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For the degree of Doctor of Philosophy

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MULTILEVEL ABSORPTIVE CAPACITY AND RADICAL INNOVATION

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ABSTRACT

Sharp, Barton M. Ph.D., Purdue University, August 2009. Multilevel Absorptive Capacity and Radical Innovation. Major Professor: Dr. Thomas Brush.

The purpose of this study is to explore organizational learning, using the lens of absorptive capacity, as a multi-level phenomenon spanning individual, group, and organizational levels of analysis. In the first chapter we explore how characteristics of individual employees interact with group and organizational level communication processes in order to better understand how knowledge collected by individuals from the environment becomes knowledge which the organization can apply to their operations. We expand on the existing literature by hypothesizing that why individuals choose to learn affects what they learn, which in turn affects the firm's ability to engage in radical innovation and entrepreneurial behaviors. In the second chapter we narrow our focus. There we look at how characteristics of one particular group of organizational members, the top executives, influence one component part of the innovation process, the generation of radical new ideas. Finally in the third chapter we examine how top executive characteristics affect an organization's ability to turn those radical new ideas into potentially valuable new products. We find that while executives seem to exert little or no influence on the kinds of new ideas spawned by the firm, they have a strong influence over the likelihood that new ideas will be turned into new products. Most interestingly, we find a strong technological contingency that determines the extent to

which executives matter. When a firm has a stock of incremental new ideas which largely build on prior art, executives bear little influence. However when a firm's portfolio of new ideas is more radical, executives strongly influence the efficiency with which those ideas can be turned into new products.

CHAPTER 1. MULTILEVEL ABSORPTIVE CAPACITY AND RADICAL INNOVATION

1.1. Introduction

Interest in "organizational learning" has grown exponentially since Cyert & March (1963) first proposed their model of learning as an evolutionary response to misalignment between internal objectives and changing external conditions (Shipton 2006). Although there is still debate on the relationship between learning and organizational performance (Harrison & Leitch 2005), there is a widely held belief that the ability to learn and adapt to new knowledge is important for firm survival and competitive advantage in the face of ever-changing competitive conditions (Schumpeter 1950). Whether through learning by doing (David 1975; Rosenberg 1976), learning by using (Rosenberg 1982; Malerba 1992), or learning from the external environment (Cohen & Levinthal 1989; Cohen & Levinthal 1990), the collection of new stocks of knowledge (Dierickx & Cool 1989) has important implications for the efficiency and effectiveness with which organizations operate.

Numerous authors have noted the multi-level nature of organizational learning (Shipton 2006) and the critical role played by learning at the individual level. For example, Nelson & Winter say that "the knowledge an organization possesses is reducible to the knowledge of its individual members." (1982, Pg. 104) Information enters organizations through their members, who often collectively "know" more than the

organization does. Only through a process of communication and embedding does individual knowledge become collectivized through the organization (Argyris & Schon 1978). Despite this important link, there is relatively little research which attempts to bridge the divide by studying the process by which individual learning leads to organizational learning (Antonacopoulou 2006).

In this research we take tentative steps towards filling this gap using the lens of absorptive capacity. Absorptive capacity, defined as an organization's ability to identify, assimilate, and exploit new knowledge from the environment, was first proposed by Cohen & Levinthal in an elegant economic model published in 1989. In 1990 they followed up with a second paper which utilized theories from psychology and sociology to suggest that firm-level absorptive capacity depends on both individual-level characteristics as well as firm-level processes. However in the empirical portion of that paper they chose to use firm-level R&D expenditures as a proxy for absorptive capacity, a choice which glossed over many potentially interesting processes taking place at lower levels of analysis and which set the tone for a great deal of subsequent research.

We propose to extend the concept of absorptive capacity by first explicitly recognizing the role of the individual, then exploring the implications of such recognition. Borrowing from economic work on agency theory (Jensen & Meckling 1976) and psychological theories of intrinsic and extrinsic motivation (Sansone & Harackiewicz 2000), we suggest that individuals learn some things because they have to, and other things because they want to. Using logic and terminology from Robert Burgelman (1983) we offer a new typology of absorptive capacity as being *induced*, an organization's ability to identify, assimilate, and exploit new knowledge through

activities directed by organizational leaders, or *autonomous*, an organization's ability to identify, assimilate, and exploit knowledge through the independent, self-directed activities of its members. Burgelman suggests that induced activities, or those directed from the top of the organization, are likely to support the existing strategic paradigm while autonomous activities are more likely to result in the opening of new strategic vistas. Similarly, we argue that the source of individual motivation for learning (intrinsic interest versus extrinsic direction) is likely to affect the type of knowledge collected. Induced learning is expected to result in local search and the collection of knowledge similar to what is already known. Autonomous learning is expected to result in more wide-ranging search and the collection of more varied knowledge.

We go on to suggest that the differential ability of firms to undertake each kind of learning will affect the firm-level behaviors of entrepreneurship and innovation. Taking a definition of entrepreneurship as "identifying and exploiting opportunities in the external environment" (Hitt, Ireland et al. 2001, Pg. 480), we suggest that the increased variety of knowledge and information which can be collected through autonomous learning will allow firms to recognize more opportunities and thus be more likely to behave entrepreneurially. We also suggest that autonomous absorptive capacity will be more strongly related to radical innovation. Innovation is often conceived of as resulting from the recombination of previously unrelated pieces of knowledge (Penrose 1995). If we examine the range of innovations on a scale from "incremental" to "radical", where radical is defined as "the capability to generate innovations that significantly transform existing products and services" (Subramaniam & Youndt 2005, Pg. 452), then we can argue that the variety of knowledge available for recombination should be related to the

radicalness of the resulting innovations. A homogenous pool of knowledge is likely to produce recombinations which differ little from the underlying technology, or in other words is likely to result in mostly incremental innovations. Thus autonomous absorptive capacity, which represents a more wide-ranging search for knowledge, should be more positively related to the degree to which a firm is capable of radical innovation.

Exploring absorptive capacity as a multi-level construct requires much more nuanced measures than the typical firm-level financial or technological proxies (Lane, Koka et al. 2006). We test our hypotheses on the relationship between various types of absorptive capacity and innovation and entrepreneurship by using a survey instrument which we administer to all employees and managers of small, technology-oriented companies. The kind of fine-grained data which can be obtained through such primary data collection will add a great deal of richness to our understanding of the phenomena.

This work contributes to the literature in several ways. First, it adds to the body of work which has attempted to explore the subtleties of absorptive capacity by subdividing the construct into various components such as relative absorptive capacity (Dyer & Singh 1998; Lane & Lubatkin 1998) and potential/realized absorptive capacity (Zahra & George 2002). We also answer the call from Lane, Koka, et al. (2006) to break open the black box of absorptive capacity and examine in more detail the ways in which it arises and affects organizational outcomes. Third, this work occupies an interesting and underexplored space as a bridge across levels of analysis from individual-level to organizational-level learning. Fourth, it extends the findings of Dushnitsky & Lenox (2005) on the relationship between absorptive capacity and corporate venturing by

exploring how the different types of absorptive capacity affect a broader range of entrepreneurial activities.

The remainder of the chapter is organized as follows. In the next section we will summarize the stream of literature on absorptive capacity which began with Cohen & Levinthal (1989; 1990) with an eye towards clarifying the underlying definitions and assumptions which have driven the development of work in that area. Next will be a section in which we develop our theoretical model, followed by a discussion of methodology and results.

1.2. Literature Review

The concept of absorptive capacity was first introduced by Cohen & Levinthal (1989) in The Economic Journal. In that paper, they offer an economic model which suggests that resources spent on R&D not only lead to the development of new information, but also contribute to an organization's ability to "identify, assimilate, and exploit knowledge from the environment." (Pg. 569) They label this latter ability "absorptive capacity". They argue that absorptive capacity, represented in their model by the Greek letter γ, is determined by several factors: the R&D effort of the firm, the complexity of the knowledge to be assimilated, and the specificity with which the information in question is relevant to the needs of the firm. Using analytical economics and empirical tests on line of business data, they demonstrate that there are conditions in which a high likelihood of knowledge spillover will actually encourage rather than discourage investment in R&D, contrary to conventional wisdom at the time (Arrow

1962; Nelson 1959). The positive effect of R&D on a firm's ability to absorb knowledge which spills out of other firms can more than offset the losses associated with the leakage of the direct fruits of that R&D effort, given the right combination of system parameters.

The same authors go on to extend the concept of absorptive capacity in a 1990 paper in Administrative Science Quarterly (Cohen & Levinthal 1990). Where the initial paper was purely economic in its reasoning, the 1990 extension offers a more socio-cognitive rationale for the existence of absorptive capacity. In this paper they define absorptive capacity as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends." (Pg 128) Drawing on literature in psychology, they argue that the depth and breadth of prior knowledge improves an individual's ability to learn. They extend that logic to the level of the organization, suggesting that an organization's ability to absorb external knowledge will depend on the level and variety of knowledge held by individual members. They also recognize that this is only part of the story. Given that their definition of absorptive capacity includes the application of knowledge, it is necessary that the knowledge absorbed by organizational members be able to flow to those who are best positioned to put it to use. Thus the absorptive capacity of an organization depends both on the characteristics of the individual members as well as the "ease or difficulty of the internal communication process". (Pg 132)

There are particular elements of these two seminal papers which deserve special note. First of all, the 1989 paper makes several very strong assumptions. Among them are that "additions to [a firm's] stock of technological and scientific knowledge…increases the firm's gross earnings". (Pg 571) While this is undoubtedly true in certain situations, it is not difficult to imagine cases where the technological and

scientific knowledge in question is irrelevant to the firm's operations. In cases where the expenditures necessary to either create or absorb the knowledge are great relative to the realized value of having the knowledge, such increase in knowledge could actually reduce gross earnings. On the same page, the authors state "We assume that the firm's own R&D increases absorptive capacity." (Pg 571) It is important to keep in mind the fact that the relationship between R&D and the ability of the firm to acquire and exploit external knowledge is simply assumed with little in the way of theoretical justification. That is an especially important assumption given the central role that R&D assumes in later work which applies the absorptive capacity framework. Second, it is of interest to note the way in which characteristics of the knowledge environment, specifically the complexity and relevance of the knowledge which is available for assimilation, are endogenized in the 1989 paper. Given that absorptive capacity is described as a firm-level "ability", it is worth questioning whether such external factors should be considered valid determinants of the construct. To make an analogy, while raising a basketball hoop from ten feet to twelve feet would make it more difficult for a given player to successfully execute a dunk, it would in no way affect their intrinsic ability to jump. Similarly with absorptive capacity, external factors such as the characteristics of the available knowledge may make it more or less likely that a firm *will* learn, but should not be expected to affect their *ability* to do so.

With regards to the 1990 paper, it is interesting to consider the implications of the theoretical development regarding the effects of individual cognitive structures and ease of communication on an organization's absorptive capacity. This seems to suggest several things. First, there is no theoretical reason to believe that personnel involved in

R&D activities would be the only ones capable of bringing new knowledge into the organization. Cohen & Levinthal clearly state that the breadth of knowledge is a critical determinant of the likelihood of recognizing and absorbing new knowledge. Given that the breadth of knowledge held by the entire population of organizational members is likely to be higher than that of a subset of members who are all involved in performing the same function, it seems likely that focusing on any one particular function will yield only part of the picture. Second, the 1990 paper in essence argues that absorptive capacity is not something which firms "have", but something which firms "do". Knowledge gained by individual members is of little or no use until it is communicated, either throughout the organization in the case of general purpose knowledge or to the point of best use in the case of more specific knowledge. The organizational processes by which this communication takes place is of the utmost importance.

With those points in mind, it is curious to note that despite the well-developed theoretical model of absorptive capacity as composed of the ability of individual employees to learn and the organization's ability to share that learning, they once again test their predictions using R&D expenditure as a proxy for absorptive capacity. This ignores two critical aspects of the theory: the role of individual cognitive structures and the importance of internal processes which allow external knowledge collected by one individual to be communicated to the point of best use and subsequently exploited. In addition, it unnecessarily constrains the task of learning to being performed by a small subset of the organizational members. As we develop our theoretical and empirical models, we will attempt to address some of these concerns.

The 1989 and 1990 papers by Cohen & Levinthal attracted a large and increasing amount of attention over the subsequent years. According to the Web of Science article database, those two works have been cited by 1716 unique papers in the intervening 17 years with 254 citations coming in 2006 alone.

In an extremely thorough review of the work which has cited Cohen & Levinthal (1989; 1990), Lane, Koka, & Pathak (2006) point out that the vast majority (78%) of that work has used Cohen & Levinthal as "a minor citation, with little or no discussion" (Pg. 840) Of the remaining 22% they identify only four papers that "extend or refine the construct" (Dyer & Singh 1998; Lane & Lubatkin 1998; Van den Bosch, Volberda et al. 1999; Zahra & George 2002). Dyer & Singh (1998) and Lane & Lubatkin (1998) both extend absorptive capacity in similar ways, by introducing partner specificity. Both papers argue that a firm's ability to learn from the environment will be conditioned by the source of the knowledge. In other words, Firm A may be better able to absorb knowledge from Firm B than it would be from Firm C. This partner specificity is a function of similarities in the existing knowledge bases, structures, dominant logics, and the existence of interaction routines between the partners. There are subtle differences in the theoretical developments of the two papers. Where Lane & Lubatkin (1998) focus on one-way learning in which knowledge held by a teacher firm is absorbed by a student firm, Dyer & Singh (1998) hold open the possibility that knowledge may flow both ways and focus on the relational rents which can accrue to both partners as the result of such sharing.

