the contact and management of both groups and allows the exploratory group to have variation and slack. Companies that seek to adopt process improvement methodologies should insulate the exploratory groups from those that will be improving current processes.

The punctuated equilibrium model explains the two phase that an industry can be in. The equilibrium phase is where the deep structure is stable and the revolutionary phase is where the structures are drastically changed. In order to gain competitive advantages in the equilibrium phase, companies introduce incremental changes to set them apart from their competitors. Companies build on their successes and refine their product offerings and technology to meet customer needs more efficiently. Companies in this phase seek to reduce costs while maintaining or improving customer satisfaction and service levels.

During the equilibrium phase of the market, customer demands are not varying dramatically and focus groups with customers get their inputs on current product offerings. Exploitative innovations can move the products and processes along to provide more value to the customer.

The revolution phase in the punctuated equilibrium model is a phase where the deep structure of the market is fundamentally changed. Rules that were followed in the previous equilibrium phase are no longer valid. Structures and processes that were created to maximize performance in the prior equilibrium period are either ineffective or impede work now needed. Process management strengthens the deep structure of a firm and an industry. The deep structure will be very resistant to change and will try to revert to the previous state, which is no longer feasible. The process management techniques seek to confine and refine processes and reduce variation. Before the new end state is settled by the market and new deep structure is established, processes cannot be formalized else they will continue to have a mismatch between processes and the needs of the environment.

Product innovation (both exploratory and exploitative) is enhanced by market knowledge, cross-function collaboration, and knowledge integration (Atuahene-Gima 1995, 2005; Day 1994; Li and Calantone, 1998; Griffin and Hauser 1996 Madhavan and Grover 1998; Maltz and Kohli 2000; Ruekert and Walker 1987; DeLuca and Atuahene-Gima, 2007). The ability to recognize opportunities is enabled by having a broad knowledge base (Kogut and Zander 1992). When the knowledge area is too broad, it can be difficult to make connections and have the knowledge transferred inside the company Galunic and Rodan 1998). If the company has a limited knowledge base, the knowledge can be spread more easily and built upon (DeLuca and Atuahene-Gima, 2007).

The ability for a firm to survive long-term hinges on many different aspects that have been touched upon so far in this dissertation. The company must be able to spot opportunities and threats in the environment through boundary spanning activities, continue to produce new products that customers value through product innovation, have access to or develop resources and competitive advantages that allow the company to compete in its current environment, and have the flexibility to adapt operations after periods of revolution.

The supplier relationships discussed by (Swink, Narasimhan, and Kim, 2005) can have a big impact on the innovation of a firm. Boundary spanning activities are important to identifying environmental risks and opportunities. The amount of vertical integration and the amount of cooperation and trust in the supply chain would impact the knowledge that the firm can get about the environment. Companies that are more vertically integrated would have fewer opportunities to interact with suppliers and competitors than a company that is more core competency and market focused. Contact with suppliers and customers at arm’s length provides some information on market needs and disruption, however more integration and trust of the supply chain allows for more learning in the company and improves the chances that needs for innovation are identified. Once suppliers sign cooperation agreements and alliances, information on opportunities in the market, opportunities for improvement, and knowledge sharing will begin to increase. This increase in knowledge sharing allows for greater sensitivity to inputs in the market. The power and control of the vertically integrated companies would allow for more exploitative innovation as the opportunities for the company to implement process management processes over the whole value chain.

2.9 Fit

Fit is a multi-dimensional construct that has received much attention in the strategy literature (Zajac, Kraatz, and Bresser, 2000). Fit tries to measure how well a company’s various functions work together to support the overall decisions by upper management and the firm's interaction with the business environment. Strategic fit is at the core of strategy implementation and strategic fit typically results in better performance (Ginsberg and Venkatraman, 1985; Miles and Snow, 1994; Zajac, Kraatz, and Bresser, 2000) but what exactly is fit?

"The strength of the strategic fit is conceptualized as the degree of adherence for a specific unit of analysis with a multidimensional, ideal profile," (Smith and Reece, 1999). The concept of fit is in the line of theory such as strategy and organization theory (Ginsberg and Venkatraman, 1985; Zander and Kogut, 1995).

Two general themes that strategy researchers use to classify their research are formulation and implementation; formulation looks to align the strategy to external variables and implementation looks to align the internal variables (Venkatraman and Camillus, 1984). Examples of external variables are product life cycles and competitiveness for market opportunities (Chandler, 1962; Hofer, 1975; Hedley, 1977; Henderson, 1979; Venkatraman and Camillus, 1984). Internal variables are things such as management systems and structure, and corporate culture (Chandler, 1962; Galbraith and Nathanson, 1979; King, 1978; Lorange and Vancil, 1977;Schwartz and Davis, 1981; Stonich, 1982; Venkatraman and Camillus, 1984).

1: Strategy Formulation School **Theme:** Aligning strategy with the environmental conditions **Contributing Streams:** IO-strategy interface Business policy/strategic management	**4: Interorganizational Networks School** **Theme:** Strategy analysis at the "collective" level, emphasizing interdependence of strategies of various organizations vying for resource allocation **Contributing Streams:** Interorganizational networks Resource-dependency Constituency analysis
2: Strategy Implementation School **Theme:** Tailoring administrative and organizational mechanisms in line with strategy **Contributing Streams:** Business Policy Normative strategy literature	**5: Strategic Choice School** **Theme:** Managerial discretion moderating the "deterministic" view regarding decisions on organizational mechanisms **Contributing Streams:** Contemporary organization theory Business policy-organization theory interface
3: Integrated Formulation-Implementation School **Theme:** Strategic management involving both formulation and implementation and covering both organizational and environmental decisions **Contributing Streams:** Business policy/strategic management Markets and hierarchies	**6: Overarching "Gestalt" School** **Theme:** Broadly configuring organization and environment, emphasizing interdependence but not causation **Contributing Streams:** Organizational theory Business policy / strategic management Population ecology-based concepts

Figure 2-4 Internal / External Focus (Venkatraman and Camillus, 1984) pg 516.

Venkatraman and Camillus (1984) (above in Figure 2-4) define the six cells depending on their internal or external focus and if the fit is from the content of strategy or the process of developing strategy. Cells 1 and 2 are pure focus on either external or external variables. Cell 3 is a combination of Cells 1 and 2. Cell 4 looks at strategy beyond the company and into the firm as part of a network or supply chain. “Cell 5 focuses on the pattern of coordination or interactions among internal elements such as struc¬ture, size, and technology,” (Venkatraman and Camillus, 1984). Cell 6 is involved with a holistic view of strategy.

St. John, Cannon and Pouder (2001) looked into the elements of strategy from the point of view of operations and identified two strategic elements of fit and these were the fit between production and organizational environment and the fit between production and strategy of the company (St. John, Cannon, and Pouder, 2001).

Apart from the items that you are looking to fit with strategy, the time frame is also important to consider to determine if the fit is looked at a single point in time (static) or changing over time (dynamic) (Venkatraman and Camillus, 1984). The concept of the dynamic and static fit is similar to the debate in the RBV. In early RBV literature, resources were treated as static and later developed into dynamic resources. This also occurs in the fit literature. Zajac, Kraatz, and Bresser (2000) look at the changes of fit over time based on changes in the environment, the ability of a company to identify changes, and the reaction to the changes. The authors developed four possibilities for this dynamic fit. “Beneficial strategic change” is a positive dynamic fit is when a company identifies the need and changes appropriately. “Insufficient strategic change” is a negative dynamic misfit is that a company identifies the need to change, but does not react appropriately. “Beneficial inertia” occurs when a company already has good fit and external changes do not require changes by the company. Lastly, “excessive change” is a negative misfit that causes the company to make large changes when they are not really required (Zajac, Kraatz, and Bresser, 2000).

The fit between the organization’s strategy, structure and operations has been addressed in literature and the fit between strategy and structure has a positive impact on a company’s performance (da Silveira, 2005; Devaraj et al., 2004; Tarigan, 2005; Kroes and Ghosh, 2010). The operations strategy should be aligned with company strategy for optimal performance (Skinner, 1969; Bozarth and McDermott, 1998; Frohlich and Dixon, 2001; Narasimhan and Carter, 1998; Safizadeh et al., 1996).

Poor performers have shown to have poor fit (Skinner, 1969, Hill, 1994; Ward and Duray, 2000), and lack of strategic alignment is related to lower market share (da Silveira, 2005; Kroes and Ghosh, 2010) while companies that have alignment between general managers and manufacturing managers have higher performance Tarigan (2005). Quality in manufacturing strategy mediates the differentiation strategy (Ward and Duray, 2000). Performance improvements from strategies are implemented in manufacturing strategy and there is a relationship between environment, performance and manufacturing (Miller and Roth, 1994; Hayes and Pisano, 1996; Devaraj et al., 2004; Ward and Duray, 2000).

Strategic initiatives should drive organizational structure (Donaldson, 1998; Nadler and Tushman, 1997; Tushman, Smith, Wood, Westerman, and O'Reilly, 2002) and must fit the environmental conditions (Lawrence and Lorsch, 1967; (Hannan and Freeman, 1989; Gresov, 1989; Chandler, 1990; Tushman, Smith, Wood, Westerman, and O'Reilly, 2002). This fit, however, can create inertia (Sorensen, 2002; Tushman and Romanelli, 1985). When the environment shifts, the company can have difficulties adapting and could fail via punctuated equilibrium model (Miller, 1994; Romanelli and Tushman, 1994; Rosenbloom, 2000; Siggelkow, 2001; Tushman, Smith, Wood, Westerman, and O'Reilly, 2002).

2.10 Surviving a Changing Environment

Companies are not closed systems that produce everything that it needs. A company must interact with its environment. “Organizations depend on environments for resources—labour, capital, technology, demand for outputs—needed for survival,” (St. John, Cannon, and Pouder, 2001). There exists a link between strategy and the environment and manufacturing often has to react to threats and opportunity (A.R.Cannon and John, 2001). The term environment includes both the macroeconomic environment and the microeconomic environment of the industry. Companies must compete for these resources in the open market in various market conditions. Recessions reduce the demand for products and reduce the availability of capital to a company. During times of economic growth, there is more competition for materials and labor. The company’s location also has an impact on the availability of resources and is an important factor in the environmental analysis.

Porter’s Five Forces (Porter, 1980) model has been a standard method for analyzing the competitiveness of the industry. The major components of the environmental analysis are the power relationships between the company and its suppliers and customers, the threats of new entrants, and threats of substitute products.

Once the environment starts to change either gradually or via punctuated equilibrium how does a company react? Organizational ecology suggests that most companies cannot change and will fail from their own momentum (Amburgey, Kelly and Barnett, 1993; Audia, Locke and Smith, 2000; Hannan and Carroll, 1992; O'Reilly and Tushman, 2008). Some companies can survive through either ambidexterity or dynamic capabilities (O'Reilly and Tushman, 2008).

A company must be able to spot opportunity and threats and this is accomplished through scanning and exploration (O'Reilly and Tushman, 2008). The company must be able to react to these changes by reallocating resources and changing the structure and operations of the company (Teece, 2006), (O'Reilly and Tushman, 2008). Often, companies will try to reduce its risk and uncertainty by saving on research costs and imitate companies within the industry by copying its processes and products which is labeled as mimetic isomorphism, (Cyert and March, 1963; Haveman, 1993; St. John, Cannon, and Pouder, 2001).

A company has two types of risk, industry risk and company specific risk measured by the financial variable β (beta) (Carhart, 1997; Fama and French, 1993). All companies in an industry faces the same industry risk and it is difficult if not impossible to insulate itself from the risk except for deciding to compete in a different industry. The company specific risk is related to the decision it makes and is mostly under the control of management. The firm β affects the ability to get financing, investment, and competitiveness of the company. This β ultimately affects a company's ability to survive over the long term. The level of exploration-exploitation, operation decisions, and structure are critical decisions made and all affect the risks of the company.

2.11 How Networks Help Innovation

This dissertation will focus on the individual company in the medical device industry and the resources available in-house. It cannot be ignored that modern companies do not act as a lone wolf and are actually part of some supply chain and network. Competition is no longer firm vs. firm, but now supply chain vs. supply chain (Ketchen and Hult, 2007). This topic of network aspects will be briefly touched on, but this is for only completeness of research and to act as a jump point for the next stage of research, which would be to analyze a company's supply chain and innovation network.

The structure of the network of researchers plays a large role in how exploratory or exploitive the industry is. Highly innovative industries would have random connectivity and exploitative industries would have higher connectivity (Lazer and Friedman, 2007). Isolation of research groups is encouraged for parallel development of technology. The lower connectivity prevents the rapid spread of knowledge. The slower that innovation spreads, the better it is for creativity. If knowledge is spread rapidly, the search for solutions will stop sooner and the chances of a suboptimal solution are increased.