Van den Bosch, Volberda, & de Boer (1999) offer a coevolutionary framework in which absorptive capacity both changes over time as the result of incremental increases

to the existing knowledge base as well as leads to changes in the external environment by affecting expectation formation and the decision to either exploit or explore (March 1991). They introduce a model in which knowledge absorption is characterized on the dimensions of efficiency, scope, and flexibility. Exploitation of knowledge in stable environments requires highly efficient absorption but low levels of scope and flexibility. Exploration of knowledge in highly turbulent environments requires just the opposite set of characteristics.

Zahra & George (2002) define absorptive capacity as "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability." (Pg. 186) They then split the construct into two elements. The first, potential absorptive capacity, encompasses the processes of acquisition and assimilation. The second, realized absorptive capacity, encompasses the process of transformation and exploitation. A firm's *efficiency factor* is calculated as a ratio of realized absorptive capacity to potential absorptive capacity and is argued to be bounded by zero and one. There are several points worth noting. First, the Zahra & George (2002) definition differs from the original Cohen & Levinthal (1989) definition primarily in the addition of "transformation". While a useful addition in terms of allowing the construct to be neatly cleaved, it is only a conceptually interesting extension if we believe that "exploitation" in the original Cohen & Levinthal (1989) was intended to encompass only the direct application of the newly acquired knowledge in its as-received condition. We believe that this was never the original authors' intention.

Second, it is worth noting the subtle and yet critical shift of the definition from an "ability" (Cohen & Levinthal 1989; Cohen & Levinthal 1990) to a "process" (Zahra &

George 2002). Examining the Zahra & George (2002) model from the perspective of the original definition reveals some important conceptual problems. First, if absorptive capacity as a construct is intended to represent an ability, then it makes little sense to talk about potential or realized absorptive capacity. The realization of the ability is a consequence, not an internal feature of the construct itself. Second, if absorptive capacity is an ability, then there is no reason to think that a firm's ability to acquire and assimilate knowledge would be any greater than its ability to transform and exploit it. Certainly knowledge which is never acquired will be unavailable for transformation or exploitation, but that is a function of outcomes rather than of ability.

Allow us to illustrate with two examples. First, a firm may be highly skilled in internal innovation and commercialization and yet be so internally focused as to be unable to effectively notice knowledge which resides outside its boundaries. Such a firm would likely be high in the ability to transform and exploit knowledge but low in the ability to acquire and assimilate knowledge, exactly opposite the relationship supposed by Zahra & George (2002). Second, a firm may operate in such an impoverished environment that there is little or nothing in the way of external knowledge available for absorption. The fact that no knowledge is available to be absorbed and thus nothing is transformed or exploited says nothing about the firm's *ability* to do so given the opportunity.

In addition to their thorough review of the ways in which absorptive capacity has been used, misused, and extended in the literature, Lane, Koka, & Pathak (2006) distill what they see as a set of five assumptions which have limited progress in absorptive capacity research. The first limiting assumption is that absorptive capacity is only

relevant in R&D-related contexts. They rightly point out that there are other types of external knowledge which are just as important as technical advance to improving firm performance, including "managerial techniques, marketing expertise, and manufacturing know-how." (Pg. 852) Learning from the environment can take place through multiple gateways into the organization, and can affect any element of the organization's products, processes, or even structure. The second limiting assumption identified is that firms develop absorptive capacity in response to the existence of external knowledge. To the contrary, firms must already possess a certain level of absorptive capacity before they can even begin to recognize the existence or value of external knowledge. As Lane, Koka, & Pathak point out, "spillovers 'favor the prepared'—those firms that maintain their investment in R&D and absorptive capacity." (Pg. 852)

The third limiting assumption is that relevant prior knowledge is the same as absorptive capacity. Evidence for this assumption is prevalent in the empirical work which uses either R&D spending or patent stocks as a proxy for absorptive capacity. A careful reading of the original theory strongly suggests that while relevant prior knowledge certainly contributes to absorptive capacity, there are a number of other individual and firm level characteristics which are equally important. Technical expertise in a particular area does likely improve a firm's ability to recognize related new knowledge in the environment, but it does not necessarily imply anything about their ability to exploit the new knowledge. The fourth limiting assumption has to do with the source of rents arising from the possession of absorptive capacity. Most authors, by focusing on the stock of prior knowledge as a proxy for absorptive capacity, implicitly invoke Ricardian rents predicated on the scarcity of that particular combination of prior

knowledge. However there is also an argument to be made in favor of efficiency rents arising from an organization's differential ability to make use of the knowledge which they possess. Taken together, these third and fourth limiting assumptions point to the need for more detailed focus on the underlying processes which contribute to an organization's ability to learn from the environment.

The fifth and final limiting assumption is that absorptive capacity resides in the firm alone. While absorptive capacity is a firm-level construct, it is determined in large part by the characteristics of individual employees. It is the individual who first spots potentially valuable external knowledge, and it is the individual who provides the creative spark necessary to profitably exploit the newly acquired knowledge. By focusing almost exclusively on macro firm-level proxies for absorptive capacity, authors have largely overlooked the importance of characteristics at multiple levels of analysis.

1.3. Theory

The primary goal of the current work is to extend the literature on absorptive capacity by explicitly recognizing the important role played by individuals in determining the firm-level absorptive capacity. This recognition leads to a series of interesting questions. First, what motivates individual organization members to absorb knowledge from the environment, share it with other members of their organization, and ultimately pursue commercial applications of that knowledge? Two, do different motives for learning lead to qualitatively different kinds of learning? And three, if different motives

do lead to different kinds of learning, what impact might those different kinds of learning have on important firm-level outcomes such as entrepreneurship and innovation?

We address these questions by drawing on literature in psychology and sociology (Burgelman 1983; Burgelman 1983) to suggest that there are in fact differences in the "why" of individual learning which translate into strategically important differences in "what" is learned. We offer a theoretical extension to the construct of absorptive capacity which distinguishes between what we will call "induced" and "autonomous" absorptive capacity. Formal definitions will be offered later, but for the sake of exposition let us briefly describe the former as the ability to absorb knowledge from outside the environment through formal, centrally directed activities. The latter can be described as the ability to absorb knowledge from outside the environment through informal, unplanned activities. Organization members bring in some new knowledge because they are directed to as part of their normal duties, but there is also knowledge which is absorbed through personal interest or curiosity. We argue that firms are likely to vary in their relative capacity for these two types of absorption, and that this distinction has important consequences for both the strategic precedents and outcomes of absorptive capacity. Induced and autonomous absorptive capacity lead to different kinds of learning, and vary in the degree to which they respond to managerial adjustment efforts. Understanding more clearly the levers available for managers to affect their firms' ability to absorb specific kinds of knowledge is an important step towards making absorptive capacity literature more "strategic".

We then consider how the proposed elements of autonomous and induced absorptive capacity affect two specific strategic outcomes, corporate entrepreneurship

and its ability to produce radical innovations (Garcia & Calantone 2002; Gatignon, Tushman et al. 2002). Where Dushnitsky & Lenox (2005) suggest that the overall level of absorptive capacity predicts investment in new ventures, we offer a more nuanced view. Induced activities are likely to be deeply rooted in the existing strategic context, and thus are unlikely to lead to the recognition of opportunities outside of incremental advancement along the current trajectory. Autonomous activities, however, are unencumbered by such shackles. Organizational members who undertake activities unrelated to their role in the organization are more likely to be exposed to new ideas which might reveal new strategic directions which can be pursued by the organization (Burgelman 1983). A similar argument is made around the radicalness of innovation. Subramaniam & Youndt (2005) define incremental innovative capability as "the capability to generate innovations that refine and reinforce existing products and services" and the obverse, radical innovative capability, as "the capability to generate innovations that significantly transform existing products and services." (Pg. 452) The wider breadth of knowledge acquired by a firm through undirected, autonomous activities is likely to be associated with more novel recombinations and more radical innovations, while directed, induced learning activities will be more closely associated with incremental innovations designed to improve existing operations.

Testing these theories requires the development of new empirical measures of absorptive capacity which are more consonant with the underlying theory. Previous work going all the way back to the original Cohen & Levinthal (1989; 1990) papers on the subject have tended to use very coarse measures of R&D expenditure or patent stocks (Dushnitsky & Lenox 2005) as proxies for firm absorptive capacity. While these

measures have the advantage of being easily observable and thus amenable to large-scale testing, there are limitations to their ability to capture the subtleties of the phenomenon. Given the Cohen & Levinthal (1989) conception of absorption as a three-step process (recognition, assimilation, and application), it should be obvious that simple measures of current knowledge stocks (patent counts) and flows (R&D spending) (Dierickx & Cool 1989) are not sufficient. Our empirical measures accomplish two goals: they more directly gauge a firm's ability to perform each of the three steps required for successful absorptive capacity, and they allow us to distinguish between autonomous and induced absorptive capacity.

There are two intermediate steps taken on the way towards developing the model of induced and autonomous absorptive capacity. The first is to argue for a return to the Cohen & Levinthal definition of absorptive capacity as a firm level *ability* rather than as a process or outcome. This has implications for the way in which we think about and measure the construct. The second intermediate step is to reassert the multidimensional character of absorptive capacity. We claim that the three constituent elements of identification, assimilation, and exploitation defined by Cohen & Levinthal are independent factors which contribute to the overall firm-level absorptive capacity in a multiplicative fashion. The ability to do each is determined by a different set of organizational characteristics, and the absence of ability in any particular one will severely reduce the overall absorptive capacity of the firm. These intermediate steps, the development of induced and autonomous absorptive capacity, and the arguments regarding the impact of those constructs on innovation and entrepreneurship, will be

taken up in the current section. The empirical measure of the constructs will be discussed in a later section.

The first order of business is to be clear on the definition of the central construct. In their original 1989 paper, Cohen & Levinthal define absorptive capacity as the ability of an organization to "identify, assimilate, and exploit knowledge from the environment" (Pg. 569). In the 1990 piece they alter the definition slightly, to be the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends." (Pg 128) While absorptive capacity is clearly a learning mechanism, the focus on learning from the environment distinguishes it from other forms of learning such as learning by doing (David 1975; Rosenberg 1976) or learning by using (Rosenberg 1982; Malerba 1992). There are important differences between the two Cohen & Levinthal definitions, not the least of which being the significant addition of the word "value" in the later work. We choose here to adopt the earlier definition with the understanding that the choice to exploit a piece of knowledge rather than discard it implies a certain value judgment.

What is common across both Cohen & Levinthal definitions is a focus on absorptive capacity as a *firm-level ability*. In other words, a firm's level of absorptive capacity is meant to reflect the degree to which the firm possesses the capacity to learn from the environment. However, they proceed in their analytical model (Cohen & Levinthal 1989) to muddy the water by including characteristics of the environment outside the firm as determinants of absorptive capacity. Specifically, they suggest that the complexity of the knowledge to be assimilated and the specificity with which the information in question is relevant to the needs of the firm help determine the firm's

absorptive capacity. We argue that this confounding of internal and external factors is not only inconsistent with the definitions offered but also has complicated the process of advancing the theory. If one accepts either of the original definitions of absorptive capacity as an "ability", then it should be clear that the knowledge environment outside the firm is exogenous to the construct in question. To make an analogy, while raising a basketball hoop from ten feet to twelve feet would make it more difficult for a given player to successfully execute a dunk, it would in no way affect their intrinsic ability to jump. Similarly with absorptive capacity, external factors such as the characteristics of the available knowledge may make it more or less likely that a firm *will* learn, but should not be expected to affect their *ability* to do so in any way. This is not meant to deny that there is a dynamic relationship between the relative abundance of knowledge available in the environment and firm-level absorptive capacity. Clearly a more munificent environment which offers more opportunities to learn will, all else being equal, lead to more learning. This learning will increase the stock of knowledge held by a firm and thus boost the firm's ability to learn more in the future. However *at a point in time,* the environment should not be expected to affect absorptive capacity. This leads to our first proposition:

> **Proposition 1:** Absorptive capacity is a firm-level ability which is determined solely by characteristics endogenous to the organization. External factors at a given point in time have no direct influence on a firm's capacity for learning from the environment.

Explicitly recognizing absorptive capacity as an ability rather than a process or an outcome has important implications for research. For example, Zahra & George (2002)

define absorptive capacity as "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability." (Pg. 186) They go on to divide the construct into potential absorptive capacity, encompassing acquisition and assimilation, and realized absorptive capacity, encompassing transformation and exploitation. They argue that potential absorptive capacity is always greater than realized and introduce an efficiency factor which is the ratio of the two. Careful consideration shows that not only is their definition of absorptive capacity inconsistent with the original construct, but that this inconsistency leads to some claims which seem indefensible from the point of view of the original theory. For example, there is no reason to believe that a firm's *ability* to acquire and assimilate knowledge is necessarily higher than its *ability* to transform and exploit it. A firm may have excellent skills in internal innovation and commercialization and at the same time be so inwardly focused that it is unlikely to acquire knowledge from the environment.

Perhaps the greater problem associated with the shift away from an ability-based definition of absorptive capacity is the way in which it deemphasizes characteristics of organizational members themselves. As we discuss in further detail later, organizational learning takes place only if and when individual learning has occurred first (McKee 1992). As emphasized in the literature on cognitive structures, individuals often learn more as a function of what they are rather than what they do (Bower 1981; Cohen & Levinthal 1990). For example, an individual with a strong background in basic algebra will be better able to learn concepts associated with more advanced mathematics regardless of the effort they expend studying the new subject (Ellis 1965). In other

words, focusing on firm-level "routines and processes" risks overlooking the critical importance of individual characteristics which affect individual learning, a necessary precondition for organizational learning.

This brings us to the second issue under consideration here, the multidimensional nature of the construct. It should be clear from the original Cohen & Levinthal definitions that a firm's ability to absorb knowledge from the environment is contingent on its capacity to do three somewhat independent things: 1) identify external knowledge, 2) assimilate external knowledge, and 3) exploit external knowledge. A lack of capability in any one of those elements will result in a greatly diminished absorptive capacity. An ability to identify knowledge is of little use if it cannot be assimilated, just as the ability to exploit knowledge is of little use if there is no new knowledge being identified or assimilated to provide grist for the exploitation mill. Although this seems to be a relatively straightforward observation, the majority of authors have chosen to ignore the complexity of the construct by using firm-level proxies like R&D intensity as a measure of absorptive capacity (Meeus, Oerlemans et al. 2001; Tsai 2001). Using such coarse measures leads to a tendency to treat absorptive capacity as a "black box" phenomenon, the inner workings of which we understand very little. Because of the importance of this point for our further discussion, we state it as our second proposition:

> **Proposition 2:** Absorptive capacity is composed of the ability to identify, assimilate, and exploit external knowledge. A lack of ability in any one dimension will lead to a lack of absorptive capacity

Recognition of the multidimensional nature of absorptive capacity leads next to a consideration of levels of analysis. As previously mentioned, most researchers have used

easily observable firm-level characteristics such as R&D intensity or patent portfolios as proxies for absorptive capacity. It should be clear at this stage that this practice is less than satisfactory. The theory would be better served by a more fine-grained focus on the specific mechanisms which underlie an organization's ability to identify, assimilate, and exploit knowledge. For example, numerous authors have suggested that organizations learn only if the members of the organization learn something first (Cohen & Levinthal 1990; McKee 1992). In other words, it is individual members of the organization who serve the initial function of recognizing knowledge and personally assimilating it. However the ability of individuals to learn is not enough to endow organizations with absorptive capacity. Knowledge which is acquired by one individual may be of little use to them but of great value to someone else in the organization, or it could be something which is of use to everyone. Unless there are organizational structures, cultures, and processes in place which encourage or at least allow knowledge to flow among members, then knowledge will remain isolated and largely unused (Szulanski 1996). Even if such structures, cultures, and processes are in place, the organization must still be able to exploit that knowledge in order to fully satisfy the definition of having a high absorptive capacity. For example, someone within a firm may acquire from the environment knowledge about a useful new production technology and communicate that to those to whom the information is useful, but if the firm is especially risk averse or does not have the financial resources to implement the technology then they will have failed to meet the requirements for having a high absorptive capacity.

So it is clear that some processes which determine a firm's absorptive capacity operate at the individual level (identification and personal assimilation), some operate at

the small group or network level (communication or group assimilation) and some at the organizational level (organizational assimilation and exploitation). Here we focus on exploring the implications of individual-level characteristics as the first step in the chain leading to absorptive capacity. Cohen & Levinthal (1990) recognized very clearly that individual characteristics such as cognitive structures and other related psychological processes are intimately related to an individual's ability to identify and assimilate knowledge from the environment (Ellis 1965; Bower 1981). They explore in some detail the questions of *how* individuals learn, but give little thought to the question of *why*. Some light can be shed on that question by appealing to the psychological literature on intrinsic and extrinsic motivation (Sansone & Harackiewicz 2000). Intrinsic motivation refers to the drive to perform some activity because of the value or enjoyment derived by the individual as a result of the activity. Extrinsic motivation refers to the drive to perform some activity because of some external reward or punishment which is associated with the activity. Individuals do some things because they want to and other things because they will either get something good if they do or something bad if they do not. This can be applied to learning to suggest that some learning will take place in a self-directed, intrinsically motivated way, and some learning will take place as a result of extrinsic motivators. Similar arguments can be derived from literature on agency theory (Jensen & Meckling 1976). Agency theory suggests that individuals are rational value maximizers who act in their own interests rather than in the organization's. In the context of absorptive capacity, this suggests that individual organization members will undertake learning activities which benefit them personally, but not necessarily the organization. The trick from the organization's point of view is to develop a suitable incentive contract

which will align the interest of the employee with that of the organization (Rousseau & Parks 1992). However, there are two characteristics of the incentive contract which suggest that employees will still pursue individual interests even in the presence of such incentives. One, such contracts are never complete. There is no economic incentive for improving the contract beyond the point where the marginal cost of such improvement equals the marginal benefit of further reducing self-interested behavior. Two, employee learning is not limited to the hours encompassing their service to the organization. They are free to pursue any avenue of learning they desire on their own time.

This suggests that while it may be possible to motivate some learning by offering a particular package of incentives, other learning will proceed largely through the intrinsically motivated actions of the employees themselves. To cast this distinction in a theoretically relevant and useful way, we borrow terminology from Robert Burgelman (1983). Burgelman describes two types of strategic actions: *induced* actions which are performed under the direction of management, and *autonomous* actions which are performed by organization members independently. This distinction can be usefully applied to absorptive capacity. Learning from the environment can take place either as part of a concerted effort directed by management or as an unstructured process of absorption which is not directed towards any particular organizational goal. We use the term "induced absorptive capacity" to describe the former, and "autonomous absorptive capacity" to describe the latter. The intrinsic motivation to learn which arises from personal interest in a subject is associated with autonomous learning. Motivation through external rewards and incentive contracts is associated with induced learning. The implication is that the characteristics which allow for the efficient and effective search for

external knowledge in an area which has been identified as strategically relevant differs from those characteristics which allow a firm to more passively recognize potentially valuable external knowledge when its members stumble across it. This leads to our next proposition:

> **Proposition 3**: Absorptive capacity is composed of two related, yet distinct elements: induced absorptive capacity and autonomous absorptive capacity

Let us be careful to define the terms. Consistent with our focus on absorptive capacity as a firm-level ability, we define induced absorptive capacity as the ability of a firm to intentionally identify, assimilate, and exploit external knowledge in a formally planned, centrally controlled manner. In contrast, we define autonomous absorptive capacity as the ability of a firm to identify, assimilate, and exploit external knowledge through the informal and self-directed activities of the employees. Note that these two distinct abilities are theorized to operate across all three component elements of absorptive capacity, although possibly not to the same extent. For example, it would be reasonable to suggest that intrinsically motivated, self-directed activities will have more potential impact on the identification and communication of relevant knowledge, which are largely an individual or network based activities, than it would on the exploitation of that knowledge within the firm, which it could be argued will likely involve a much larger group of decision makers and more stringent constraints.

Examples of the kinds of characteristics and behaviors which are expected to contribute to the two distinct abilities can help clarify the point. Individuals who hold company-sponsored memberships in various trade or professional organizations are likely

to have the opportunity to identify and assimilate knowledge which is relevant to the existing operations. By contrast, individuals who are active in organizations which are unrelated to their organizational roles such as various community groups or associations related to personal hobbies are likely to be exposed to a broader range of information which they find to be of interest. Once an individual has identified a piece of knowledge, they can communicate that within the company through either formal or informal channels. Standing committees or ad hoc task forces charged with fixing existing problems or improving current operations are likely to be more receptive to the communication of knowledge which is directly relevant to the existing situation, whereas more informal types of communication networks will be more permissive of transmitting knowledge whose application may not be immediately apparent.

There is evidence in the literature supporting such a theoretical bifurcation of absorptive capacity. For example, Itami & Numagami (1992) argue that formal planning procedures are unlikely to be effective in developing future core competencies, since "these tools are overly concerned with contemporaneous fit between strategy and resources." (Pg. 125) They go on to discuss the emergence of new theoretical directions by saying that "idea generation may, in the beginning, be quite fragmentary and autonomous rather than very systematic and well-coordinated." (Pg. 128) Silverberg (1991) draws a distinction between policies designed to encourage the diffusion of existing technologies and those designed to encourage innovation in unexplored technological regimes. Kelley & Brooks (2001) discuss learning through informal exchanges (or learning through "osmosis") and more structured learning through formal

trade organizations or efforts to obtain relevant information from customers and suppliers.

Any such division of a learning related phenomenon into two components naturally invites questions about how the two relate to exploration and exploitation (March 1991). We argue that there are several key differences which make the proposed theory distinct. First, exploration and exploitation in the March model are *activities* that firms perform, whereas induced and autonomous absorptive capacity are *abilities* which firms possess. Beyond that, we can see elements of exploration and exploitation in both of our constructs, autonomous and induced. For example, organizational members may explore either because they were told to by the organizational hierarchy, or because they are pursuing their own personal interest. Likewise, in either case the firm must be able to exploit the knowledge which is collected in order for us to claim that they are high in either kind of absorptive capacity.

Previous authors have discussed the consequences of absorptive capacity in terms of innovative capacity (Cohen & Levinthal 1990); expectation formation and the choice to follow either an exploration or exploitation strategy (Van den Bosch, Volberda et al. 1999); and competitive advantage through strategic flexibility, innovation, and performance (Zahra & George 2002). Dushnitsky & Lenox (2005) suggest that absorptive capacity increases the likelihood that a firm will invest in new ventures. Our goal is to explore the implications of the proposed theoretical bifurcation of absorptive capacity on two specific firm-level behaviors: corporate entrepreneurship and the introduction of radical innovations. We first address the question of entrepreneurship.

Any work aimed at describing, explaining, or predicting entrepreneurship must begin with a discussion of definitions. Consistent with a field in a pre-paradigmatic stage of development, there is little consensus on how best to define the central construct of "entrepreneurship". Table 1.1 is a sampling of definitions which have been offered by different authors in the literature and is by no means comprehensive. Clearly there is little consensus (Lumpkin & Dess 1996). Definitions range from the extremely broad conception of entrepreneurship as "the process of…pursuing opportunities" (Stevenson & Jarillo 1990, Pg. 23) to the extremely narrow view of entrepreneurship as "the creation of new organizations" (Gartner 1988). Lumpkin & Dess (1996) make a distinction between entrepreneurial action, which they say is characterized by new entry, and the entrepreneurial process, characterized by the degree to which a firm can be described as being oriented towards autonomy, innovation, proactiveness, and risk taking. In doing so they extend the construct of entrepreneurial orientation originally introduced by Miller & Friesen (1982) and subsequently used by many others (Covin & Slevin 1989; Morris & Sexton 1996; Knight 1997; Lyon, Lumpkin et al. 2000; Attuahene-Gima & Ko 2001).

Table 1.1: Definitions of entrepreneurship[1]

Author	Definition
Hisrich 1989	The process of creating something different with value by devoting the necessary time and effort; assuming the accompanying financial, psychological, and social risks; and receiving the resulting rewards of monetary and personal satisfaction
Thornton 1999	Creation of new organizations, which occurs as a context-dependent, social and economic process
Aldrich and Waldinger 1990	Combining of resources in novel ways so as to create something of value
Shane and Venkataraman 2000	Processes of discovery, evaluation, and exploitation of opportunities
Gartner 1988	Creation of organizations
Lumpkin and Dess 1996	New entry – entering new or established markets with new or existing goods or services; act of launching a new venture, either by a start-up firm, through an existing firm, or through internal corporate venturing
Sharma and Chrisman 1999	Acts of organizational creation, renewal, or innovation that occur within or outside an existing organization
Hitt, Ireland et al. 2001	Identifying and exploiting opportunities in the external environment
Ireland, Hitt et al. 2001	Creating new resources or combining existing resources in new ways to develop and commercialize new products, move into new markets, and/or service new customers
Lounsbury and Glynn 2001	Citing, Venkataraman (1997), discovering, creating, and exploiting opportunities in the form of goods and services
Zahra 2005	Recognizing and exploiting opportunities by reconfiguring existing and new resources in ways that create an advantage
Stevenson and Jarillo 1990	A process by which individuals – either on their own or inside organizations – pursue opportunities without regard to the resources they currently control
Sarkar, Echambadi et al. 2001	Creation of value through the discovery and exploitation of profitable business opportunities, usually manifested as market entry or new product introduction

[1] Special thanks to Tim Holcomb and Justin Webb for their work in developing this table