For less established and smaller firms, the network connections it has is more important that larger firms with more in-house resources (Baum, Calabrese and Silverman, 2000; Shan, Walker and Kogut, 1994; Stuart, 2000). Companies that are more innovative cooperate more in the network and have more centrality (Castellacci, Grodal, Mendonca, and Wibe, 2005). The company's location in the network determines the structural holes that it can see (Frankort, 2008; Brass, Galaskiewicz, Greve, and Tsai, 2004).

Chapter 3

Model

To highlight the literature review, innovation is a critical component of the economic and company success. Innovation is loosely defined as "doing new things that customers ultimately appreciate and value," (Cash, Earl, and Morison, 2008). From early work of March (1991), innovation was broken into two major categories called Exploration and Exploitation. March believed these are two distinctly separate ideas and were mutually exclusive paths for innovation. Exploration is the quest for new knowledge that is not based on pre-existing knowledge available inside the firm or industry and this knowledge results in radical, game-changing, disruptive technologies that change the trajectory of technology development in an industry and opens new product markets (Benner and Tushman, 2003; He and Wong 2004).

Exploitation is the application, refinement, optimization, and improvement of existing products and knowledge (March 1991) and continues the existing trajectory of (Benner and Tushman, 2003; He and Wong 2004). Through research and anecdotal evidence, some companies do appear to do both at the same time. A new concept of ambidexterity was devised to describe the existence of the two mutually exclusive innovation types occurring in the same company. Ambidexterity can occur through either asynchronous models where the company does one and then switches to the other or it can structurally modify its research so that the company can have both occurring at the same time, but in different parts of the company (Gupta, Smith, and Shalley, 2006).

Operations management is important because in our area is where resources are turned into products and services. Operations strategy balances efficiency, flexibility, capital budgeting, and risk. The study of manufacturing strategy as separate from corporate strategy began to come into focus in works like Skinner 1978, Hayes and

Wheelwright 1984; Miller and Roth, 1994) Organizations seek to integrate the overall corporate strategy with the operations of the individual manufacturing facilities (Swink, Narasimhan, and Kim, 2005). How well this integration is achieved affects the profitability and long-term success of the firm (Ward and Duray, 2000).

Poor performers have shown to have poor fit (Skinner, 1969, Hill, 1994; Ward and Duray, 2000), and lack of strategic alignment is related to lower market share (da Silveira, 2005; Kroes and Ghosh, 2010) while companies that have alignment between general managers and manufacturing managers have higher performance Tarigan (2005). Stock and Tatikonda (2008) developed a model for fit between technology uncertainty and inter organizational interaction in Figure 3-1 where the fit between the two predicted the effectiveness of the organization to integrate new technology.

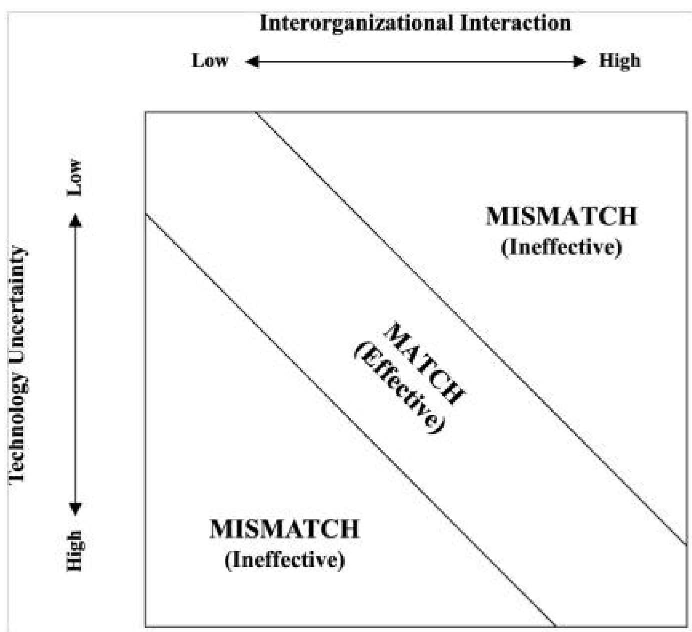

Figure 3-1 Model of Fit (Stock and Tatikonda, 2008)

This model has been adapted to the relationship between the innovation strategy and operations strategy. Figure 3-2 below shows the concept for the pure research models where a company predominantly follows one type of innovation or another and is profitable only where the strategies fit.

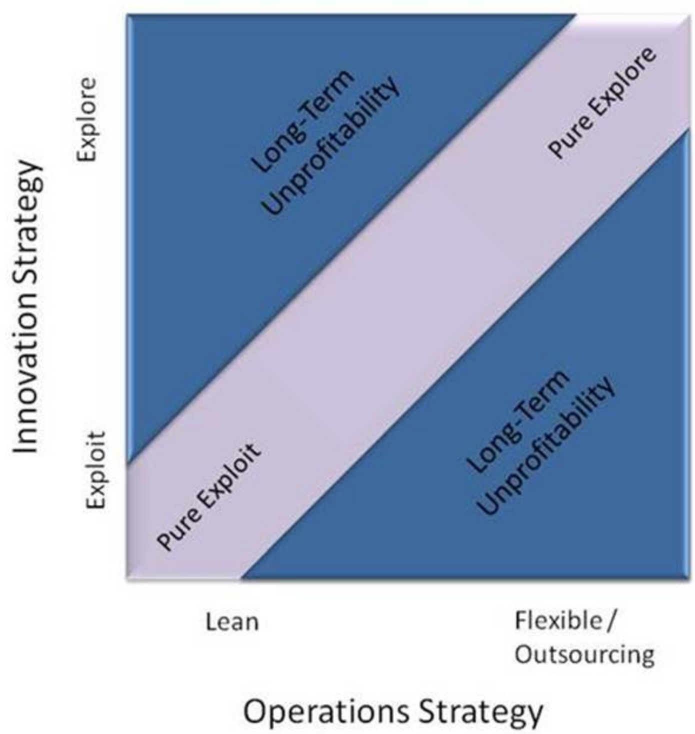

Figure 3-2 Operations Strategy Model

Following the literature and research model shown about that the fit between the corporate strategy and operations strategy has a positive effect, it is proposed that a similar relationship between innovation strategy and operations strategy exists.

H1: Companies with better fit between operations strategy and innovation strategy will have better performance.

Although having a great fit between the operations strategy and innovation strategy is a good indicator of a company's success, its resources can moderate this success. If the company does not have sufficient resources to carry on as a company or maintain operations, it cannot compete long term and will not be able to make profits. The concept of resources comes from the Resource Based View (RBV) of the firm is a theory of the firm that seeks to match the strategy of the organization to its internal resources (Grant R. M., 1991).

The RBV assumes firms are profit-maximizing entities directed by bounded rational managers in markets that are to a reasonable extent predictable and moving towards equilibrium (Bromiley and Papenhausen, 2003; Leiblein, 2003; Kraaijenbrink, Spender, and Groen, 2010; Rugman and Verbeke, 2002). The Resource Based View seeks to explain the competitive advantages of the company by looking at the resources a company has and how it uses them and that resources are heterogeneous across companies (Barney, 1991; Grant 1991; Schroeder, Bates, and Junttila, 2002; Knott, Bryce, and Posen, 2003; Rugman 2002). Resources that firms have are different and the differences can persist long-term, despite the system's attempt to reach equilibrium (Barney, 1991; Rumelt, 1984; Wernerfelt, 1984; Chuang, 2004). There are six major categories of resources upon which capabilities are made. These are classified as financial, physical, human, technological, reputation, and organizational (Grant R. M., 1991).

The resource-based model is fundamentally concerned with the internal accumulation of assets, with asset specificity, and, less directly, with transactions costs" (Peteraf, 1993). The competitive advantages of companies are not static and can change over time (Helfat, Peteraf 2003).

Linking the RBV to exploitation and exploration can be seen on the inputs to the barriers to entry, cost advantage and differentiation advantage. Patents leading to barriers to entry and technology linked to product differentiation advantage would be results of exploration.

Therefore, a company's resources affect how well the company can take advantage of its fit between innovation and operations strategy.

H2: The resources a company has will positively moderate the difference in profitability of companies with good fit between operations strategy and innovation strategy.

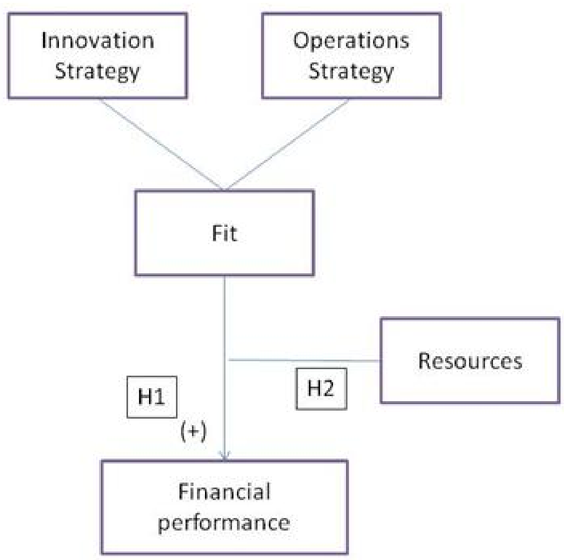

Figure 3-3 Model for H1 and H2

Figure 3-3 graphically shows the relationships between Innovation and Operations Strategies into the concept of Fit. H1 examines the relationship between Fit and Financial Performance. H2 introduces resources as a moderating variable.

What is good in the long run is not always good in the short run," (March, 1991) Established companies must continue to invest in RandD to maintain or increase its status and competitiveness in the market (Cesaroni, Minin, and Piccaluga, 2005). Companies must stay up to date on the current state of the art of their industries and maintain collaborative relationships with partners (Cesaroni, Minin, and Piccaluga, 2005) The focus on exploitation will eventually lead to technological decline in competitive markets, (Lee and Ryu, 2002; Lee, Lee, and Lee, 2003). While both types of innovation are needed in the long-term, there are competing demands of each and a company often moves towards exploitation since the positive feedback is often stronger (Benner and Tushman, 2002; Gupta, Smith and Shalley, 2006; Henderson and Clark, 1990; Levinthal and March, 1993; March, 2003; O'Reilly and Tushman, 2008).

"Ambidexterity refers to the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either exploration or exploitation," (Gupta, Smith, and Shalley, 2006). The ambidexterity of the firm is not feasible at the group level due to the difference in expected outcome of tasks in exploration and exploitation, but can exist when the groups are separated (Gupta, Smith, and Shalley, 2006). Ambidextrous organizations have high level of differentiation with dedicated management and groups focused on each form of innovation with reporting structures that go to senior management, low integration and contact between groups, and top management support for both exploration and exploitation (Tushman, Smith, Wood, Westerman, and O'Reilly, 2002). Ebben and Johnson (2005) conducted a study of 300 small companies and found they did better when following a single strategy of either flexibility of efficiency instead of trying to do both.

Research has identified three main reasons why a company would not be able to do both effectively at the same time. March, (1991) said that pursuit of one makes you naturally do less of the other. Firms that try to do both have to select which to give more resources to and lack focus (Miller and Friesen, 1986). And finally, it should match its strategy to the business environment (Galbraith, 1973; Lawrence and Lorsch, 1967; Kyriakopoulos and Moorman, 2004). More recently, research has shown that there is a middle ground between the Exploiters and Explorers. The group that occupies the middle ground is called ambidextrous organizations (Gupta, Smith, and Shalley, 2006). While there is some variations in definitions of exploration and exploitation (Nerkar, 2001; Vassolo, Anand, and Folta, 2004; Vermeulen and Barkema, 2001, Rosenkopf and Nerkar's, 2001; Benner and Tushman, 2003), the definitions below will be used for this paper. Exploitation innovation is focused on efficiency, productivity, and variance reduction while exploration is about wide search, new discovery, and embracing variation (O'Reilly and Tushman, 2008). Ambidexterity is about doing both (Duncan, 1976; Tushman and O'Reilly, 1997; O'Reilly and Tushman, 2008)

H3: Companies with higher ambidexterity will have better performance.

This hypothesis is graphically represented in figure 3-4 demonstrating the relationships between variables in H3.

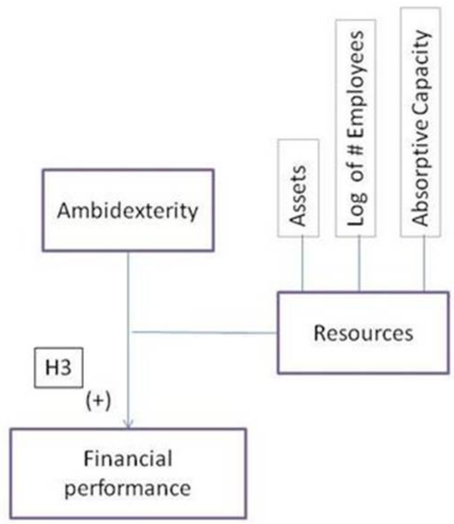

Figure 3-4 Model for H3

Chapter 4

Analysis / Methodology

4.1 Industry and Company Selection

The industry of focus for this dissertation will be the medical device industry. One aspect of the medical device industry that lends itself well to using patent data is that every device used on a human must have FDA approval. This approval process is lengthy and public. The public aspect of the application process is a strong incentive for companies to patent their innovation. Some other industries may use secrecy to protect their innovation from competitors, but that is not possible in medical devices. Another benefit of the medical device industry is the large number of publicly traded companies with easily accessible financial data over a long timeframe to cover multiple economic cycles.

4.2 Data Sources

The analysis presented in this dissertation builds off of the research using patents as a measure of knowledge (Dutta and Weiss, 1997; Henderson and Cockburn, 1994, Jaffe, Trajtenberg and Henderson, 1993, Engelsmann and van Raan, 1994, Albert, Avery, Narin, and McAllister, 1991; Narin, Noma, and Perry, 1987; Rosenkopf and Nerkar, 2001). The patent data for this dissertation will come from secondary sources of data that are readily available to the research community. Data for patents are from the National Bureau of Economic Research (NBER) database of patents approved by United States Patent and Trade Mark Office (USPTO) between 1963 to 1999 (Hall, Jaffe, and Trajtenberg, 2001) and from the updated files from the updated patent data project which included patents awarded until 2006 (Hall B. H., 2010). The data in the updated files also fix many of the problems associated with the original database. Among other improvements, the researchers standardized the assignee data and eliminated many of the spelling discrepancies in the assignee names. The update project also included the CUSIP number for referencing the assignee in the North American Compustat database. One problem for the new data files is that it did not include the calculated variables such as Originality and Generality. These were included in the 1963-1999 data files but not in the 1976-2006 data. The data is critical to the hypotheses of this paper, so a new dataset was created that matched the patents, assignees, and CUSIP numbers of the 1976-2006 data with the original data of the 1963-1999 dataset to create a more complete dataset for 1963-1999. The dataset was also limited to sub group 32 (medical devices) and limited to data entries with non-blank entries for CUSIP number and Originality. The resulting dataset contains 11,310 separate patents assigned to 354 unique firms.

Song et. al. found through a meta-analysis that supply chain integration and patent protection were significant factors in success of new technology ventures (Song, Podonitsyna, Bij, and Halman, 2008). Patent data have been used to investigate innovation. (Almeida, 1996; Rosenkopf and Nerkar, 2001; Ahuja and Lahiri 2006; Trajtenberg, Henderson, and Jeffe, 1997). The USPTO requires patent applicants to provide citations to other patents that were used in development of the idea being patented, name of researchers, assignees, and industry codes. The citations and industry codes will be used in the analysis and classification of exploration and exploitation innovation. Financial and securities information for public companies will be obtained from the COMPUSTAT database. These data will be used to test the hypotheses for profitability and long-term competitive advantage. Although there are some limitations using secondary sources of financial and operational data, this data is appropriate because the data is not readily accessible from other sources and will be used from public companies in the same industry and therefore subject to the same accounting and reporting rules (Venkatraman and Ramanujam, 1986).

4.3 Variables

4.3.1 Innovation

An effective measure of innovation is patent data (Dutta and Weiss, 1997; Henderson and Cockburn, 1994, Jaffe, Trajtenberg and Henderson, 1993, Engelsmann and van Raan, 1994, Albert, Avery, Narin, and McAllister, 1991; Narin, Noma, and Perry, 1987; Rosenkopf and Nerkar, 2001; Ahuja and Lahiri 2006; Ahuja, 2000; Silverman, 1999; McGrath and Nerkar, 2004).

For this dissertation, each patent will be classified as exploratory and exploitative based on if the innovation is based upon knowledge familiar inside the company. This is a simplification of both the Daneels and Rosenkopf and Nerkar models (Danneels, 2002; Rosenkopf and Nerkar, 2001). While their models further delineate the breakdown of innovation, the root of the innovation is if the innovation is based on existing knowledge within the firm. For this, the measure will be if the patent is related to work previously patented by the firm. This classification is included in the NBER database as the self citation variable (Trajtenberg, Henderson, and Jeffe, 1997; Hall, Jaffe, and Trajtenberg, 2001) and used to measure innovativeness (Palomeras, 2007; Yang, 2010). The higher the self citation measure is, the higher the exploitation of knowledge inside the company.

The exploration of the company is measured by the originality of the patents. The variable originality is a measure of the breadth of use of knowledge outside the patent class. The ratio is the patent citations from outside the patent class compared to the total reference patents. The higher the originality variable equates to a broader the base of knowledge that the patent references (Trajtenberg, Henderson, and Jeffe, 1997). So the higher the originality variable is, the higher the exploration of the patent.

Ambidexterity is theoretically modeled as how the company is able to do both exploration and exploitation at the same time. For this dissertation, the measure of ambidexterity will be the product of the variables self citation and originality.

4.3.2 Value

Valuation of the firm has been measured in multiple ways in literature from finance, management, marketing and operations. Traditional financial metrics and ratios used to measure performance include Return on Equity (ROE) is a common measurement of firm performance in strategic management journals due to its ease of use and that it eliminates the need for controlling for firm size (Tothaermel and Alexandre, 2009), return on assets, return on sales and cash flow margin are also common (Fullerton, McWatters, and Fawson, 2003; Cron, Sobol, 1983; Hitt, Brynjolfsson, 1996; Strassman, 1990; Weill, 1992; Bharadwaj, 2000) and sales growth rate, (Bierly and Chakrabarti, 1996; Katila and Ahuja, 2002; Rosenkopf and Nerkar, 2001; McGrath, 2001; He and Wong, 2004)

Tobin's Q is used to measure the company's value over time (Uotila, Maula, Keil, and A.Zahra, 2009; Modi and Mishra, 2011). "Market value based measures such as Tobin's Q have the advantage of capturing short-term performance and long-term prospects (Lubatkin and Shrieves, 1986; Allen, 1993), allowing us to operationalize both short- and long-term performance effects using a single performance variable," (Uotila, Maula, Keil, and A.Zahra, 2009).

For this dissertation, I will be using the approximated Tobin's Q as presented in Chung

approximate q = (MVE + PS + DEBT) / TA

where MVE is the total market value of outstanding stocks at calendar year end, PS is the value of preferred stock, DEBT is the net value of short-term debt minus short-term assets plus book value of long-term debt, and finally TA is the total assets at book value (Chung and Pruitt, 1994).

4.3.3 Resources

(Grant R. M., 1991) identified six categories of resources: financial resources (short term assests), physical resources (ppe), human resources (employees), technological resources (IT budget), reputation (goodwill), and organizational resources. (Grant R. M., 1991).

I will use the following measures for the resources a company has based on information available in the COMPUSTAT database:

Human Resources: number of employees (Ahuja and Katila, 2001)

Technical Resources: RandD intensity as a ratio of RandD spending/sales (Cohen and Levinthal, 1989, 1990; Tothaermel and Alexandre, 2009; Knott, Bryce, and Posen, 2003)

4.3.4 Efficiency

Again, there are many options to use to measure efficiency. One measure that is often used is the traditional ROA which is ROA = Revenue / Assets and the other is

Production Efficiency which is Sales / PPE (Modi and Mishra, 2011; Hendricks, Singal, and Zhang, 2009; Herold, Jayaraman, and Narayanaswamy, 2006; Bharadwaj, 2000) defined some more operational measures commonly used such as OI/A and OI/S Operating Income to assets or sales (McKeen and Smith 1993, 1996); OI/E - operating income to employees (Bharadwaj, 2000); and OEXP/s - operating expenses to sales (Bharadwaj, 2000); COGS/s - COGS to sales (Mitra and Chaya, 1996; Bharadwaj, 2000; Ferdows and De Meyer, 1990; Hayes and Wheelwright, 1984; Miller and Roth, 1994; Schroeder, Bates, and Junttila, 2002).

These ratios will be compared to industry averages, where the industry is defined by SIC code until 1997 and NAICS codes after 1997, to determine if the companies are above or below average efficiency. I believe there must be an additional segment carved out of this number for the companies that outsource operations. These firms would appear to be highly efficient since the limited PPE in the denominator would tend to send both Production Efficiency and ROA to very high levels. I again propose to initially use a quartile system of segmenting the data and then following up with a k means cluster analysis. Firms with Production Efficiency >.75 would be classified as highly efficient outsource; firms with ROA and Production Efficiency >.5 ≤ .75 be labeled as efficient; >.25 ≤ . 5 would be called inefficient; and finally they bottom quartile would be labeled as highly inefficient and likely companies in distress.

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4.3.5 Fit Variables

The main focus of this dissertation is the degree the degree to which the company matches their operations to the innovation strategy. These variables will be binary 0,1 variables where 1 is true and 0 is false. Since I am going to test the lower left, upper right, and diagonals for fit and performance, I need to construct three variables.

Fit-Exploit: This is for the quadrant that matches above average efficient operations with exploitative innovation. The variable will be 1 if the firm is Exploitative (Originality <.25) and if the firm is above average in efficiency. It will be 0 for all other combinations.

Fit-Explore: This is for the quadrant that matches below average efficiency with exploratory innovation. The variable will be 1 if the firm is Exploitative (Originality >.75) and if the firm is below average in efficiency. It will be 0 for all other combinations.

Fit-General: This is a general measure if the firm is following a strategy along the diagonal and will be 1 if it meets either Fit-Exploit, Fit-Explore, or if it is ambidextrous. Table 4-1 summarizes the variable definitions and relevant literature foundations.

Table 4-1 Variable Definition

Variable	Measure	Reference
Patent Count	General amount of innovation in a company	Dutta and Weiss, 1997; Henderson and Cockburn, 1994; Jaffe, Trajtenberg and Henderson, 1993; Engelsmann and van Raan, 1994; Albert, Avery, Narin, and McAllister, 1991; Narin, Noma, and Perry, 1987; Rosenkopf and Nerkar, 2001; Ahuja and Lahiri 2006.
Originality	Measure of patents reference count on outside patents and therefore a measure of exploration	Trajtenberg, Henderson, and Jeffe, 1997; Ahuja and Katila, 2001.
Self Citation	Measure of the company's reliance on internally created knowledge (patents) and is a measure of exploitation.	Trajtenberg, Henderson, and Jeffe, 1997;
Ambidexterity	Cross product of originality and self citation.	
ROE	Return on Equity	Fullerton, McWatters, and Fawson, 2003; Tothaermel and Alexandre, 2009.
ROA	Return on Assets	Fullerton, McWatters, and Fawson, 2003
Sales Growth Rate	% change in sales from year t-1 to year t	Bierly and Chakrabarti, 1996; Katila and Ahuja 2002; Rosenkopf and Nerkar 2001; McGrath, 2001; He and Wong, 2004.
Tobin's Q	Measure of short-term and long term performance based on stock price and book value	Uotila, Maula, Keil, and A.Zahra, 2009; Modi and Mishra, 2011; Lubatkin and Shrieves, 1986; Allen, 1993.
Human Resources	Number of employees	Ahuja and Katila, 2001
Technical Resources / Absorptive Capacity	RandD expenditures; RandD / Sales	Tothaermel and Alexandre, 2009; Parthasarthy and Hammond, 2002.
Efficiency	Sales / PPE	Modi and Mishra, 2011; Hendricks, Singal, and Zhang, 2009; Herold, Jayaraman, and Narayanaswamy, 2006.

Table 4.1 continued

OI/A and OI/S	Ratios of Operating Income to Assets or Sales	McKeen and Smith 1993, 1996; Bharadwaj, 2000.
OI/E	operating income to employees	Bharadwaj, 2000
OEXP/s	operating expenses to sales	Bharadwaj, 2000
COGS/s	COGS to sales	Mitra and Chaya 1996; Bharadwaj, 2000
Absorptive Capacity	RandD expenditures	Tothaermel and Alexandre, 2009
Beta	Firm specific risk	Fama French 1993, Carhart 1997

4.4 Analysis and Results

Three separate methodologies were utilized to test hypotheses. First, cluster analysis was used to let the data determine grouping and those groups were used for testing hypotheses. Second, theory and quartiles were used to divide the data for hypothesis testing. Finally, a regression analysis was used to test the relationships between variables.