Barringer and Bluedorn 1999	Citing Schumpeter (1936), the process of creative destruction, in which the entrepreneur continually displaces or destroys existing products or methods of production with new ones
Birkinshaw 1997	A predisposition towards proactive and risk-taking behavior (Covin & Slevin, 1991; Miller, 1983); use of resources beyond the individual's direct control (Kirzner, 1973; Stevenson & Jarillo, 1990); or a clear departure from existing practices (Damanpour, 1991)
Stopford and Badenfuller 1994	Innovations that require changes in the pattern of resource deployment and the creation of new capabilities to add new □ossibilities for positioning in markets
McMullen and Shepherd 2006	Behavior in response to a judgmental decision under uncertainty about a possible opportunity for profit
Ireland, Hitt et al. 2003	Creation of newness or novelty in the form of new products, new processes, and new markets as the drivers of wealth creation (Daily, McDougall, Covin, & Dalton, 2002; Lumpkin & Dess, 1996; Sharma & Chrisman, 1999; Smith & Di Gregorio, 2002); Discovering and exploiting profitable opportunities for wealth creation (Shane & Venkataraman, 2000); Bundling resources and deploying them to create new organizational and industry configurations (Schoonhoven & Romanelli, 2001)
Dobrev and Barnett 2005	The participation of an individual in the founding of a new organization
Hult, Ketchen et al. 2002	The pursuit of new market opportunities and the renewal of existing areas of an organization's operations (Naman & Slevin, 1993)
Zahra 1996	Corporate entrepreneurship – Innovation aimed at business creation and venturing, and strategic renewal (Zahra & Covin, 1995)
McKelvey 2004	An activity focusing on new order creation rather than on equilibrium

Without minimizing the validity or contribution of the many authors who have attempted to address the definition of entrepreneurship, we focus here on the definition and typology offered by Hitt, Ireland, et al. (2001) and Schollhammer (1982). Hitt, Ireland, et al. (2001) define entrepreneurship as "identifying and exploiting opportunities

in the external environment" (Pg. 480). This definition is superior for our purpose for several reasons. First, relying on a definition which is extant in the literature rather than proposing a new one increases the probability that this work will contribute towards building a cumulative body of knowledge rather than simply adding to the current chaos. Second, the Hitt, Ireland, et al. (2001) definition avoids any potentially troublesome confounding of entrepreneurship and innovation which exists in many other formulations. Given a focus on new entry as a characteristic outcome of entrepreneurship, it seems clear that entrepreneurship can take place even in the absence of innovation. For example, entrepreneurship can be imitative or acquisitive (Schollhammer 1982). Likewise, innovation can take place without necessarily leading to either new entry or pursuit of external opportunities. For example, the shifting of corporate structure to the M-form organizational design was clearly innovative, yet would not fall under the definition of "entrepreneurship" (Chandler 1962). The conceptual division between entrepreneurship and innovation is further consonant with Kirzner's (1997) view of entrepreneurship as a process of opportunity recognition rather than the result of waves of innovation leading to creative destruction (Schumpeter 1950).

Opportunities clearly cannot be pursued unless they are spotted (Stevenson & Jarillo 1990). Even at that, simply spotting an opportunity is not enough. In order to be entrepreneurial, firms must also be able to take actions necessary for the pursuit of the opportunity. To the extent that a firm is better able to recognize, assimilate, and exploit external information on new marketing opportunities or new technological advances which suggest new products or improvements to existing products, the more likely they will be to behave entrepreneurially. Dushnitsky & Lenox (2005) eloquently argue for a

link between the absorptive capacity of the firm and the likelihood of engaging in corporate venturing. Given that corporate venturing is one form of corporate entrepreneurship (aligning to some extent with both the acquisitive and opportunistic types of entrepreneurship), we expect a similar relationship to hold for corporate entrepreneurship in general. To state the Dushnitsky & Lenox (2005) hypothesis in more general terms, we expect the following relationship:

> **Hypothesis 1**: Absorptive capacity will be positively associated corporate entrepreneurship

Where our model departs from previous work is in the recognition of the fact that different types of motivation lead to different kinds of learning, and thus different outcomes. Referring to induced strategic behaviors, Burgelman (1983) says "They make incremental learning likely in known directions, but by the same token may impede learning in *new* directions." (Pg. 1359, emphasis in original). The logic is that the management team which is responsible for allocation of resources is likely too enmeshed in the current strategy to be able to move the organization in unknown directions. To put it in behavioral terms, managers are likely to search for new solutions only in response to perceived problems with the current course of action, and then only in the areas substantially similar to what they already do (Cyert & March 1963). To extend this logic to absorptive capacity, not all types of absorption are created equal. Organizations are likely to direct learning only in areas where there is a recognized need to improve performance of the existing strategy. It would be impossible to induce learning about new strategic directions when there is no way of knowing ex ante what those new directions are or from where they might arise. We expect that this difference in learning

affects both the amount and type of entrepreneurship which is pursued. A firm which excels at centrally planned, formally directed activities of knowledge recognition, assimilation, and exploitation may be especially capable when it comes to improving current operations, but may be less sensitive to the emergence of potentially valuable opportunities which lie outside their area of primary focus. By contrast, organizations which excel at recognizing, assimilating, and exploiting knowledge obtained through the autonomous, undirected activities of employees will be better able to "shift gears" as the opportunity arises. Thus the following hypothesis:

> **Hypothesis 2**: Relative to induced absorptive capacity, autonomous absorptive capacity is more positively associated with corporate entrepreneurship

There is also likely to be differences in the type of opportunity pursued. Schollhammer (1982) defines five types of entrepreneurship: administrative, opportunistic, imitative, acquisitive, and incubative. Administrative entrepreneurship refers to entry which takes place as the result of consistent strategic resource allocations made for the purposes of achieving new entry. Opportunistic entrepreneurship is new entry which takes place as the result of a firm taking advantages of opportunities which are not purposely sought but which are encountered accidentally. Imitative entrepreneurship is entry into product or market arenas in which competitors are already present. Acquisitive entrepreneurship is entry through the purchase of existing firms. Finally, incubative entrepreneurship is entry through investment and nurturing of new ventures either inside or outside the firm. The type of entrepreneurship a firm engages in is likely to be affected by the type of knowledge which the firm is best able to absorb.

When entrepreneurship is the result of centrally planned resource allocation, as is the case with administrative entrepreneurship, a firm's ability to absorb and exploit knowledge in a pre-defined and directed arena is paramount. Thus we expect administrative entrepreneurship to be more positively related to induced absorptive capacity than it is to autonomous absorptive capacity. In order for a firm to pursue a strategy of imitative entrepreneurship, they must already have in place many of the complementary assets required to produce the imitated product or supply the imitated market. The companies which a firm monitors for imitable advances are thus likely to be limited to those companies which do what is substantially similar to the focal firm. This suggests that imitative entrepreneurship is also more positively associated with induced absorptive capacity. By contrast, incubative and acquisitive entrepreneurship have the potential to be more distant from the current operations of a firm. The ability to identify, assimilate, and exploit knowledge unrelated to the existing strategic posture of the firm enables them to recognize opportunities to invest in potentially frame-breaking technologies through venture management, or to diversify into promising new areas through acquisition of whole companies. Thus we expect those types of entrepreneurship to be more positively associated with autonomous absorptive capacity. Finally, opportunistic entrepreneurship is almost by definition the result of autonomous rather than induced absorptive capacity. Schollhammer (1982) describes opportunistic entrepreneurship as resulting from "accidental encounters with technical innovations" (Pg. 213). Autonomous absorptive capacity is very much about the "accidental" collection of knowledge through employee activities which are unrelated to their roles in the firm. These outside activities are likely

to lead to discovery of unexpected opportunities which the company can subsequently exploit. This leads to our next hypothesis:

> **Hypothesis 3**: Relative to induced absorptive capacity, autonomous absorptive capacity is more positively associated with opportunistic, acquisitive, and incubative entrepreneurship, and less positively associated with administrative and imitative entrepreneurship

We can extend this thinking further to examine the effect of induced and autonomous absorptive capacity on innovation. Innovation can be defined broadly as a new idea or invention which is employed in some potentially valuable way (Roberts 1988; Porter 1990; Ahuja & Lampert 2001). The inventions which lead to innovation are often characterized as arising from the recombination of existing resources or knowledge in previously unrecognized ways (Penrose 1995; Rosenkopf & Nerkar 2001). Many attempts have been made in the literature to subdivide innovation into categories (Govindarajan & Kopalle 2006) such as disruptive (Christensen 1997), radical/incremental (Ettlie, Bridges et al. 1984; Dewar & Dutton 1986), and competency destroying/enhancing (Tushman & Anderson 1986). For the sake of focus, we concentrate on the concept of radical versus incremental innovation.

There are numerous extant definitions of "radical" in the context of innovation. Dewar & Dutton (1986) say that radical innovations are those which "contain a high degree of new knowledge" (Pg. 1422) Chandy & Tellis (1998) take a market-oriented perspective when they suggest that a radical innovation is one which involves both a high degree of technological newness and a large increase in customer need fulfillment per dollar. Rosenkopf & Nerkar (2001) offer a similar two-by-two typology when they

define a radical innovation as one which spans both technological and firm boundaries. According to Garcia & Calantone (2002), "radical innovations often do not address a recognized demand but instead create a demand previously unrecognized by the consumer." (Pg. 121) Given the nature of invention and innovation as the result of knowledge recombination, it stands to reason that there would be a relationship between the type of knowledge available for recombination and the type of innovation which results. When the diversity of the available knowledge is relatively low, the recombinations which result are likely to differ little from the original homogenous stock. The more varied the inputs into the recombination process, the more likely the resulting innovations are to be radical in their departure from current practice.

Since absorptive capacity represents the ability to add external knowledge to the internal knowledge stock of the organization (Dierickx & Cool 1989), we would expect the type of absorptive capacity possessed to influence the type of knowledge accumulated and thus the potential for recombination. Specifically, we propose that induced absorptive capacity is likely to lead to the accumulation of knowledge which is largely similar to that already possessed. As discussed previously, learning which takes place under the direction and control of organizational management is likely to be primarily local search triggered by a failure to meet organizational aspirations (Cyert & March 1963). This local search begins in knowledge realms which are close to what the firm already knows, and proceeds farther afield only to the extent that a suitable satisficing solution is not identified locally. Thus the knowledge gathered is expected to bear a strong resemblance to what was already known. The resulting homogeneity reduces the range of innovation which can be expected to arise.

Autonomous absorptive capacity, on the other hand, is likely to lead to much more widely dispersed knowledge. An organization's autonomous absorptive capacity is embodied in its ability to assimilate and exploit knowledge which is brought into the firm serendipitously as a result of the personal interests and activities of the organizational members. Given the great diversity of human interests, hobbies, and passions, we propose that the pool of knowledge which is thus accumulated is likely to be much more varied relative to that associated with induced activities. That variety increases the odds that the resulting recombinations will give rise to some innovations which are significantly different from existing practice.

Clearly any addition to the stock of knowledge represents a possible new source of recombination regardless of its source of origin. However, inasmuch as knowledge is collected through the centrally directed pathways of induced absorptive capacity, we expect the associated innovations to be relatively more incremental. Induced learning is likely to lead to the discovery of new and possibly better ways to do what is already being done rather than entirely new fields of endeavor. Autonomous learning, with its associated breadth and variety, opens the possibility for much more radical innovations which open new strategic vistas. For that reason, we offer our next hypothesis:

> **Hypothesis 4:** Autonomous absorptive capacity is associated with more radical innovation, where induced absorptive capacity is associated with more incremental innovation

1.4. Methods

The types of constructs proposed here pose a difficult empirical challenge. Not only must we be able to distinctly measure the organizational-level ability to identify, assimilate, and exploit information, we must also be able to measure each of those three dimensions separately for induced and autonomous absorptive capacity. The multi-level nature of the constructs requires data both on individual-level characteristics of the organizational members as well as organization-level characteristics such as internal communication systems and culture. There is no secondary data source which contains the level of detail required to test the hypotheses proposed here. Therefore, primary data must be collected through the administration of survey instruments.

This method of data collection has important implications for the selection of a suitable sampling frame. Testing hypotheses on absorptive capacity as a firm-level construct requires data from a large enough population of firms to offer sufficient statistical power. At the same time, the individual-level characteristics which determine absorptive capacity requires detailed data on a significant portion of the individual employees of each organization. This suggests a focus on small organizations. The initial sampling frame for this work is the population of firms which are either located in or associated with the Purdue Research Park. At the beginning of the study there were more than 140 companies active in the park across a range of industries including defense, digital imaging, biomedical, and software. That sampling frame is nearly ideal for several reasons. It is geographically convenient while still maintaining a certain degree of generalizability based on the range of industries covered. The companies tend to be small enterprises, meaning that it may be more reasonable to collect data at the

individual employee level. Also, the affiliation with the university may predispose these firms towards participation in this kind of research. Appendix A contains a list of the companies in the research park.

Numerous steps were taken in order to maximize response rate. CEOs of all Research Park companies were invited to enroll their firms in the study by an e-mail message from Mr. Greg Deason at the Purdue Research Foundation. Our hope was that a message from someone of authority with the PRF, which is responsible for developing the Research Park, would increase the chances that executives would agree to participate. The text of the letter sent by Mr. Deason is included here in Appendix B. After giving interested executives several weeks to respond to the e-mail invitation, we then made personal phone calls to every Research Park CEO in order to further explain the study and invite them to take part. Those which did agree were provided with additional information via e-mail, including explicit instructions and links to the online surveys. The follow-up letter sent to interested executives is included here as Appendix C, and the instructions for employees and executives are included as Appendices D and E.