4.4.1 Dataset Review

The data set used was created by combining data from CRSP and USPTO databases. The first step in the analysis was to look for problems in the data. Initial investigation shows that there were 1077 unique data points for companies issued patents between 1969 and 1999 in the medical device industry. This long time frame provides a rich source of data but can also cause issues of cross-sectional dependences in samples with timeframes > 20 years (Baltagi, 2001; Torres-Reyna, 2010).

Simple scatter plots for various pairs of variables are shown below to look for any anomalies in the data over time.

Scatter Plots

The scatter plot of originality vs efficiency (Figure 4-1) shows that there are two distinct groups that appear to be outliers. Once group that are questionable are the data points for companies that have 0 originality. The other group is the companies that have efficiency of 1. There is an unexpected gap between the majority of data with efficiency less than .6 and those with efficiency of 1. These will be looked at more in depth in the cluster analysis section.

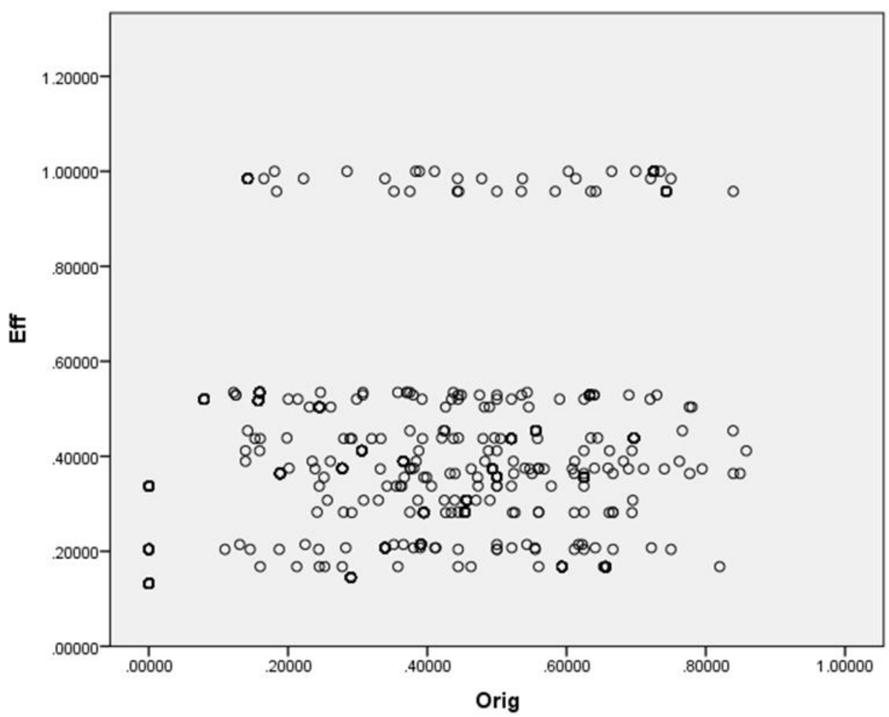

Figure 4-1 Efficiency vs. Originality

The two plots of revenue per company (Figure 4-2) and revenue per year (Figure 4-3) shows that the companies follow similar functional forms but one company follows a extreme version of that form. The company will be included in the dataset, but after hypotheses are tested, this company will be examined to see if it has an effect on the hypotheses and the individual companies will be examined to see what makes them unique.

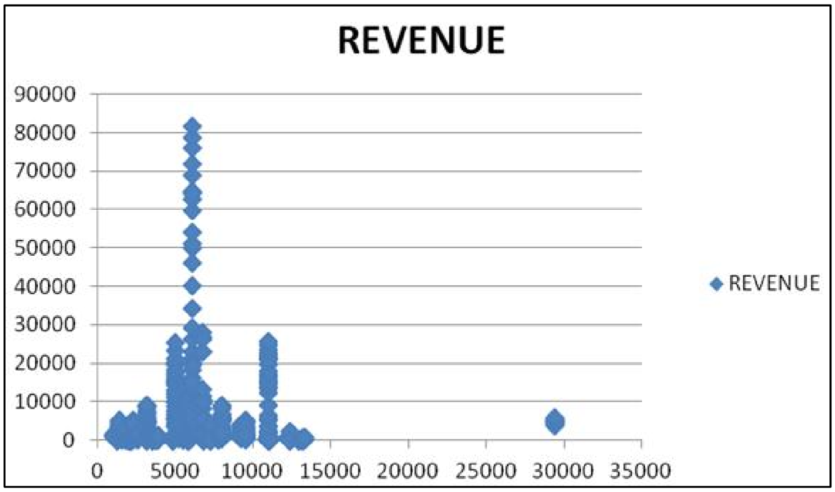

Figure 4-2 Revenue per Company (CUSIP Number)

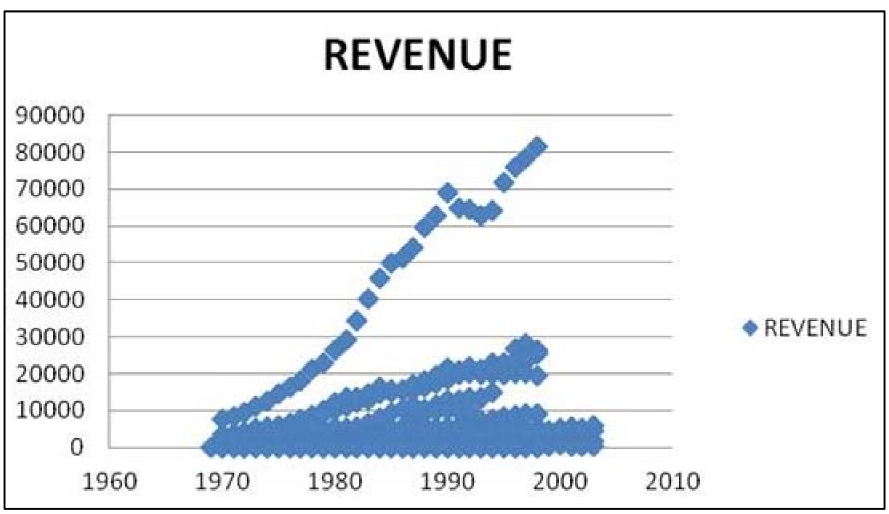

Figure 4-3 Revenue per Year per Company

The graph of Tobin's Q per company over time (Figure 4-4) shows the rise and fall of some companies. The majority of companies never exceed Tobin Q values of 3, but there are companies that are way above and could influence the analysis.

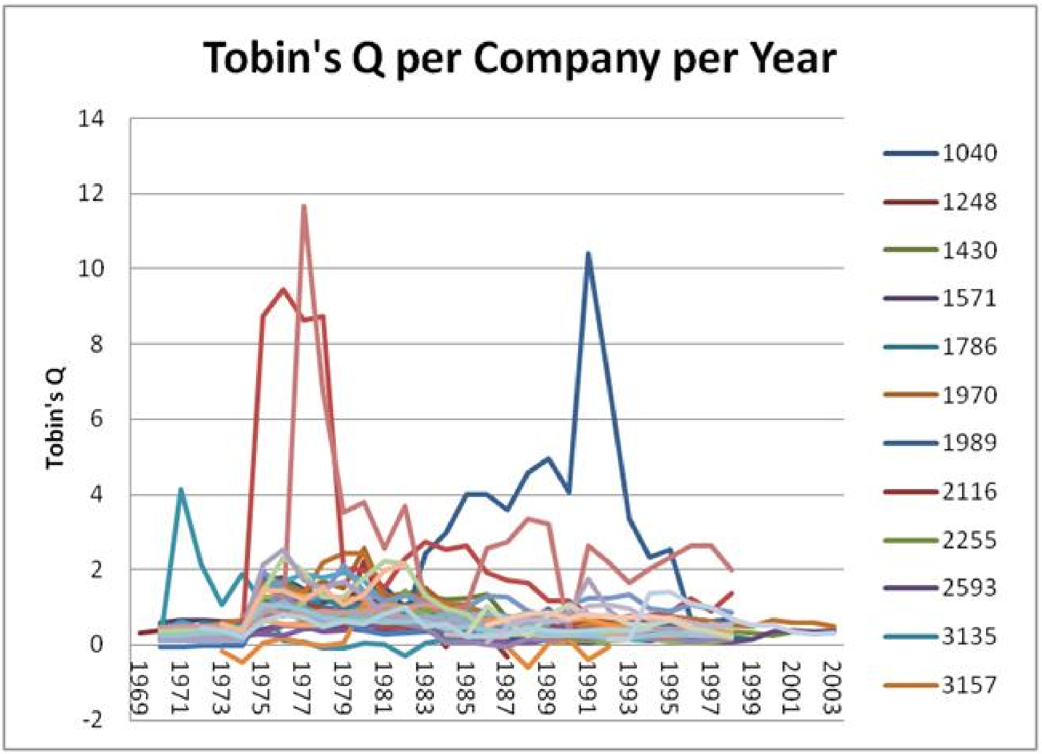

Figure 4-4 Tobin's Q per Year

Unique aspects that were not expected were the number of data points that had values of 0 for originality, the number of data points that had 1 for the efficiency, and the few companies that had Tobin's Q values far above those of their competitors. The originality variable is allowed to be between 0 and 1 where 0 is perfectly exploitative and 1 is perfectly explorative. These values would be expected to be limited in the dataset. The large number of 0's in the originality could be a problem with the dataset where blanks were treated as 0's. If 0's appear to affect the analysis, they may be revisited for possible exclusion from the dataset. If 0's were eliminated, it would leave 959 unique data points. The data points that have 1's for efficiency are less troublesome because these are normalized measures of the ratio of sales to PPE so some 1's are expected by the nature of normalization. For the exceptional Tobin's Q values over certain periods, in the panel data regression, these points may require further analysis for outliers or their effect on the analysis.

Assuming the 0's should stay in the data set, a cluster analysis using R's function mclust was conducted. Theoretically, the clusters should form along a diagonal of low originality (0) and high efficiency (1) to high originality (1) and low efficiency (0). The expected clusters are: pure exploitative (near originality= 0; efficiency=1); pure explorative (near originality= 1; efficiency=0); ambidextrous along the diagonal between these two extremes; and then two clusters off the diagonal in the high and low positions. In addition, it is hypothesized that the majority of companies will tend to fall along this diagonal since it should be the highest profitability based on the theoretical construct of fit.

4.4.2 Cluster Analysis

To identify patterns and grouping in the data that demonstrate how companies actually structure their efficiency and innovation programs, a hierarchical cluster analysis was done using the open source statistical program R function "mclust". The mclust function displays the Bayesian Information Criteria (BIC) as the measure of goodness of fit of the clusters using twelve different models as shown in table 1. Of these twelve, only four are compatible with hierarchical clusters for multivariate analysis. These four are EII (Spherical distribution, equal volume, and equal shape), VII (spherical distribution, variable volume, and equal shape), EEE (ellipsoidal, equal, equal) and VVV (Ellipsoidal, variable, variable). The BIC value of each of these four models will be reviewed and the model with highest BIC value will be chosen.

Table 4-2 shows the parameterizations of the covariance matrix "k currently available in mclust for hierarchical clustering (HC) and/or EM for multidimensional data. ('•' indicates availability)."

Table 4-2 Parameters of Covariance Matrix

identifier	Model	HC	EM	Distribution	Volume	Shape	Orientation
E		•	•	(univariate)	equal		
V		•	•	(univariate)	variable		
EII	λI	•	•	Spherical	equal	equal	NA
VII	$\lambda_k I$	•	•	Spherical	variable	equal	NA
EEI	λA		•	Diagonal	equal	equal	coordinate axes
VEI	$\lambda_k A$		•	Diagonal	variable	equal	coordinate axes
EVI	λA_k		•	Diagonal	equal	variable	coordinate axes
VVI	$\lambda_k A_k$		•	Diagonal	variable	variable	coordinate axes
EEE	λDAD^T	•	•	Ellipsoidal	equal	equal	equal
EEV	$\lambda D_k A D^T_k$		•	Ellipsoidal	equal	equal	variable
VEV	$\lambda_k D_k A D^T_k$		•	Ellipsoidal	variable	equal	variable
VVV	$\lambda_k D_k A_k D^T_k$	•	•	Ellipsoidal	variable	variable	variable

Theoretically, the clusters should form along a diagonal of low originality (0) and high efficiency (1) to high originality (1) and low efficiency (0). The clusters should form into five (5) clusters: pure exploitative (near originality= 0; efficiency=1); pure exploratative (near originality= 1; efficiency=0); ambidextrous along the diagonal between these two extremes; and then two clusters off the diagonal in the high and low positions. In addition, it is hypothesized that the majority of companies will tend to fall along this diagonal since it should be the highest profitability based on the theoretical construct of fit.

The first cluster analysis is using all of the proposed variables originality (orig), efficiency (eff), the ratio of originality/efficiency (i.e. fit), the natural log of number employees (lnEmp), and the environmental uncertainty which is the standard deviation of the last three years of industry sales. The BIC (Bayesian Information Criterion) values are shown below. The higher the BIC value, the better the fit of the clusters to the dataset. This BIC value is a measure of the intra cluster homogeneity and inter cluster heterogeneity.

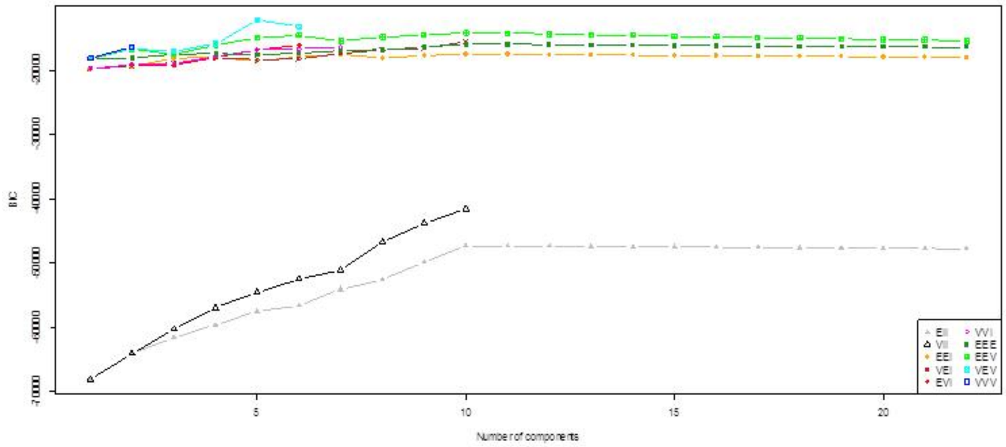

Figure 4-5 BIC Values

As can be seen in Figure 4-5, BIC values are higher for all models across all clusters compared to the EII and VII models with a peak at five clusters for the VEV model and near constant BIC values for clusters above two clusters (non EEI and VII models). Without any theoretical or data reason to chose one model over another, the VEV model was chosen due to higher BIC values. Another difficulty with cluster analysis is to know when to stop forming clusters. Theoretically, my model should form clusters diagonally along a line from high efficiency, low originality to low efficiency, high originality and clusters off of this diagonal. Instead of determining how many clusters to form before analysis, I would allow the software to present the optimal number of clusters based on BIC value.

The result of the cluster analysis is shown below in figure 2 but unfortunately, the clusters do not form in any pattern close to what is hypothesized. The clusters formed are often overlapping and do not collect along a diagonal that was envisioned in the literature review. Some interesting patterns do occur in the cluster display highlighted in red of originality vs environmental uncertainty and efficiency vs environmental uncertainty (right column of Figure 4-6). Companies in general are more original in their research and less efficient as uncertainty increases until the economy becomes highly uncertain when the trend reverses.

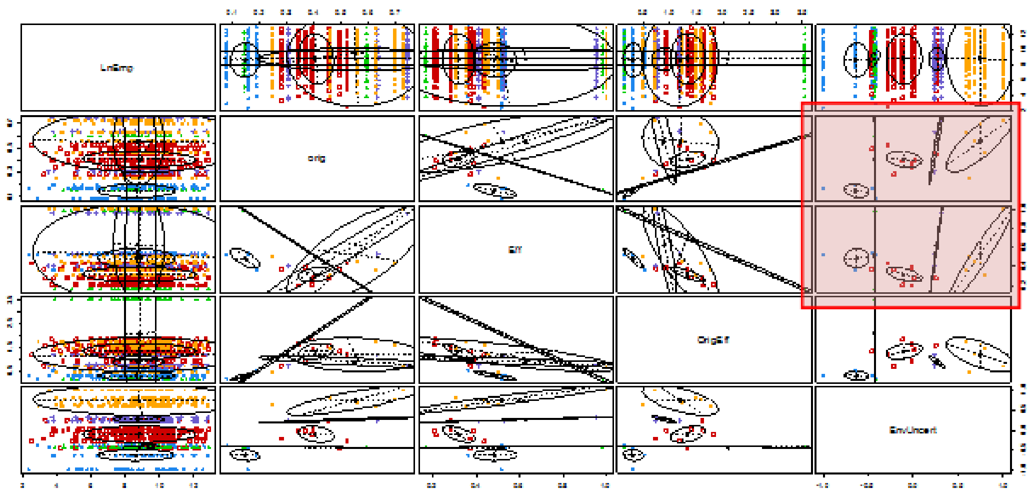

Figure 4-6 Cluster Analysis

The cluster analysis with all possible variables did not lead to clusters that were in line the model developed and also BIC values were very low. The next step in the cluster analysis was to reduce the variables and see if BIC values improved and if the clusters became more like the model. The variables were reduced to the main two variables of the study, efficiency and originality. The first pass included all data points in the data set, including the originality = 0 and efficiency = 1. Figure 4-7 shows the BIC values for increasing numbers of clusters and 4-8 shows the clusters created when the BIC is maximized at 12 clusters and using the EEV model.

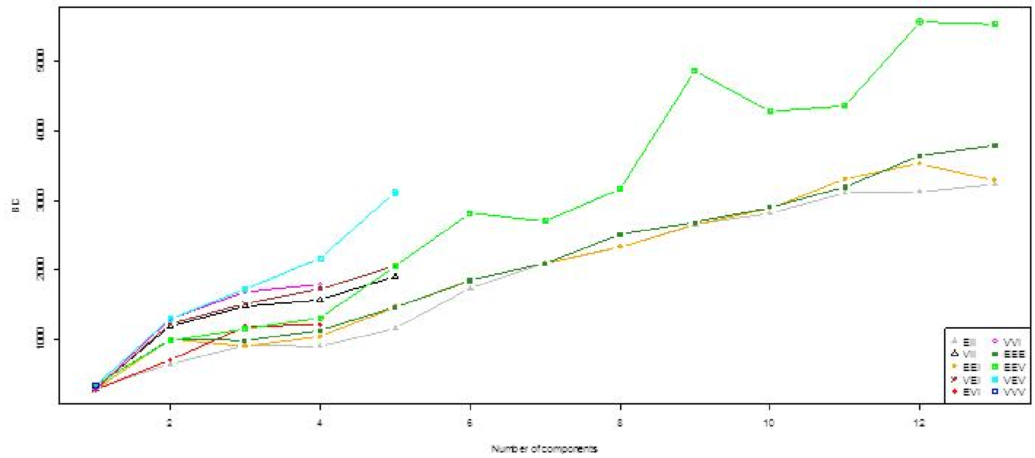

Figure 4-7 BIC Values with 0’s Included

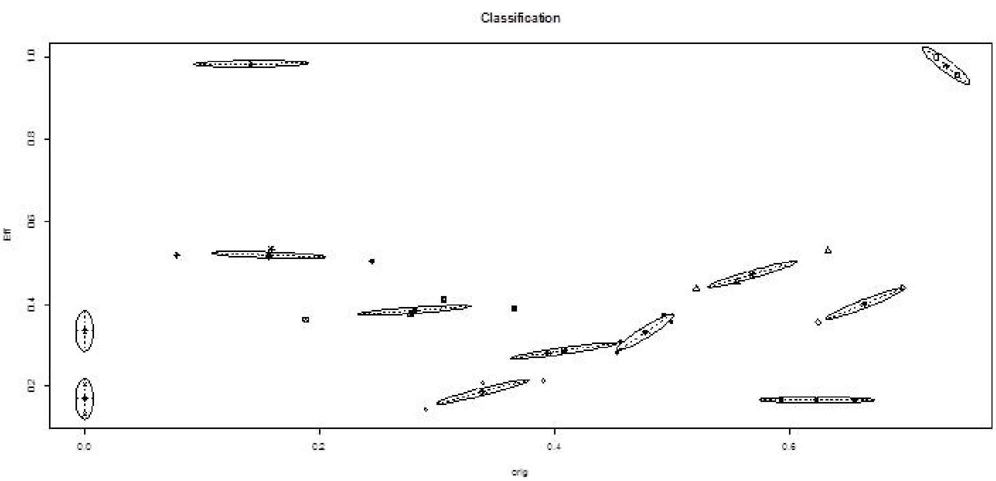

Figure 4-8 Clusters with 0’s Included

Cluster analysis is sensitive to outliers, so the cluster analysis was repeated again with the 0’s omitted to see if the clusters were affected by the data points that were outside the majority of data. With no 0’s, the BIC values increase when compared to the model with the 0’s included, but the cluster membership and shapes are not affected:

Figure 4-9 shows the BIC values for increasing numbers of clusters and 4-10 shows the clusters created when the BIC is maximized at 13 clusters and using the EEV model.

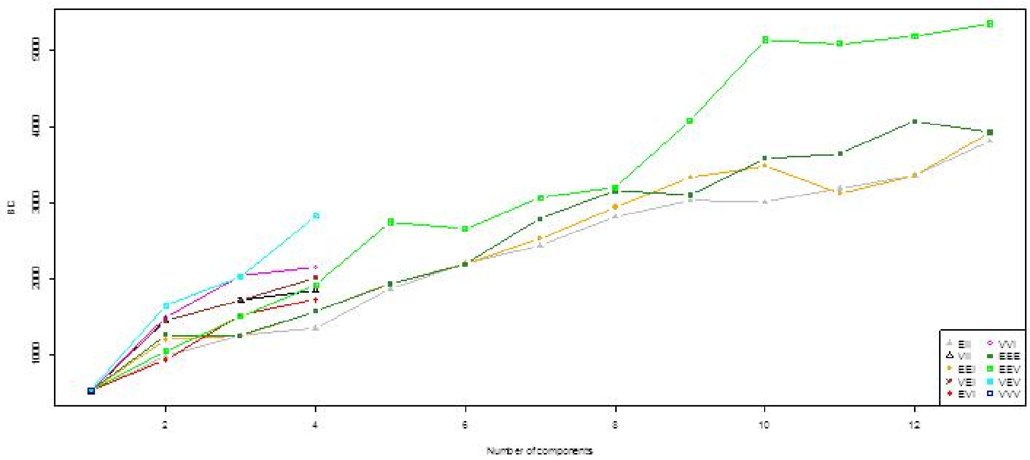

Figure 4-9 BIC Values without 0's

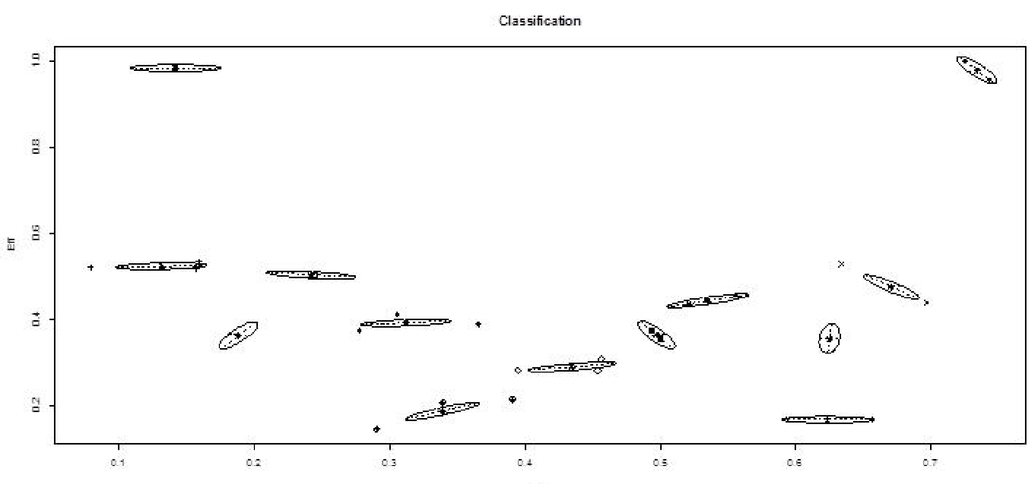

Figure 4-10 Clusters without 0's

Using the same rationale as before, the data points that occur at efficiency = 1 were removed to investigate the impacts. With No 0’s no high eff values in the data again shows and increase in BIC value but the model again does not have different clusters although zoomed in on just the data in this region, there does appear to be a pattern in line with what theoretically should happen.