After some time it became clear that the rate of response was going to be insufficient for the purpose of our study. In order to expand the sampling frame and hopefully boost the statistical power of our analyses, we made a decision to include all companies associated with an Indiana Certified Technology Park. There were 19 such parks including the Purdue Research Park. We contacted the managers of all 19 parks and asked them to pass information about the study along to their member firms. We also contacted the President of the Illinois Technology Development Alliance, a similar program aimed at encouraging the development and growth of small, technology based

firms in the state of Illinois. Their President was interested in the study and agreed to pass information along to his member firms.

The data collection instrument itself consists of two surveys developed by the researchers. One, aimed at the top executive team, consists primarily of questions regarding the entrepreneurial outcomes, innovative outcomes, and general demographic information about the firms. The second, aimed at all other employees, consists of questions designed to measure the degree to which the employees were involved with activities associated with the six elements of autonomous or induced absorptive capacity. Having two separate surveys is helpful in two ways. One, it allows us to collect a broader range of data without inducing as much fatigue in a particular participant. Two, it allows us to collect our dependent variables on entrepreneurship and innovation from one population of respondents (executives) and our independent measures of absorptive capacity from another (employees), thus reducing concerns of bias from having all variables collected from a single source. The surveys themselves are included here as Appendices F and G. More specific information regarding particular variables is discussed in the next section.

1.5. Variables

1.5.1. Corporate Entrepreneurship

Consistent with the definition of entrepreneurship as the identification and exploitation of opportunities in the external environment (Hitt, Ireland et al. 2001), our measure of entrepreneurship concentrates on the outcome or behavior rather than the

entrepreneurial process of proclivity of the firm. Top managers are asked to report on whether or not their firm has been active, as well as the number of times, in each of the five categories of entrepreneurship: administrative, opportunistic, imitative, acquisitive, and incubative. They are also asked to simply rate how entrepreneurial their firm is (Morris & Paul 1987). Top management is asked to respond to these questions because of their comprehensive knowledge of the firm's activities and strategic decisions. The sum of responses to the five questions can then be used as the independent variable for testing Hypothesis 2. The individual responses to those five questions is used to test Hypotheses 3 and 4.

1.5.2. Radical Innovation

Similar to the discussion of entrepreneurship, our measures of radical innovation focus more on the outcome rather than the process which led to it. Doing so avoids some of the potential confounding between our constructs of interest. For example, the Rosenkopf & Nerkar (2001) process-oriented framework uses the source of the knowledge which led to the innovation as one element in determining whether or not an innovation is radical. This is clearly inappropriate for a study which is focused on absorptive capacity, which by definition involves knowledge which originates outside the firm boundaries. Also, because the primary unit of analysis for testing our hypotheses is the firm, perceptual measures of radicalness at the level of the innovation (Green, Gavin et al. 1995) are inappropriate. It would be too much to expect organizational respondents to accurately recall the technological uncertainty, technological inexperience, business

inexperience, and technology cost of all innovations over any timeframe long enough to fairly characterize the organization.

Keeping those limitations in mind, we choose to operationalize radicalness in two ways, one qualitative and one quantitative. The hope is that having both will boost the validity of our results. The qualitative measure is an instrument adapted from Gatignon, Tushman et al. (2002) which is designed to capture managerial perceptions of the organization's general tendencies towards radical innovation. Where their four questions focus just on the radicalness of the product, we have added three additional questions in an attempt to capture how the products introduced affect the marketplace. A firm which realizes that an existing product or a slightly altered one could satisfy a previously unrecognized consumer need could fairly be characterized as undertaking a radical market innovation.

The quantitative measure is patent-based. Patents are required to cite both the scientific literature as well as previously filed patents which have influenced the development of the focal invention. Authors have suggested several measures which take advantage of those citations in order to quantify the radicalness of an invention. One, introduced by Dahlin & Behrens (2005), uses patent citation patterns to measure the degree to which a particular invention is novel (dissimilar from prior inventions), unique (dissimilar from current inventions), and adopted (influences future inventions). They construct measures of dyadic citation overlap between all pairs of patents within a very restricted sampling frame (tennis racket patents). They evaluate novelty by calculating the overlap between a focal patent and all patents filed prior to the focal patent. Uniqueness is calculated as the overlap between the focal patent and all other patents

filed in the same year as the focal patent. The adoption of a focal patent is measured as the overlap between the focal patent and patents filed after the focal patent. High novelty and uniqueness (suggested by low prior and contemporary overlap scores) combined with high impact (suggested by high post overlap scores) are taken as a sign of a radical innovation. This measure, while interesting, is not feasible in the current study. Because of the cross-industry nature of the sample, the number of patents for which it would be necessary to calculate dyadic citation overlap would be staggering. However future extensions of this work which are conducted in more bounded settings might profitably use this measure.

Other options are suggested by Ahuja & Lampert (2001), Carpenter, Narin, & Wolf (1981), and Shane (2001). Ahuja & Lampert (2001) use a simple count of the number of previous patents cited by a focal patent as their measure of radicalness. A patent which cites no other patents is considered to be a pioneer in a new technology and thus a radical innovation. Carpenter, Narin, & Wolf (1981) suggest that the number of previous scientific articles which a particular patent cites is a measure of novelty. The more scientific articles referenced, the more likely it is that the patent is based on basic principles rather than on existing technology. Finally, Shane (2001) measures radicalness of a particular patent as the number of different three digit technology classes which its cited patents belong to. None of these measures is perfect. For example, Dahlin & Behrens (2005) point out that "since many firms deliberately avoid backwards citations (Naiberg 2003), zero citations may indicate a strategic choice rather than highly novel patents" (Pg. 10) To help boost validity, our intention is to construct a multi-dimensional

scale using all three metrics (backward patent citations, backward scientific citations, and the number of three-digit technology classes claimed).

1.5.3. Absorptive Capacity

In order to stay consistent with our theoretical development, it is necessary for us to construct variables representing both induced and autonomous absorptive capacity. Each of those two constructs consists of three components: the ability to identify, assimilate, and exploit knowledge from outside the organization. Thus the variables to be collected can be thought of as falling into a two-by-three matrix. Each element in the matrix is measured using a multiple item survey instrument administered to employees of the firms. As we discussed earlier, the definition of absorptive capacity requires organizations to possess the capability to identify, assimilate, *and* exploit knowledge in order to be considered to have a high absorptive capacity. To reflect that empirically, we intend to construct measures of induced and autonomous absorptive by multiplying together each of the three constituent elements. A multiplicative construction is appropriate given our adoption of the original definition of absorptive capacity as the ability of a firm to identify, assimilate, and exploit external knowledge. The word "and" in that definition carries critical weight. If a firm is able to identify external knowledge but is unable to either assimilate it or exploit it, then by definition that firm does not have absorptive capacity. If a firm has the capabilities necessary to assimilate and exploit knowledge but is so blind as to be unable to recognize what knowledge is available in the environment, then that firm cannot be said to have absorptive capacity. Each element is a

necessary condition for learning through absorptive capacity, and a lack of any one would result in a lack of absorptive capacity. Therefore multiplying a given firm's score on each of the three dimensions is a valid empirical representation of the construct.

Identification is defined here in the sense of "recognition" or "detection" of knowledge. As has been argued previously, identification of external knowledge is a process which operates almost exclusively at the individual level. Organizations see and hear only to the extent that its employees have eyes and ears. Thus in the measures of ability to identify we focus on individual characteristics which are then aggregated to create a firm-level measure. What makes an individual more or less able to identify knowledge in the environment? The conditions necessary for an individual to recognize or identify a piece of knowledge can be divided into elements of exposure and sensitivity. An individual cannot be expected to identify something which they do not see. Likewise, simple exposure to an idea or piece of knowledge will not necessarily cause someone to notice it. The individual must be sensitive to the knowledge in the sense that it interests them or is within their realm of understanding. In the first dimension, individuals who are exposed to multiple sources of knowledge are better positioned to spot something interesting than are those with less extensive contacts. These contacts can arise through a number of sources, including exposure to published materials, personal contacts, and membership in organizations. We measure this by asking organization members to characterize their ego networks (Wasserman & Faust 1999) as well as to report on their reading and web-surfing habits. We propose that membership in organizations which are closely related to an individual's job (trade associations, technical societies, etc.) reflects participation in an activity which is consonant with existing strategies and managerial

direction, thus contributing to induced absorptive capacity. Memberships in organizations which bear no relationship to the individual's employer (hobby clubs, community organizations, etc.) represent self-directed exposure and thus contribute towards autonomous absorptive capacity.

In the second dimension, literature on cognitive psychology suggests that individuals will be more sensitive to knowledge which is similar to that which they already possess (Ellis 1965; Bower 1981). Individuals possess dispositional interests in certain topics which predispose them to be more alert and aware of knowledge pertaining to those topics. Thus an individual is most likely to identify knowledge which is consonant with their prior training, background, and interests. In order to capture this, we collect survey data at the individual employee level on educational experience (level and area of specialization) as well as work experience. We expect that work experience within the same industry as their current employer as well as educational experience within their current functional area within the organization both contribute to induced absorptive capacity, while work and educational experience outside those arenas contribute to autonomous absorptive capacity.

Assimilation is defined here in the sense of integration of knowledge into the existing framework of the organization. Whereas identification occurs at the individual level, assimilation is the process by which individually acquired knowledge is disseminated through the organization. This process can be divided into elements of communication and acceptance. Knowledge collected by one individual must be communicated through the organization in order for it to reach the person or people for whom it holds the most value. They, in turn, must be willing to accept the new

knowledge and integrate it into their personal schema. As with identification, it is necessary to further subdivide the elements of communication and acceptance into characteristics which contribute to either induced or autonomous absorptive capacity. For communication, the autonomous component is measured using a survey instrument designed to capture informal communication which happens outside the chain of command, while the induced component will be based on questions about formal communication which takes place through the established chain of command. This reflects the theoretical distinction between autonomous activities which are undertaken by the employees at their own discretion versus induced activities which are done in response to directives or expectations from superiors. For acceptance, a survey instrument is developed to gauge how accepting individuals in the firm are of new ideas which are related to what they already do (induced) versus ideas which are farther afield (autonomous).

Exploitation is defined in the sense of putting new knowledge to some potentially valuable use. Survey instruments are designed to measure how well a firm is able to implement ideas which are closely related to what they do (induced) and ideas which are less related to current operations (autonomous).

Instruments to measure the ability to identify, assimilate, and exploit knowledge are administered to all employees in each participating organization. While questions on assimilation and exploitation refer to the organization as a whole, questions on identification are directed at the respondents themselves. Therefore it is necessary to aggregate their responses to develop a measure of firm-level ability to identify knowledge. The link between the level of prior knowledge and the ability to acquire new

knowledge is well accepted (Ellis 1965). Our hope is to represent this at the organizational level by averaging the responses to questions such as those on educational level and membership in outside organizations across all employees to develop a single score for the firm. The presumption is that more educated or better connected individuals will be better able to identify new knowledge in the environment, and an organization which has a higher proportion of well-educated or well-connected individuals will be better able to identify knowledge as a whole. However there is also evidence of the value of breadth to learning (Bower 1981). A group of employees who are homogenous in terms of background or education, regardless of how well educated or well connected they may be, are likely to share common blind spots which prevent them from identifying certain types of knowledge. To capture the potential value of variety, we also intend to calculate the standard deviation of those individual traits. We expect that a wider distribution of traits will contribute positively to the firm's overall ability to identify knowledge.

1.5.4. Controls

Top managers are asked to report on several variables which may also influence either the innovativeness or the entrepreneurial activities of the firm (Damanpour 1991; Dushnitsky & Lenox 2005). To account for potential governance issues (Zahra, Neubaum et al. 2000), we ask about ownership structure, CEO duality, founder ownership, and top management ownership. To control for issues of age and size, we ask how many years the firm has been in operation and how many people are currently

employed (Damanpour 1992). Structural issues are addressed by asking whether the firm is organized functionally or divisionally, and by asking about average span of control. To control for slack resources, we ask about the current debt and cash situations at the firm (O'Brien 2003). The presumption is that firms with low debt or high cash reserves have the resources necessary to undertake innovation or entrepreneurship. We hypothesize about the radicalness of innovation and the pursuit of entrepreneurial activity, both of which are affected by the overall level of innovation. We intend to control for this by asking how many total new products have been introduced over a certain period of time, as well as how many patents are held. In theory, we can verify this second measure using the USPTO database. We also ask whether the firm is a service firm or a manufacturing firm and for the executives to describe their industry. Finally, a measure of R&D expenditures along with the previously mentioned measure of patenting activity are intended to control for the firm-level proxies of absorptive capacity most often used in the literature (Lane, Koka et al. 2006).

1.6. Results

Unfortunately, the results of this study are extremely disappointing. Despite all of the efforts made to increase the number of companies involved, our response rate is devastatingly low. We received responses to the executive survey from nine individuals, although three of them only answered a small handful of questions. The six relatively complete executive responses represent three organizations. We received 60 responses to the employee survey, 49 of which were relatively complete. Those 49 responses are from

individuals at five different organizations. Since by design we collect independent variables from employees and dependent variables from executives, we need responses to both surveys in order for a particular company to be useful to us as an observation. Unfortunately there were only two organizations for which we have both executive and employee response data.

As we discuss in our section on variables, we hoped to use patent data in order to supplement the survey questionnaire with regard to innovative output. Once it became clear that the survey data would be grossly insufficient to conduct any meaningful analysis, we hoped that we might be able to partially test our hypotheses by looking at the radicalness of the patents filed by the five companies for which we had employee responses. In this case the small size and relative youth of the companies work against us. Based on our searches of the USPTO database, it appears that only one of the firms have received any patents at all.