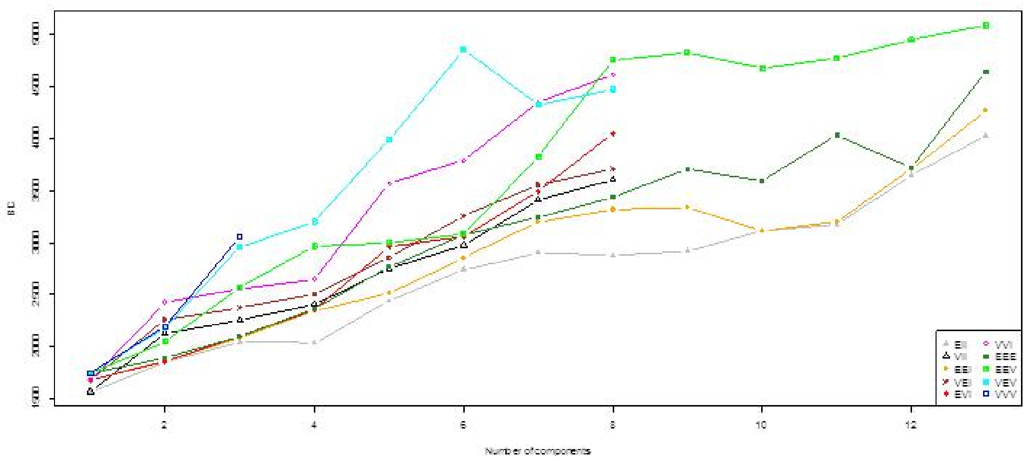

Figure 4-11 BIC Values with no 0’s or 1’s

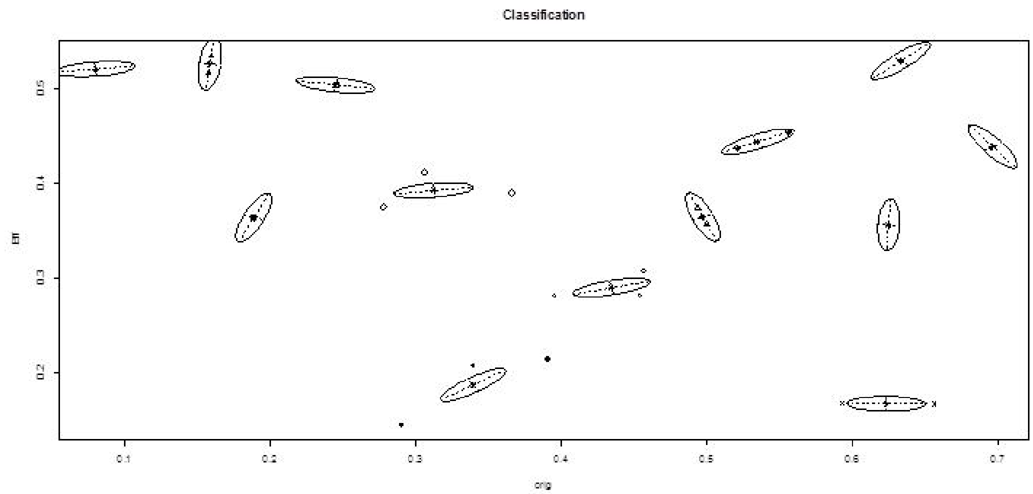

Figure 4-12 Clusters with no 0's or 1's

Since there is no theoretical reason to eliminate data points and the clusters are not greatly impacted, I will retain all data points and below in figure 4-13 is theoretically what should occur based on literature and my hypotheses. Unique cases of Outsource manufacturing, depreciated PPE, and errors with data are not used in the hypotheses test.

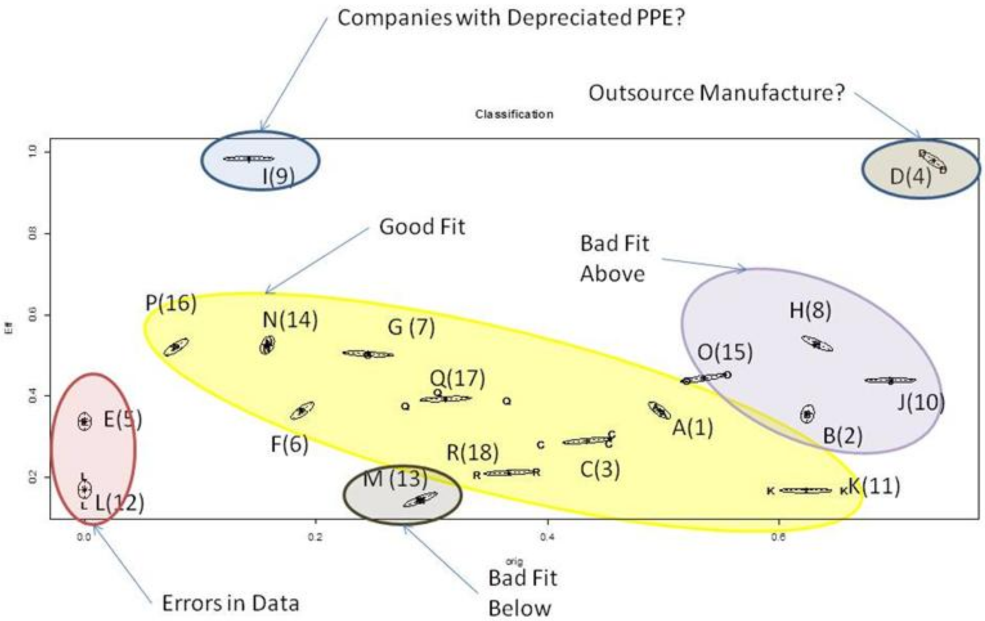

Figure 4-13 Theoretical Grouping of Clusters

Good Fit: (P+N+G+F+Q+R+C+A+K)

Bad Fit Above: (H+O+B+J)

Bad Fit Below: M

4.4.2.1 Hypotheses Testing

H1: The company's fit between its operations and innovation strategy is positively associated with the company's performance.

This hypothesis has to be split into two separate hypotheses, one for the area above the diagonal and one for below the diagonal so that the two bad fit areas do not interfere with each other in the hypothesis testing.

The analysis was conducted twice using different response variables of Tobin's Q and Revenues.

4.4.2.1.1 H1a: μ fit=good > μ fit = bad above; H1b: μ fit=good > μ fit = bad below

H1a: μ fit=good > μ fit = bad above

μ (P+N+G+F+Q+R+C+A+K – μ (H+O+B+J) > 0

Below in Table 4-3 is the output for Tukey Simultaneous Tests using the statistical software MiniTab. The raw output will only be shown once for clarity in how the anaylsis was conducted and for here forward, only the relevant information will be presented in tabular form. All analyses will be done using both Tobin's Q as a response variable and repeated using Revenue or Revenue per Employee as appropriate.

Table 4-3 Tukey Results for Hypothesis 1

Tukey Simultaneous Tests
Response Variable REVENUE
All Pairwise Comparisons among Levels of C-Fit

C-Fit = Bad-High subtracted from:

C-Fit	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Bad-Low	473.7	1594.6	0.291	0.9525
Good	417.1	718.7	0.583	0.8306

C-Fit = Bad-Low subtracted from:

C-Fit	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Good	-56.62	1536	-0.03687	0.9993

Tukey 95.0% Simultaneous Confidence Intervals
Response Variable TobinQ
All Pairwise Comparisons among Levels of C-Fit
C-Fit = Bad-High subtracted from:

Tukey Simultaneous Tests
Response Variable TobinQ
All Pairwise Comparisons among Levels of C-Fit
C-Fit = Bad-High subtracted from:

C-Fit	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Bad-Low	-0.1451	0.16645	-0.8715	0.6583
Good	0.0236	0.07501	0.3147	0.9469

C-Fit = Bad-Low subtracted from:

C-Fit	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
Good	0.1687	0.1603	1.052	0.5439

Table 4-4 Hypotheses H1a and H1b Results

Hypothesis	Comparison	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H1a	$\mu_{fit=good} > \mu_{fit = bad\ above}$	Revenue	417.1	718.7	0.8306	Fail
		Tobin's Q	0.0236	0.07501	0.9469	Fail
H1b	$\mu_{fit=good} > \mu_{fit = bad\ below}$	Revenue	-56.62	1531	0.08	Reject H0
		Tobin's Q	-2.307	0.5701	0.04	Reject H0

Based on the T test shown in Table 4-4, the tests fail to reject at $\alpha/2=5\%$. It cannot be said with 90% confidence that there is significant difference between good fit and bad fits above using Tobin's Q or Revenue as a response variable.

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H1b: μ fit=good > μ fit = bad below

μ (P+N+G+F+Q+R+C+A+K) – μ M > 0

The hypothesis will again be testing using first Tobin's Q as a response variable and then repeated with Revenue. Referring back to Table 3, the T tests reject the null hypothesis using both Tobin's Q or Revenue. The results suggest that there is a relationship between fit and company performance using cluster analysis and suggest a potential of a efficiency frontier that companies must reach to maximize performance.

4.4.2.1.2 H2: The Relationship Between Fit and Performance Will Be Positively Moderated by a Company's Resources

H2: The relationship between fit and performance will be positively moderated by a company's resources. This is modeled as the change in difference between mean values of good fit strategies versus poor fit-below at the high level of resources and the low level of resources.

The variable cluster corresponds to the cluster identified in the cluster analysis coded 1-18 for each cluster and the LnEmpQ is a variable (-1,0,1) that represents SME (-1), Large (0), and Very Large (1).

H2: $(\mu_{(P+N+G+F+Q+R+C+A+K), VL} - \mu_{M,VL}) \neq (\mu_{(P+N+G+F+Q+R+C+A+K), SME} - \mu_{M, SME})$

$(\mu_{(P+N+G+F+Q+R+C+A+K), high} - \mu_{M,high}) - (\mu_{(P+N+G+F+Q+R+C+A+K), low} - \mu_{M,low}) \neq 0$

Table 4-5 H2 Results

Hypothesis	Comparison	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H2	$(\mu_{good, high} - \mu_{bad, high}) \neq (\mu_{good, low} - \mu_{bad,low})$	Revenue	6805	1121	0.0001	Reject H0
		Tobin's Q	-0.4528	0.1236	0.0007	Reject H0

Table 4-5 shows there is a statistically significant difference between the change in performance from good fit versus bad fit at the high resource company versus a low resource company at the α=.01 level.

4.4.3 Quartiles Analysis

After finding lack of significance using the cluster analysis the initially proposed method of segmenting the data by quartiles was used where the upper, middle and lower quartiles of variables were used to identify the levels of the variables. Variables were coded as (-1) for lower quartile, 0 for mid range, and (1) for upper quartile and shown in Table 4-6.

Table 4-6 Quartiles for Analysis

Quartiles of Independent Variables			
	-1 (<.25)	0 (.25-.75)	1 (>.75)
Originality (OrigQ)	Exploit		Explore
Efficiency (EffQ)	Low	Moderate	High
Resources Company Size (# Emp)	SME	Large	Very Large
Environmental Uncertainty (EnvUncertQ)	Low	Moderate	High

4.4.3.1 Hypothesis 1

H1: The company's fit between its operations and innovation strategy is positively associated with the company's performance.

H1: μ fit=good > μ fit = bad

Table 4-7 H1 Using Quartiles

Hypothesis	Comparison	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H1	μ fit=good > μ fit = bad	Revenue	5516	2077	0.2	Fail
		Tobin's Q	0.0833	0.10608	1.000	Fail

As shown in Table 4-7, the fit between operations strategy and innovation strategy is not statistically significant using either revenue or Tobin's Q as response variable.

4.4.3.2 Hypothesis 2

H2: The relationship between fit and performance will be positively moderated by a company's resources which is modeled as the change in difference between mean values of good fit strategies versus poor fit below at the high level of resources and the low level of resources.

H2: $(\mu_{(\text{Good Fit}),\text{high}} - \mu_{\text{Bad Fit},\text{high}}) \neq (\mu_{(\text{Good Fit}),\text{low}} - \mu_{\text{Bad Fit},\text{low}})$

$(\mu_{(P+N+G+F+Q+R+C+A+K),\text{high}} - \mu_{M,\text{high}}) - (\mu_{(P+N+G+F+Q+R+C+A+K),\text{low}} - \mu_{M,\text{low}}) \neq 0$

Table 4-8 H2 Using Quartiles

Quartile Analysis						
Hypothesis	Comparison	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H2	(μ (Good Fit), high - μ Bad Fit,high) ≠ (μ (Good Fit), low - μ Bad Fit,low)	Revenue	239.6	95.41	0.1309	Fail
		Tobin's Q	0.6681	0.1966	0.0845	Reject H0

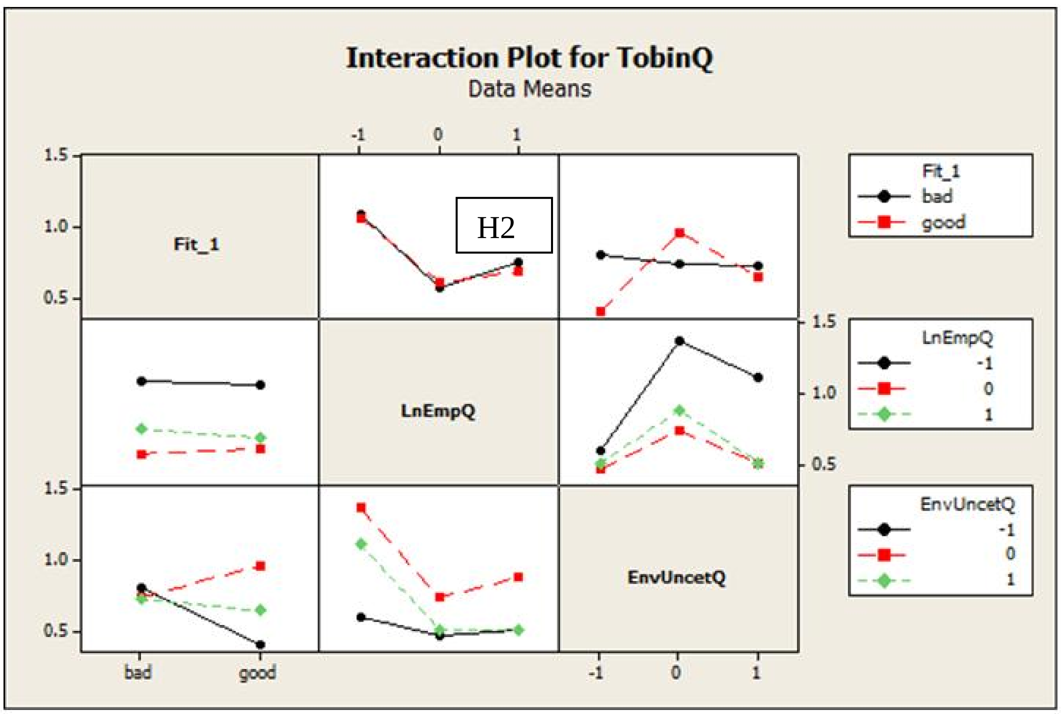

Figure 4-14 Interaction Effects

The analysis shows in Table 4-8 that the null hypothesis is rejected at the α=10% confidence level using Tobin's Q as response variable, but failed to reject the null hypothesis using revenue as response variable. Figure 4-14 shows the interaction effects for H2 using Tobin's Q as a response variable.

4.4.3.3 Hypothesis 3

H3: Companies with higher ambidexterity will have better performance.

Table 4-9 presents the results for H3 testing using quartiles and based on the results, failed to reject the null hypotheses for both Revenue and Tobin's Q.

Table 4-9 H3 Quartile Results

Quartile Analysis					
Hypothesis	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H3	Revenue	4485	21927	0.0211	Reject
	Tobin's Q	-.03606	0.1684	0.8307	Fail

4.4.4 Regression Analysis

Following clustering analysis and ANOVA to test for significance, a regression model was fitted to determine the relationship between the variables. Not all hypotheses can be examined with a regression model. The concept of fit is one of those non-continuous variables and the hypotheses will have to be modified or combined.

H1: The measures originality and efficiency are positively associated with the company's performance.

Table 4-10 H1 Regression Results

H1 Regression				
Revenue	Coef.	Std Err	t	P>|t|
Const	1663	1080	1.54	0.124
Orig	5587	1957	2.86	0.004
Eff	3663	1923	1.91	0.057
Rsq	2.2%			
Tobin's Q	Coef.	Std Err	t	P>|t|
Const	0.74345	0.0729	10.2	0
Orig	-0.113	0.1331	-0.85	0.396
Eff	0.1229	0.1317	0.93	0.351
Rsq	10%			

Based on the regression model results shown in Table 4-10, originality and efficiency are both positively related to company performance. The coefficients have high statistical significance. The coefficient for originality is significant at $\alpha/2=1\%$ confidence and the efficiency coefficient is significant at the $\alpha/2=10\%$ confidence level using revenue as the response variable. The R-sq value of 2.2% is very low and suggests that the model is missing variables that would contribute to more explanation of the variation in revenue. The regression model using Tobin's Q as response variable only had the constant coefficient with significance. The expected predictor variables of originality and efficiency had no statistical significance.

H2: The operations strategy and innovation strategy are positively associated with the company's performance but will be positively moderated by a company's resources

Table 4-11 H2 Regression Results

H2 Regression				
Revenue	Coef.	Std Err	t	P>|t|
Const	-3880.1	677.4	-5.73	0
Orig	5378	1135	4.74	0
Eff	3075	1117	2.75	0.006
Emp	0.1144	0.00322	35.54	0
Rsq	47.20%			
Tobin's Q	Coef.	Std Err	t	P>|t|
Const	0.68614	0.0732	9.37	0
Orig	-0.1237	0.1318	-0.9	0.396
Eff	0.1229	0.1317	0.93	0.351
Emp	0.00000213	0.00000045	4.73	0
Rsq	2.20%			

Table 4-11 shows the results from the regression analysis using both Revenue and Tobin's Q. The addition of number of employees as a measure of research capacity added greatly to the R-sq value of the model increasing it to 47.2% up from 2.2% when using Revenue as the response variable. All coefficients for the model with revenue as response variable are significant at the 99% confidence level. The regression model indicates that if the number employees are held constant, increasing originality and efficiency would both increase revenue, but suggests increasing originality will increase revenue more than the same incremental increase in efficiency.

The regression model using Tobin's Q again only had the constant and employees as a significant terms. This suggests that Tobin's Q as a response is not impacted by either efficiency or originality.

Chapter 5

Conclusions and Discussion

As shown in Chapter 4, the analysis had mixed support for the hypotheses developed. It was interesting to see the strong support for some hypotheses, mixed results for some depending on the response variable, and some with no support at all. Each hypothesis will be discussed individually and then a discussion of what the results mean to business in general and for operations. The results that were presented throughout the chapter are shown again below for clarity and ease of discussion. Table 5-1 shows the results from the cluster analysis; Table 5-2 shows results from the ANOVA analysis using quartiles; and, finally Table 5-3 show the results of the regression analysis.

Table 5-1 Cluster Analysis Results

Cluster Analysis						
Hypothesis	Comparison	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H1a	$\mu_{fit=good} > \mu_{fit=bad\ above}$	Revenue	417.1	718.7	0.8306	Fail
		Tobin's Q	0.0236	0.07501	0.9469	Fail
H1b	$\mu_{fit=good} > \mu_{fit=bad\ below}$	Revenue	-56.62	1531	0.08	Reject H0
		Tobin's Q	-2.307	0.5701	0.04	Reject H0
H2	$(\mu_{good,\ high} - \mu_{bad,\ high}) \neq (\mu_{good,\ low} - \mu_{bad,low})$	Revenue	6805	1121	0.0001	Reject H0
		Tobin's Q	-0.4528	0.1236	0.0007	Reject H0

Table 5-2 Quartile Analysis Results

Quartile Analysis						
Hypothesis	Comparison	Response Variable	Difference of Means	SE of Difference	Adjusted P-Value	Reject H0
H1	μ fit=good > μ fit = bad	Revenue	5516	2077	0.2	Fail
		Tobin's Q	0.0833	0.10608	1	Fail
H2	(μ (Good Fit), high - μ Bad Fit,high) ≠ (μ (Good Fit), low - μ Bad Fit,low)	Revenue	239.6	95.41	0.1309	Fail
		Tobin's Q	0.6681	0.1966	0.0845	Reject H0
H3	μ amb > μ not amb	Revenue	4485	21927	0.0211	Reject
		Tobin's Q	-.03606	0.1684	0.8307	Fail

Table 5-3 Regression Analysis Results

H1 Regression				
Revenue	Coef.	Std Err	t	P>|t|
Const	1663	1080	1.54	0.124
Orig	5587	1957	2.86	0.004
Eff	3663	1923	1.91	0.057
Tobin's Q	Coef.	Std Err	t	P>|t|
Const	0.74345	0.0729	10.2	0
Orig	-0.113	0.1331	-0.85	0.396
Eff	0.1229	0.1317	0.93	0.351
Rsq	0.10%			

H2 Regression				
Revenue	Coef.	Std Err	t	P>|t|
Const	-3880.1	677.4	-5.73	0
Orig	5378	1135	4.74	0
Eff	3075	1117	2.75	0.006
Emp	0.1144	0.00322	35.54	0
Rsq	47.20%			
Tobin's Q	Coef.	Std Err	t	P>|t|
Const	0.68614	0.0732	9.37	0
Orig	-0.1237	0.1318	-0.9	0.396
Eff	0.1229	0.1317	0.93	0.351
Emp	2.13E-06	4.5E-07	4.73	0
Rsq	2.20%			

Table 5.3 continued

H3 Regression				
Revenue	Coef.	Std Err	t	P>|t|
Const	5037	1280	3.93	.0000
Orig-Self	-46246	33240	-1.39	0.166
Rsq	5.0%			
Tobin's Q	Coef.	Std Err	t	P>|t|
Const	1.0069	.1107	9.09	.0000
Orig-Self	1.818	2.875	.63	.528
Rsq	5.0%			

5.1 H1: Operations and Innovation Strategy Fit Effect on Performance

Hypothesis H1a that looked at the difference for the bad fit above and good fit was not supported by any of the analysis. This suggests that fit is not important for higher values of efficiency and originality. Further, it appears that highly efficient and highly original companies do not differ in performance than companies with an operations and innovation strategy fit. Potential causes of this result could be explained by other variable not included in model that moderate the relationship between the innovation and operation strategy fit and company performance. An example of which could be outsourcing or use of contract manufacturing. This would make their efficiency high and while still being able to be highly innovative.

Hypothesis H1b was supported using both Tobin's Q and Revenue. H1b looked at the difference between good fit and bad fit below the line. The significant difference shows that there is a threshold of fit that a company needs to achieve to achieve industry average results. The equation of the lower boundary will need to be investigated to determine what the minimum mix is so companies can understand what the threshold is for the fit. This suggests an efficiency frontier exists and future research may determine the optimal mixture for efficiency and originality and is shown in Figure 5-1.

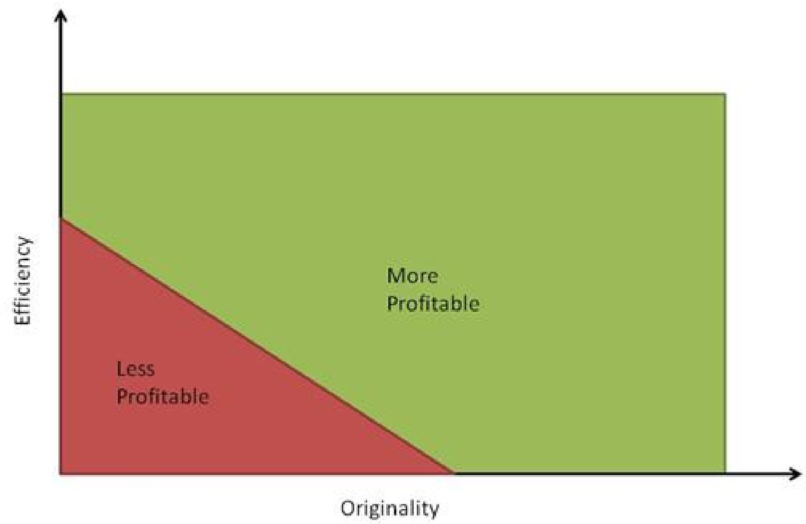

Figure 5-1 Possible Efficiency Frontier

5.2 H2: The Relationship Between Fit and Performance Will Be Positively Moderated by a Company's Resources

Using the cluster analysis results, there was support that company resources do impact the effect of fit on company performance for both Tobin's Q and Revenue. The more resources the company has, the less the fit affects the revenue of the company. This result opens up the opportunities for large and very large companies to allow for ambidexterity and also allows the company to follow different strategies for operations and innovation. It also shows that companies with fewer resources need to focus on the strategic fit of their decisions.

The results of the quartile analysis also support the hypothesis but only when using Tobing's Q as response variable and the support is not as strong as in the cluster analysis. The regression analysis also shows strong support for hypothesis H2 using revenue for response, but not Tobin's Q.

5.3 H3: Companies with Higher Ambidexterity Will Have Better Performance.

The hypotheses and literature review suggested that companies that are able to follow an ambidextrous strategy will have higher revenue per employee. This is due to the higher level of exploitation which increases efficiency and exploration that creates new, advanced products. The null hypothesis was rejected for H3 using revenue per employee but not for Tobin's Q.