As a result, we are completely unable to develop any valid measures of absorptive capacity or perform any meaningful statistical analysis. The best we can hope for is to compare responses to select questions across the two organizations for which we have both dependent and independent variables in the hope that we might discover some anecdotal evidence for the theory we have proposed. The data in Table 1.2 shows how the average responses to selected survey questions compare across the two companies for which we have data. Specific questions are chosen to illustrate some of the more pertinent elements of the theory.

Table 1.2 Selected Survey Responses

	Company A	Company B
Descriptive Statistics		
Executive responses	3	2
Employee responses	19	17
Year founded	2004	1995
Employees	43.67	123.50
Top management team ownership	19.33%	2.67%
Founder ownership	21.67%	100.00%
Founder still in top management?	Yes	No
Industry	Biotech/Diagnostics	Biomed/Medical Products
Entrepreneurship:		
How entrepreneurial is your firm?	4.33	2.50
New products introduced in the past year?	2.67	5.50
New markets entered in the past year?	1.67	4.00
Radical Innovation:		
Innovations we introduce tend to be breakthrough innovations:	4.67	3.50
Innovations we introduce tend to disrupt the markets we introduce them in:	4.67	1.50
Innovations we introduce tend to fulfill needs or wants which the customers were previously unaware of	2.67	2.00
Absorptive Capacity		
My firm as a whole excels at recognizing potentially useful information outside firm boundaries	3.42	3.71
My firm as a whole excels at absorbing potentially useful information outside firm boundaries	3.05	3.41
My firm as a whole excels at exploiting potentially useful information outside firm boundaries	3.11	2.94
Autonomous Learning		
How many organizations do you belong to that are unrelated to your job?	1.47	1.71
How many hours a day do you spend reading literature not related to your job?	1.26	1.41
I am good at finding information from the environment when that information is of personal interest to me	4.21	4.35
I join organizations which expose me to new knowledge that I find interesting	4.33	4.23
Induced Learning		
How many organizations do you belong to that are related to your job?	0.47	0.88
How many hours a day do you spend reading literature which is related to your job?	1.00	2.00
I am good at finding information from the environment when asked to by my supervisors	4.26	4.29
I choose to belong to certain organizations because doing so improves my prospects for advancement at work	2.32	3.35

While it would be exceedingly presumptuous to draw any real conclusions from such a miniscule sample, perhaps examining the data can give us some indications of possible effects. Looking at the data, we see that both of the responding companies operate primarily in the biomedical industry. Unfortunately that eliminates the diversity of context that we were hoping to achieve through our choice of sampling frame, but in this case where we are reduced to conducting side-by-side comparisons it does mean that the two firms are somewhat more comparable. One of the companies has existed as a legal entity since 1995, with the other coming into existence in 2004. Predictably, the older firm has nearly three times as many employees as the younger.

The responses from the firm executives suggest a potential disconnect between our subjective and objective measures of entrepreneurial activity. Note that the executives of Company A rate their company as being significantly more entrepreneurial compared to the rating executives at Company B give theirs ($p<0.05$). However on the two questions which asked the executives to specifically count the number of entrepreneurial outcomes, Company A reports fewer new product introductions and fewer new market entries (although the difference does not reach statistical significance in the t-test). This seems to highlight the difficulty we discussed earlier with respect to the myriad of ways that academics and laypeople alike define entrepreneurship. This is something that we will need to be even more careful about in future survey work.

Looking at the executive responses with regards to radicalness of innovation, we see that responses from Company A indicate more radical innovations with respect to all three dimensions reported. While the difference does not rise to the level of statistical significance for either the question on breakthrough innovations or the one on customer

needs, Company A does report significantly more radical innovations in terms of disrupting the markets in which their new products are introduced ($p<0.05$). Executives at Company A subjectively view their firm as being both more entrepreneurial as well as more radically innovative.

Unfortunately, there is very little else in terms of significant differences across the two responding companies in terms of the three elements of absorptive capacity (recognition, absorption, and exploitation), or the apparent prevalence of behaviors which we theorized to be associated with either induced or autonomous learning. The only significant difference among the variables reported here is on the question of belonging to organizations because of the prospect for advancement at work. On that question the employees from Company B report a significantly higher value, suggesting to some extent that their knowledge seeking behaviors might tend to be more induced. This is marginally interesting since Company B was also the one which the executives subjectively report as being less entrepreneurial and having less radical innovations. It is extremely thin but at the same time encouraging to see that the only significant relationships in our minute sample point in the direction we expect.

1.7. Discussion

The outcome of this study is exceptionally disappointing. Our inability to attract the interest and participation of a sufficient number of companies crippled whatever chance we might have had to either support or refute our theories. At the same time, the scale and scope of the project is enormously ambitious. Convincing executives to invest

both their time as well as their employees' time to complete fairly extensive surveys would be difficult under the best of circumstances. Even the full backing and support of the Purdue Research Foundation, the organization responsible for developing the Park in which the target companies operated, was not enough to overcome the resistance.

Yet we remain convinced that we are on the right track. The processes underlying absorptive capacity are at their heart multilevel phenomenon which will never be fully understood by researchers who are limited to viewing their research subjects from the 30,000 foot perspective of gross R&D expenditures or patent portfolios. Organizational learning begins with individual learning, and we will never fully understand the former until we get a handle on how it interacts with the latter. Successfully unraveling these processes in the future will most likely require us to revert back to much more in-depth, on-site, ethnographic studies of a very small handful of firms. Observing the processes of individual knowledge recognition and sharing followed by organizational exploitation from a firsthand perspective while they unfold will likely give us the insight we need. Even if our ideas do seem to bear fruit in such small scale studies, it will still be necessary for researchers in the future to verify the generalizability of the theory on a larger sample of organizations. This will require them to secure an exceedingly high level of support and cooperation from the target population. As we have seen in this study, that will not be easy.

CHAPTER 2. TOP MANAGEMENT TEAMS AND RADICAL INVENTION

2.1. Introduction

Thanks to the depressingly low response rate received from the surveys which were the heart of the original study, we are unable to draw any statistically supported conclusions regarding the proposed theory and hypotheses. We are left with the necessity of developing a new study which will allow us to collect a larger dataset in the hopes of finding "the pony in the manure", or some defensible indication that our theories are on the right track. This is a difficult task given the inherently individual nature of the constructs and behaviors that make up the phenomenon of organizational learning. Data on individual organizational members is notoriously difficult to come by, especially in the form of secondary data.

There is, however, a subset of organizational members upon which much more attention is lavished and about which we are much more likely to find relevant and useful information: top executives. Through biographies, interviews, SEC filings, etc. we are able to gather a significant amount of data regarding the characteristics of the top management team members for the purpose of exploring how those characteristics affect their firm's ability to generate radical new inventions.

2.2. Theory

In terms of the model developed in the original study, examining the effect of executive characteristics on organizational learning and subsequent invention corresponds to the third stage of the knowledge absorption process. Looking at that model, we can see that the external knowledge can initially be recognized by any individual organization member. That recognition can then be communicated through any number of channels to others within the social network of that individual member. However the final stage of the model, in which the absorbed knowledge is somehow applied in a potentially valuable way, is likely to require a significant amount of top executive involvement. It is the top executive team that bears the responsibility and authority for allocating resources, thus acting as a gateway through which new ideas must pass before being broadly implemented.

The idea that organizations are shaped in large part by the decisions, characteristics, and cognitive frames of their top executives is most clearly elucidated by Hambrick & Mason (1984). The essence of their theory is that organizations are "reflections of the values and cognitive bases of powerful actors in the organization". (Hambrick & Mason 1984, Pg. 193) Since their work was published, scholars have looked at how top executive characteristics affect such wide ranging organizational outcomes as resource value creation (Holcomb, Holmes, & Connelly 2009), firm performance (Mackey 2008; Cannella, Park, & Lee 2008), corporate entrepreneurship (Ling, Simsek, Lubatkin, & Veiga 2008), foreign expansion (Barkema & Shvyrkov 2007), and strategic change (Denis, Lamothe, & Langley 2001). There is a stream of research within the upper echelons perspective which focuses on the influence of

executives on organizational innovation. Wei (2007) finds that top management teams characterized by shorter tenures with the organization and more output-oriented functional backgrounds are associated with higher levels of innovation intensity. Barkema & Shvyrkov (2007) examine how top management team diversity affects strategic innovation in the form of entering new geographical markets. Srivastava & Lee (2005) find that top management team size and heterogeneity affect the likelihood that a firm will either be a first mover or a fast follower in introducing new products. While these studies broadly consider the impact of executives on the innovative efforts of the organization as a whole, there is also a literature on executives as innovation champions who foster and promote individual innovations (Howell & Boies 2004, Howell 2005).

What seems to be missing in the literature on top management teams and innovation is an exploration of how executive characteristics affect the type of innovations organizations tend to produce. How do the values and cognitive bases of the top executives affect the likelihood that an organization will innovate radically? This is a question that encompasses both ability and motivation. Executives influence the capabilities of the organization through their decisions on resource allocation, training, and hiring, and the motivation of the employees through their effect on reward structures and culture. These influences can serve to either increase or decrease the radicalness of innovation within the organization.

We can look to the literature on innovative teams as a starting point for developing our hypotheses. There is a significant body of work pointing to the effect of team diversity on creativity. For example, Taylor & Greve (2006) propose that teams in which the members have multiple non-overlapping knowledge domains will generate

innovations of more variable value (big successes, but also big failures). Kurtzberg (2005) finds that cognitively diverse teams generate more creative outcomes, although the members of the diverse team tended to underrate the outcomes. Chen, Chang, & Hung (2008) find that R&D teams with higher collective levels of social capital generate more creative outcomes.

Although suggestive, this is not sufficient evidence for us to leap to the conclusion that more diverse executives would result in a more radically innovative organization. The majority of the studies examining diversity and creativity have focused on the diversity of the team responsible for actually generating the innovation. In the case of top executives, that is not necessarily the case. It is far more likely that the innovations themselves will come from within the organization, such as R&D teams or operations level workers. However there is evidence that top management does exert a direct influence on the innovative efforts of those toiling beneath them. Participative leadership (Somech 2006) and transformational leadership (Kearney & Gebert 2009; Shin & Zhou 2007) have both been shown to affect the innovative outputs of other in the organization. There is also anecdotal evidence that companies which are interested in developing radical innovations will work to develop executives who exhibit the characteristics which have been shown to lead to radical innovations at the team level (cognitive diversity, access to wide ranging social networks, etc). (Cohn, Katzenbach, & Viak 2008).

It is useful to think about the specific role of the top management team in the absorptive capacity process modeled in the original study. As gatekeepers and resource allocators, perfectly rational top executives choose those innovative projects which they

feel bear the greatest potential to add value to the firm going forward. From a slightly less rational perspective, managers are also likely to green-light projects which they find personally interesting. We propose that there are particular observable characteristics of management teams which would make them more likely to favorably evaluate the value of more radical innovations, and also to find them more personally appealing. A background in science or engineering suggests that an individual has an inherent interest in technology as well as the insight necessary to better understand an innovation when faced with the decision of whether or not to support it. Confronted with a radical innovation, an executive with no technical background will have little basis for evaluation other than how the new innovation fits with the existing strategic frame of the organization. The more radical the innovation, the less likely non-technical executives are to recognize the potential value, and the more likely they are to overlook a game-changing advance (Christensen & Bower 1996). To cast this in terms of absorptive capacity, executive teams with a large proportion of technically oriented executives should be better able to identify, assimilate, and exploit information about radical innovations relative to their non-technical counterparts due to their stock of technical knowledge as well as their sensitivity to and interest in technological innovations. That individual- and group-level ability to notice, value, and pursue radical technologies contributes to the overall firm-level absorptive capacity in the same way that individual employee level learing activities and proclivities contributed to firm-level absorptive capacity in our first chapter. This suggests our first hypothesis:

Hypothesis 1: Organizations with a higher percentage of executives who have a technical background in science or engineering will innovate more radically.

In terms of functional backgrounds, if engineers and scientists are less likely to be beholden to the current realm of operations in terms of their willingness to support radical innovation, then we might expect those with marketing backgrounds to be on the other end of the spectrum. As Christensen & Bower (1996) point out, it is an overly keen sense of the need to satisfy existing customers that can cause incumbent firms to overlook the next big breakthrough. Given the focus of marketing on understanding and fulfilling customer needs, we would expect that executives with marketing backgrounds might dampen radical innovation. Thus our second hypothesis:

Hypothesis 2: Organizations with a higher percentage of executives who have a marketing background will innovate less radically.

We can make a similar argument with regards to level of education. At the undergraduate level, the focus of education is on learning basic rules of operation, the way things are done, regardless of the field of education. As one continues on into masters or doctoral level work, the focus generally shifts more towards the creation of new knowledge, or at least a more critical evaluation of existing knowledge and procedures. Thus those executives with more advanced educations may be more inclined to look favorably on innovations which break with the status quo, and will likely be better able to fairly evaluate their potential. Thus our third hypothesis:

Hypothesis 3: Organizations with a higher percentage of executives who have achieved advanced degrees (masters or doctorates) will innovate more radically.

Up to this point we have hypothesized on the effect that average top management team characteristics have on the organization's tendency towards radical innovation. However, considering the enormous body of work on diversity and creativity, we must also consider the effect of diversity at the top management level. Borrowing from our arguments in the original model, executives with diverse backgrounds are likely to have diverse interests, diverse cognitive bases, and diverse social networks. If all the executives at a given firm had the same educational backgrounds, functional experiences, and work tenures, then chances are they would have largely overlapping circles of contact. As that commonality starts yielding to diversity, the likelihood that someone on the management team will become aware of a radical innovation fermenting in the organization will increase dramatically. Diversity of top managers also dramatically increases the likelihood that one or more of them will find the innovation potentially valuable enough or intriguing enough to become a champion and push it through to completion. While too much diversity can be associated with communication breakdowns and interpersonal conflicts (Roberts & O'Reilly 1979; Byrne 1961; Pfeffer 1983), diversity in top management teams is likely to be bound at the upper limit by the selection processes which lead some people to be chosen as top executives over others (Bantel & Jackson 1989). While we are confident that diversity does exist and is an important determinant of innovative outcomes, we suspect that top management team

diversity is unlikely to become so high as to be dysfunctional. Thus we hypothesize a positive link between top management team diversity and radical innovation:

Hypothesis 4: Organizations with more diverse executives will innovate more radically.

2.3. Sample

The above hypotheses are tested here using a sample of firms from the biomedical device industry. This is an especially appropriate setting for the current study for at least three reasons. One, the biomedical device industry is driven in large part by the development and commercialization of new ideas. Advances in the field have been characterized by the introduction of novel new products such as the portable defibrillator and needle-less injection systems which were invented and subsequently brought to market. As such, it is an especially ripe area for the study of the innovative processes. Two, the regulatory requirement for disclosure of new products makes data on commercialization much more readily available than in many other industries. And three, the amount of public disclosure required during the FDA approval process makes it more likely that firms will file patents to protect intellectual property as opposed to keeping new inventions as proprietary trade secrets. Thus patents are more likely to be an accurate measure of inventive activity than they would be in other industries where secrets are easier to keep. The initial sampling frame consists of all publicly traded firms operating in Standard Industrial Classification (SIC) codes 3841-3845, corresponding to

the biomedical device industry. A Compustat search on those codes turns up 641 unique companies as identified by their Committee on Uniform Security Identification Procedures (Cusip) numbers. Our hypotheses deal with processes of innovation which develop over time, often taking years to proceed from initial idea to final commercial product. For that reason, the collected data must span some period of years. By the same token, the time span covered must be limited in order to keep the task of data collection manageable. We choose to restrict our sample to only those firms which were in continuous operation from 2002 through 2006. That reduces the number of companies under consideration to 215.

Because our hypotheses are based on the demographics of the top management teams, it is necessary then to collect the identities of all executives for each company over the five year window. The names, positions, cash compensation, and total compensation for each top management team are collected using the Lexis-Nexis Executive Compensation database. Due to incomplete executive data, our sample is further reduced. There were 121 companies which were in continuous operation from 2002 through 2006 and for which we were able to determine the identities of the executives for each of the five years. Other missing variables reduce the sample size for our regressions to 86.

2.4. Variables

The independent variables for this study consist of a number of measures representing the demographics of the top management teams. In order to bound the data

collection efforts to a more reasonable scale, we choose to find detailed information on only those executives which were at the focal firms in 2004. Using the list of executives identified from Lexis-Nexis, we conduct extensive online searches for each name, including variants of names ("William Bolt" and "Bill Bolt" for "William J. Bolt"; "Bob Douglas" and "Rob Douglas" for "Robert Douglas") in order to find the following information for each executive: age, sex, bachelors degree major (if any), masters degree major (if any), doctorate degree major (if any), functional background, years of experience in the biomedical field, years of experience outside the biomedical field, and years of experience with the focal company. Data is collected from a number of sources, including Condé Nast Portfolio (www.portfolio.com), Forbes (www.forbes.com), Business Week (www.businessweek.com), and company SEC filings found on numerous outlets. Then based on the data on educational and functional backgrounds, we code a series of dummy variables indicating if a particular executive possesses a background in science or engineering, a background in sales or marketing, a diverse education (such as a bachelors degree in engineering and a masters degree in business), a diverse work experience (bachelors degree in chemistry and a work background in marketing), or R&D experience. All dummy variables are coded one if yes, zero otherwise. As the hypotheses and analyses are at the firm level, the final step in constructing the top management team variables is to aggregate them up from the individual level to the team level. The result is a series of variables indicating the proportion of the top management team who have earned bachelors degrees, earned masters degrees, earned doctoral degrees, have diverse educational backgrounds, have science or engineering backgrounds, have sales or marketing backgrounds, and have R&D experience. We also

calculate measures of proportion of female executive team members, average age, age range, average cash compensation, range of cash compensation, average total compensation, and range of total compensation.

Specifically, Hypothesis 1 is tested using the proportion of the top executive team which has a background in science or engineering as the primary dependent variable. Hypothesis 2 is tested using the proportion of the top executive team which has a background in sales or marketing. Hypothesis 3 is tested using the proportion of executives who have earned either a masters or doctorate degree. For Hypothesis 4, there is no compelling theoretical reason to think that certain types of diversity would be more relevant to the radicalness of innovation at the organizational level than others. For that reason we explore a range of diversity measures, including the standard deviation of years of experience in the biomedical industry, experience outside the biomedical industry, tenure with the company and executive age. In order to characterize the diversity of knowledge represented by the executive team, we use Blau's index of diversity (Blau 1977) to assign a diversity score to each team. The traditional form of Blau's index is:

$$D = 1 - \sum_i p_i^{\,2} \qquad \text{Eq. 2.1}$$

where p_i is the proportion of the team which belongs to category i. In our case, we categorize each executive as having a background in science, business, or other (political science or law for example). As traditionally used, Blau's index is bounded by zero at the bottom (no diversity) and approaching one at the top (large groups with only one member belonging to each category). However the measure only exhibits these

properties when the categories are mutually exclusive. In our case, where an individual may have a background in both science and business, the equation above can result in negative values for diversity. While we do not expect that this would affect the empirical properties of the measure, it does make the values difficult to interpret.

It is desirable then to refine the measure to account for the fact that individuals may belong to more than one category while still retaining the ease of interpretation inherent in the original formula. We alter the formula as follows:

$$D' = \sum_i p_i - \sum_i p_i^2 \qquad \text{Eq. 2.2}$$

Regardless of the extent to which members of the executive team fall into multiple categories, this measure of diversity is still bound by zero and one, with higher values representing more diverse teams. Specifically how this works is illustrated in the Table 2.1.

Table 2.1 Example of Blau Index of Diversity calculations

		Science/Engineering Background	Business/Economics Background	Other Background
Firm A	Executive 1	X	X	X
	Executive 2	X	X	X
	Executive 3	X	X	X
	Executive 4	X	X	X
	Executive 5	X	X	X
	Proportion	1.0	1.0	1.0
	Diversity	$D'=(1+1+1)-(1^2+1^2+1^2)=0$		
Firm B	Executive 1	X		
	Executive 2	X		
	Executive 3	X		
	Executive 4	X		
	Executive 5	X		
	Proportion	1.0	0.0	0.0
	Diversity	$D'=(1+0+0)-(1^2+0^2+0^2)=0$		
Firm C	Executive 1	X	X	
	Executive 2	X		
	Executive 3	X		X
	Executive 4			X
	Executive 5	X		
	Proportion	0.8	0.2	0.4
	Diversity	$D'=(0.8+0.2+0.4)-(0.8^2+0.2^2+0.4^2)=0.56$		
Firm D	Executive 1	X		
	Executive 2	X		
	Executive 3			X
	Executive 4		X	
	Executive 5		X	
	Proportion	0.4	0.4	0.2
	Diversity	$D'=(0.4+0.4+0.2)-(0.4^2+0.4^2+0.2^2)=0.64$		

Firms A and B are both lacking in any diversity, since in the one every executive has a background in science or engineering, and in the other every executive has a background in science, business, and other. Firm C is more diverse, with four out of five having a science background, one coming from business, and two with other experience. Firm D illustrates that in cases where the categories are mutually exclusive (each

executive belonging to only one category), the proposed measure collapses to the original Blau value.

The dependent variable for the first set of hypotheses is the degree to which firms innovate radically. Up to this point we have been somewhat imprecise in our use of the words innovation and invention. For the sake of operationalizing the construct, it is necessary that we clarify exactly what it is that we intend to predict. In this study, we focus on invention, or the creation of new ideas and technologies. For our purposes the firm's inventions are represented by patents granted to them by the US Patent and Trademark Office (USPTO). The radicalness of those patents is measured in two ways. Following Ahuja & Lampert (2001), the first radicalness measure considers the degree to which the patents filed by a focal firm cite previous patents. This is a measure of radicalness to the extent that patents which are more significant departures from the prior state of the art will have less in common with preceding technologies and will thus be required to cite fewer prior patents. Since our hypotheses are at the firm level of analysis, this measure is calculated as the average number of previous patents which are cited by the focal firm's patents over some given period of time. We will return to the issue of timeframe shortly. Fewer citations on average indicate a firm which innovates more radically, so this measure is inverted to ease interpretation. The second radicalness measure follows Shane (2001) by looking at the number of technology classes claimed on patent applications. Inventions which are more radical in nature are more likely to cut across technological boundaries, thus increasing the number of technology classes called out on the patents. This is calculated at the firm level in the same way as the citation measure, as an average across all of a firm's patents in a given timeframe. A higher

number of average technology classes indicates a firm which innovates more radically. Data on firm patents is collected from the US Patent and Trademark Office database.

Given the episodic nature of invention, it is desirable to calculate these measures over a sufficiently long time horizon to smooth excessive noise in the data and to get a better feel for the phenomenon as a whole. For that reason, both of our radicalness measures are calculated considering all patents issued to the focal firms over the entire five year window of our study (2002-2006). It seems conceptually inconsistent to assign a value to the radicalness of a firm's patents when they did not have any in our specified timeframe, so only those firms who had received patents in the five year span from 2002 through 2006 are included in our analyses.

In order to control for alternative explanations, we include variables for other factors that can affect an organization's ability to innovate radically. These include R&D intensity, the size of the executive teams, and a measure of slack resources (debt-to-equity). Since we are using data on the executives in one year (2004) as a predictor of radical innovation over a five year window (2002-2006), we must also control for turnover in the executive ranks. Turnover is calculated by counting the number of new executives hired from 2002 until 2006, adding the number of executives who departed during that time, and then dividing by the number of executives on staff in 2002. (Cho 2006; Cho & Shen 2007)

2.5. Analysis

Tables 2.2, 2.3, and 2.4 below show the summary statistics and pairwise correlations for all variables used in the analysis.

Table 2.2 Summary Statistics

Variable	Obs.	Mean	s.d.
1. Patent technology classes	93	1.52	0.34
2. Patent backward citations (inverted)	93	0.07	0.06
3. Debt to equity	120	0.48	0.56
4. R&D Intensity	108	1.20	8.74
5. Executive turnover	121	1.19	1.33
6. Number of executives	121	4.87	1.84
7. Percent of execs with mktg exp	121	0.20	0.20
8. Percent of execs with science exp	121	0.31	0.26
9. Percent of execs with masters or doctorate degrees	121	0.43	0.33
10. Blau index of diversity	121	0.39	0.20
11. Standard deviation of executive ages	121	6.87	4.32
12. S.D. of years experience in biomed	121	6.93	3.99
13. S.D. of years experience outside biomed	121	8.04	4.65
14. S.D. of years experience with company	121	5.08	3.76
15. S.D. of cash compensation	121	86618.0	65862.0
16. S.D. of total compensation	121	316186.6	994791.7

Table 2.3Pairwise Correlations

Variable	1	2	3	4	5	6	7	8
1. Patent technology classes	1.00							
2. Patent backward citations	-0.16	1.00						
3. R&D Intensity	-0.07	-0.03	1.00					
4. Executive turnover	0.14	-0.01	0.03	1.00				
5. Debt-to-equity	0.03	-0.08	-0.07	0.26**	1.00			
6. Number of executives	-0.01	-0.17†	-0.19*	0.13	0.03	1.00		
7. Percent of execs with science exp	0.04	0.06	0.10	-0.01	0.09	-0.06	1.00	
8. Percent of execs with mktg exp	-0.05	-0.11	0.12	-0.06	0.01	0.04	0.15†	1.00
9. Percent of execs with masters or doctorate	-0.02	-0.06	0.20*	-0.08	0.11	-0.18*	0.44**	0.03
10. Blau diversity index	0.03	0.06	-0.08	0.01	-0.10	0.42**	0.36**	-0.10
11. S.D. of executive ages	0.15	0.04	-0.14	0.05	0.05	0.16†	-0.03	-0.17†
12. S.D. of years in biomed	0.01	-0.13	0.22*	0.08	0.01	0.33**	-0.05	-0.04
13. S.D. of years outside biomed	0.00	-0.07	-0.18†	0.15	0.14	0.25**	0.03	-0.07
14. S.D. of years with company	0.04	-0.02	-0.15	-0.22*	0.02	0.17†	-0.11	-0.13
15. S.D. of cash compensation	0.10	-0.15	-0.02	-0.11	0.08	0.29**	-0.12	-0.11
16. S.D. of total compensation	0.11	-0.02	-0.03	-0.01	0.01	0.08	-0.11	0.00

†p<0.10

*p<0.05

**p<0.01

Table 2.4 Pairwise Correlations

Variable	9	10	11	12	13	14	15	16
9. Percent of execs with masters or doctorate	1.00							
10. Blau diversity index	0.14	1.00						
11. S.D. of executive ages	-0.17†	0.14	1.00					
12. S.D. of years in biomed	-0.03	0.29**	0.26**	1.00				
13. S.D. of years outside biomed	-0.02	0.17†	0.46**	0.32**	1.00			
14. S.D. of years with company	-0.17†	0.22*	0.35**	0.39**	0.23*	1.00		
15. S.D. of cash compensation	0.02	0.14	0.16†	0.22*	0.15	0.43**	1.00	
16. S.D. of total compensation	0.08	-0.02	-0.06	-0.01	-0.03	0.07	0.19*	1.00

†p<0.10

*p<0.05

**p<0.01

All hypotheses testing is performed using ordinary least squares (OLS) regressions in the Stata statistical analysis software package. Baseline models are run for each dependent variable containing only the controls. The fully saturated models are run containing all controls and explanatory variables. Regression results are shown in Table 2.5 below.