Chapter 6

Conclusions and Recommendations

Effective operations management has been shown to contribute positively to the performance of the company. While there have been many studies that examined the relationship between operations and other functions like finance and marketing, few have looked at the relationship between operations and innovation. This dissertation attempted to develop a quantitative method for measuring the fit of operations strategy and innovation strategy and determine if the fit is positively associated with company performance.

This study utilized secondary data publicly available from the United States Patent and Trademark Office (USPTO) and CompuStat databases. Three separate types of analyses were conducted using cluster analysis, quartile division of the variables, and a linear regression to examine the relationships between the variables and gain understanding of the role of fit plays on the performance of the company.

6.1 Contributions of this Study

New product development (NPD) and innovation are critical to the long-term success of companies. Although some operations management aspects of NPD have been examined such as project management's role in NPD and concurrent design, few studies have looked at the operational structure and the role of this structure in the innovation and company success. This research developed a model that detailed the role of operations strategy in company learning, innovation and performance. The model suggested a path dependency that reinforced the internal resources of the company both physical and intellectually. This model provides a theoretically based model explaining how companies align the operations to innovation strategy. One key to this model is the concept of fit. Unfortunately, the method proposed to measure the fit did not achieve statistical significance. This does not mean that they concept is invalid, but only that the relationship is more complicated than expected based on the results that innovation and efficiency do have statistically significant relationships. It is also shown that a certain threshold of innovation and efficiency must be accomplished to achieve higher performance. This suggests the existence of an efficient frontier that will need to be developed further.

6.2 Limitations of this Study

This study looked only at public companies in the disposable medical device industry with patents granted in the United States. This narrow view facilitated analysis but it limits the extension of results to other industries and other countries. The use of patents as a measure of innovation is an easily available and widely accepted measure of innovation. The use of patents, however, excludes a large population of innovations that are not patentable. Trade secrets, company proprietary, and other non-published research can also have an effect on corporate abilities. Also, the threshold of difference in product that must be demonstrated for a patent may skew the research to unique and exploratory innovation where the least innovative patent might be more exploratory than the other innovation created in the industry. There is a more fundamental limitation of the dissertation and that is the ability to measure the constructs effectively. Relying on secondary data allowed for easier analysis and the opportunity to create a longitudinal study including companies that were no longer in business, but the reliance on secondary data also limits the ability to directly measure the construct and develop deep understanding.

6.3 Conclusions

The efficiency and innovation of the company do have a positive relationship in the performance of companies but the concept of fit is not modeled properly. More research into how to quantify fit must be done to develop a better measure. While there was an expectation that certain regions were the optimal performance is achieved, there was only one region that had a statistically lower performance than other areas. This region was the area of bad fit below the theorized optimal region. This suggest that there is either a threshold to achieve above average performance or an efficient frontier that can show where the optimal mix of efficiency and innovation.

Beyond the impact of operations on innovation, hypotheses of which innovation strategy works better for environmental uncertainty and company size had mixed results. Six of nine hypotheses had significant results based on at least one of the response variables. This suggest that theoretically the hypotheses and models are on the right track but need some refinement. There were some differences that were actually significant but opposite sign than the model suggested. These need to have further investigation to identify why the results and proposed results were opposite.

6.4 Recommendations for Future Research

There are many avenues for future research. The five main areas are:

- improvement in measurement and analysis;
- incorporate more primary data and case study methodology;
- incorporating organizational learning and innovation strategy into the model;
- expand the research into other industries to see if results hold in other industries; and
- applying the model to supply chains and strategic partnerships.

The analysis conducted could be refined to develop a better measure of fit that can be utilized in regression analysis and can be quantitatively evaluated instead of qualitatively. The ambidextrous measure must also be enhanced. There was strong debate in development of dissertation on how to measure ambidexterity. This dissertation treated ambidexterity as the mid range of average originality. Going back to the original patent data and look at each individual patent to determine ambidexterity could provide a better result.

This dissertation presented a model in Figure 1-2 that shows the interrelationship between innovation strategy, operations strategy, organizational learning, and resources. There are many rich interactions that could provide insight into how operations interact with other departments. The industry chosen was the disposable medical industry. The research needs to be repeated in other industries to test what relationships can be generalized.

As discussed in the introduction, this dissertation was limited to in-house innovation. Another extension would be to test the model in supply chains to understand how innovation works with suppliers, partners, and universities to develop products and maximize value in the supply chain. The lack of significance in testing hypothesis H1 about fit could be enhanced if data on outsourcing of either innovation or manufacturing was available for each company. Expanding the research to the supply chain could help fill in that missing data and help management develop its larger supply chain strategy keeping in mind the effects on innovation.

6.5 Synopsis

Highly competitive markets demand new or improved products to maintain corporate performance and long-term survival. The effectiveness of innovation and new product development is dependent on many competing concepts. Operations Management has always played an important role in the launch of new products, but the impacts of operations on the development cycle needs more research. This dissertation was an exploratory look into how operations management can impact the innovation and new product development process. While some relationships hypothesized were found to have statistical support, the key concept of fit did not. The concept of fit has proof in other settings, but as modeled in this dissertation, it did not. This is likely due to poor measurement of the concept of fit, the reliance on secondary data, and other moderating variables not included in the model.

Chapter 7

Post Hoc Analysis

Limited statistical significance was found in the hypotheses tests and low R^2 values for the regression analysis. This could be possibly due to missing variables that were not included in the model. Future research on this topic will likely need to have more variables and to set the foundation for that future research, a secondary review of the data was conducted without a theoretical lens to determine if variables from the original data source omitted by the theoretical model add more predictive power. The variables included in the Post-Hoc analysis are shown in table 7-1. The standard deviation of some of the variables was calculated for a measure of the distribution of values. The standard deviation variables are per company, per year.

Table 7-1 Independent Variables for Post-Hoc Analysis

Variable Name	Description
Count	Total Number of Patents per Company per Year
Orig	Mean Originality
Eff	Efficiency of company
EnvUncert_B	Environmental Uncertainty
CRECEIVE	Total Claims Approved
GENERAL	Range of Generality
ORIGINAL	Range of Originality
SELFCTUB	Self Citations Upper Bound
SELFCTLB	Self Citations Lower Bound
StDvCRECEIVE	Std Dev of Claims Approved
StDvGENERAL	Std Dev of Generality
StDvORIGINAL	Std Dev of Originality
StDvSELFCTUB	Std Dev of Self Citations Upper Bound
StDvSELFCTLB	Std Dev of self Citations Lower Bound
Fwdaplag	Mean forward citation lag
ratiocit	Percent of Citations Made to Patents Granted Since 1963
secdlwbd	Share of Self-Citations Received - Lower Bound
cmade	Number of Citations Made
Orig-Self	Product of Orig and Self Variable
LnCount	Natural Log of Count
LnOrig-Self	Natural Log of Orig-Self

Using the variables in the NBER dataset, a stepwise regression analysis was conducted to explore which variables might produce the best fit in future research and to direct future model development. This analysis does not relate to the hypotheses or theoretical model developed during literature review. It is only an investigation to lay the ground work for future research using the NBER data.

Table 7-2 Stepwise Regression with Revenue per Employee as Response

Step	1	2	3	4	5	6
Constant	0.9030	0.8906	0.8860	0.8890	0.8812	0.8772
StDvFWDAPLAG	-0.0132	-0.0124	-0.0119	-0.0106	-0.0105	-0.0105
T-Value	-11.40	-10.84	-10.59	-8.87	-8.81	-8.93
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
Orig		0.0271	0.0302	0.0289	0.0289	0.0295
T-Value		3.53	4.04	3.93	3.96	4.07
P-Value		0.001	0.000	0.000	0.000	0.000
RATIOCIT			0.00020	0.00019	0.00020	0.00017
T-Value			3.65	3.50	3.66	2.96
P-Value			0.000	0.001	0.000	0.003
StDvRATIOCIT				-0.042	-0.048	-0.049
T-Value				-2.65	-2.98	-3.04
P-Value				0.009	0.003	0.003
Eff					0.024	0.029
T-Value					1.86	2.19
P-Value					0.065	0.030
StDvSECDLWBD						0.021
T-Value						1.98
P-Value						0.049
S	0.0188	0.0182	0.0176	0.0173	0.0172	0.0170
R-Sq	42.21	46.01	49.82	51.75	52.69	53.74
R-Sq(adj)	41.89	45.40	48.96	50.65	51.33	52.14
Mallows Cp	31.0	19.4	7.8	2.8	1.5	-0.3

Table 7-3 Stepwise Regression with Tobin's Q as Response

Step	1	2	3	4
Constant	0.8746	1.6415	1.4968	1.5231
StDvNCLASS	0.00498	0.00493	0.00460	0.00457
T-Value	5.56	5.63	5.16	5.16
P-Value	0.000	0.000	0.000	0.000
Eff		-2.28	-2.11	-2.10
T-Value		-3.08	-2.84	-2.85
P-Value		0.002	0.005	0.005
StDvCMADE			0.0114	0.0137
T-Value			1.78	2.11
P-Value			0.076	0.036
ORIGINAL				-0.0019
T-Value				-1.72
P-Value				0.088
S	1.03	1.01	1.00	0.995
R-Sq	14.79	19.12	20.55	21.87
R-Sq(adj)	14.32	18.21	19.20	20.09
Mallows Cp	3.3	-3.8	-4.8	-5.6

The stepwise regression showed that using revenue per employee (Table 7-2), the best stepwise regression model achieves an R^2 of 53.74 using the variables of: St Dev of FwD Lag (how long before a patent is referenced), Orig, Ratio of Citations, St Dev of Ratio of Citations, Efficiency, and St Dev of SecDLWBD. The best fit using the model based on literature only achieved an R^2 of 47%. The only issue with the model suggested by the stepwise regression is that some of the variables are backward looking instead of forward looking, meaning that when a company files a patent, it is not able to obtain the value of some variables until time has passed.   This does not help management making decisions and is not likely a useful research path. Using Tobin's Q (Table 7-3), the best model reaches 20.09 for R2 using St Dv NClass, Eff, St Dv CMade, and Original. This was much better than any model using Tobin's Q in the theory-driven model. The variables selected by the stepwise regression for Tobin's Q are forward looking and would help management make decisions on the innovation strategy. Future research is needed to understand why the Tobin's Q and Revenue have such different predictor variables.

Revising the stepwise regression using only forward looking variables and created new variables using the natural log of number of patents and the natural log of the variable Orig-Self created to measure ambidexterity.

Table 7-4 Stepwise Regression with Only Forward Looking Variables

Step	1	2	3	4	5	6
Constant	0.12973	0.12353	0.08835	0.05725	0.05151	0.04936
StDvRATIOCIT	-0.262	-0.241	-0.228	-0.204	-0.203	-0.202
T-Value	-5.17	-4.95	-4.85	-4.34	-4.36	-4.36
P-Value	0.000	0.000	0.000	0.000	0.000	0.000
GENERAL		0.00019	0.00020	0.00022	0.00023	0.00017
T-Value		3.71	3.92	4.38	4.58	2.60
P-Value		0.000	0.000	0.000	0.000	0.010
Orig			0.080	0.066	0.069	0.066
T-Value			3.48	2.85	2.99	2.89
P-Value			0.001	0.005	0.003	0.005
LnOrig-Self				-0.0089	-0.0085	-0.0090
T-Value				-2.56	-2.48	-2.64
P-Value				0.012	0.014	0.009
count					0.00060	0.00053
T-Value					1.99	1.72
P-Value					0.049	0.087
ORIGINAL						0.00011
T-Value						1.59
P-Value						0.114
S	0.0521	0.0498	0.0479	0.0470	0.0465	0.0462
R-Sq	16.24	23.88	30.10	33.34	35.25	36.46
R-Sq(adj)	15.63	22.77	28.56	31.36	32.84	33.59

The newly created variable of LnOrig-Self was significant on the 4th step but the other created variable of LnCount was not significant for any of the steps. The model reached and R^2 of 36.46% which is not as good as the model with backward and forward looking variables, but is useful for managers in making decisions of innovation strategy.

Future research should include new literature review to determine if forward looking variables suggested by the stepwise regression have a theoretical foundation and help direct management in strategy decisions.

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Biographical Information

James Edward Brown earned a BS in Mechanical Engineering from the University of Texas at El Paso in 1996, an MBA from Texas Christian University in 2001, and will earn a PhD in Operations Management from the University of Texas at Arlington in December 2012. He has worked in industry for over 15 years as an engineer and program manager managing new product development from initial concept definition into production. He currently is a project manager of strategic enterprise asset management focusing on plant transitions and warehouse optimization.

His research interests are innovation management, entrepreneurship, supply chain management, and design thinking. After graduation, he plans to teach full-time at a university in the Dallas-Fort Worth area and open a boutique-consulting firm specializing in early stage start up management.