Unfortunately, none of our hypotheses are supported. We obtain the same non-findings whether our dependent variable of invention radicalness is the number of backward citations or the number of technology classes claimed. Extensive exploratory regressions were run using various combinations of control variables and different variable transformations in an attempt to find some statistically significant evidence that the hypothesized phenomenon was in effect. In every case we obtained the same non-findings.

Table 2.5 OLS Regression Results

Dependent Variable:	Patent Backward Citations		Patent Technology Classes	
	Base Model, Controls Only	Fully Saturated Model	Base Model, Controls Only	Fully Saturated Model
R&D intensity	0.00	0.00	-0.03	-0.04
Turnover 2002-2006	0.01	0.01	0.05	0.07
Debt-to-equity	-0.01	-0.01	0.05	-0.05
Number of executives	-0.01*	-0.01†	-0.02	-0.02
Ratio of Executives with Technical Backgrounds		0.03		-0.07
Ratio of Executives with Mktg Backgrounds		-0.02		-0.38
Ratio of Executives with Masters or Doctorate Degrees		-0.04		0.05
Blau index of diversity		0.04		0.12
S.D. of executive age		0.00		0.03
S.D. of years in biomed		0.00		0.00
S.D. of years outside biomed		0.00		0.00
S.D. of years in company		0.00		-0.01
S.D. of cash compensation		0.00		0.00
S.D. of total compensation		0.00		0.00
Constant	0.12**	0.14**	1.57**	1.37**
n	86	86	86	86
Prob>F	0.26	0.75	0.88	0.88
Adjusted R-squared	0.02	-0.05	-0.03	-0.08

2.6. Limitations

We can suggest a number of reasons why our empirical results have failed to support our proposed hypotheses. First of all, the tested sample size of 86 firms is insufficient when trying to find small effects. According to an analysis of statistical power, we would require a sample size of 135 to detect medium sized effects, and a whopping 926 if the effect is small. (Cohen, Cohen, Aiken, & West 2003, Cohen 1988) Given the number of intervening factors between top executives and the inventions

realized by members of their organizations, it is safe to assume that the effect we are seeking is likely to be on the small side.

Of course we must also acknowledge the possibility that the phenomenon in question just simply does not exist. In this particular part of the work we are specifically focusing on the ways in which executive characteristics exerted a direct influence on the kinds of inventions bubbling up from those members of the organization responsible for such activities. In the context of the theory developed in the first chapter, we can interpret our non-findings here as being consistent with a bottom-up view of knowledge creation and invention. Where executive characteristics are much more likely to be in effect is in the next phase of the process, whereby these new inventions are selected and shepherded through to commercial introduction. That is the focus of the next chapter, looking at how executive characteristics moderate the organization's ability to turn new ideas into new products.

CHAPTER 3. TOP MANAGEMENT TEAMS AND THE PROCESS OF INNOVATION

3.1. Introduction

All of the previous chapters composing this work have had an explicit focus on innovation. It would be difficult to understate the role of innovation as a driver of economic progress. Despite the critical importance of innovation to both academics and practitioners, there continues to be a certain lack of consensus when it comes to defining what innovation is and how best it can be studied. Researchers tend to treat innovation either as either the creation of new ideas or the introduction of new products, often without explanation or justification of why they chose one over the other. At best this situation leads to conceptually muddy theorizing. At worst, it leads to confounding research findings. In this study we explore the possibility that a more well-developed theoretical foundation can be built by taking a more fine-grained view of innovation as a multi-step process rather than as a unitary phenomenon. Specifically, we argue that invention and commercialization are neither "innovation" in and of themselves, but rather that they represent separate and necessary processes which constitute innovation. We further suggest that within the innovative process, invention is a necessary precursor to commercialization. Where previous work on innovation has been concerned with factors which directly affect a firm's ability to either invent or bring new products to market, we view the process more holistically.

Specifically, here we address the question of how firm-level characteristics affect a firm's ability to turn inventions into new products. In keeping with the previous two studies, we focus on the characteristics of the top management team as important moderators of the invention-commercialization relationship.

The beginning point for our development is recognition of the fact that innovation is of economic value only if it involves the implementation of a new idea which addresses some existing problem. From an industrial point of view, this can mean marketing a new product which meets a previously unfulfilled need or introducing a new production process which significantly reduces cost. In either case, the idea which underlies the innovation would offer no direct contribution if it were simply conceived of and then discarded. For our purposes, the term commercialization is defined as the implementation of a new idea, product, or structure in a potentially valuable way. This leads to the second important point to be discussed here, which is the recognition that innovation simply cannot happen in the absence of new ideas. If there are no new ideas, then there will be nothing to commercialize and consequently no economic advance. Given a certain body of new ideas, only some of them are likely to go on to be commercialized. However if the pool of ideas is dry, then there will be no new products at all. We define invention as the process of creating and developing novel ideas, products, or structures. Although drawing heavily from the definitions offered by Ahuja & Lampert (2001) for invention and innovation, we believe our definitions to be more clear to the extent that we define "innovation" without explicitly referring to "invention" as Ahuja and Lampert do.

This definitional deconstruction of innovation into its component processes is certainly not a new idea. Referencing a discussion held at a 1970 meeting of the Industrial Research Institute (IRI), Roberts (1988) says that "Innovation is composed of two parts: (1) the generation of an idea or invention, and (2) the conversion of that invention into a business or other useful application." (Pg 12) Porter makes a very similar distinction when he says that innovation is "a new way of doing things (termed an invention by some authors) that is commercialized." (1990, Pg. 780, emphasis in original) Freeman & Soete (1997) and Afuah (1998) also suggest that innovation is a multi-step process. However, the majority of empirical studies on innovation have either treated the entire process as a single concept, or have studied one part or the other and called it innovation. Our goal here is to draw a sharper line in the sand, demonstrating that better theoretical and empirical clarity can be gained by explicitly treating innovation as a multi-step process.

Once innovation is thus broken into distinct steps, it becomes useful to think about how the two parts of the process are different, and how they may relate to each other. For example, the creation of a new idea is likely to take place at the level of individual people or small groups and can often be accomplished with little or nothing in the way of additional resources (Jewkes, Sawers, & Stillerman, 1959). By contrast, the commercialization process is more likely to involve large numbers of people from across an organization and require large amounts of complementary resources. It is reasonable to believe that the forces which affect invention and thus the theories which are invoked to explain relevant behaviors will be different from those which affect commercialization. It is also reasonable to think that two companies, given similar pools of new ideas, will

differ in their ability to transform those inventions into new products. Bridging the gap between invention and commercialization requires a complex series of steps which draw on a heterogeneous mix of firm resources and capabilities. As firms differ from one another in their endowment of those critical resources and capabilities, then their ability to successfully commercialize inventions will also differ. Since commercialization is the final step in innovation as conceived here, this will bear directly on a firm's ability to innovate relative to its competitors.

The purpose of this paper is to introduce and test a model which explicitly separates invention from commercialization in a manner which is conceptually consistent with the definitions adopted. In this framework, invention's role as a necessary but insufficient condition for commercialization becomes clear. It is the examination of the critical step from idea to commercialization which constitutes the primary contribution of the current work. Where previous studies have broadly asked "How do certain factors affect an organization's ability to innovate?", the more nuanced question raised here is "How do certain factors affect an organization's ability to turn inventions into new products?" Figure 3.1 graphically contrasts the general form of the proposed model with the more common model used in prior research. To be specific, we examine the effect of top management team characteristics on a firm's ability to turn inventions into products. We are unaware of any previous studies which have examined innovation using this more detailed moderation-based formulation.

In the previous two chapters we have focused exclusively on the determinants of radical innovation. In the first chapter we looked at how learning behaviors and motivations across all levels of the organization impact a firm's ability to radically

innovate. In the second chapter we focused specifically on how top executive team characteristics affect the ability of the firm to develop radical inventions, the first step towards innovation. In this chapter we use the moderated model of innovation to better understand radical innovation from a process perspective. We examine not only how executive characteristics moderate the invention—commercialization relationship, but also whether or not that moderating influence depends on the types of invention being fed into the process. Do executives exert more influence on commercialization when the company's stock of inventions is more radical? Does diversity in the executive team lead to more efficient use of either radical or incremental inventions relative to the other? This study is exploratory in nature as a starting point towards a better understanding of the phenomenon.

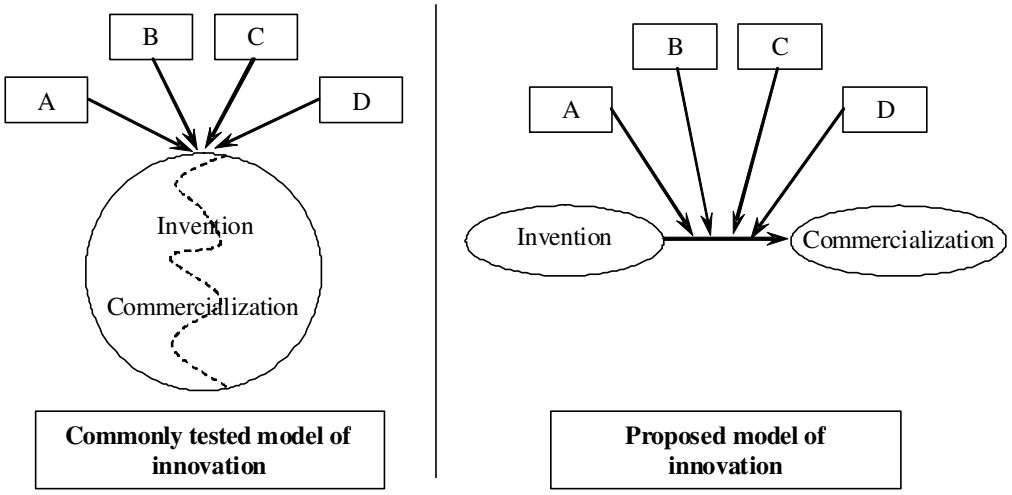

Figure 3.1 Graphical representation of alternative models used to test the influence of various factors on innovation

3.2. Data

This study uses essentially the same sampling frame and data as the previous chapter. The context under study is the biomedical device industry. Our sample begins with all publicly traded companies in the biomedical sector (SIC codes 3841-3845) which were in continuous operation from 2002 through 2006. The dependent variable for these analyses is the number of new products registered with the Food and Drug Administration (FDA) in 2006. The independent variable is the number of new patents filed for with the US Patent and Trademark Office (USPTO) by the focal firms in 2002. The lag is necessary in order to account for the time required to develop new technologies into commercially viable products. Our moderators are the same top management team characteristics which were examined in the second chapter: proportion of executives with a background in science or engineering; proportion with a background in marketing; proportion who have received either a masters or doctorate degree; and a number of variables characterizing the diversity of the top executive team, including the Blau index of diversity in functional backgrounds, the standard deviations of the executive ages, S.D. of years experience in the biomedical device industry, S.D. of years experience outside the biomed industry, S.D. of years tenure with the company, S.D. of cash compensation, and S.D. of total compensation. All executive team variables are calculated as of 2004. Moderation effects are modeled by calculating multiplicative interaction terms between each moderator and the independent variable, the number of patents filed for in 2002.

We also include a handful of variables in order to control for alternative explanations. These include R&D intensity, turnover in the executive team between 2002

and 2006, debt-to-equity, the cumulative number of new products registered with the FDA prior to 2006 (in order to control for experience effects), and the size of the executive team. Analysis is allconducted using ordinary least squares regressions in the Stata statistical analysis package.

The data contains several outliers in terms of both patents filed as well as new products introduced. In order to prevent these from biasing the results of the analysis, observations are dropped if they are more than three standard deviations above the mean on either measure. This results in the loss of five observations.

3.3. Results

We analyze the data in four steps. The first model is a base case containing all four controls as well as the direct effect of patenting on new product introduction. The second model then is a fully saturated model including all of the executive characteristics both as direct effects as well as interaction terms with patent count. These interactions represent the moderating effect of the executive team on the relationship between patenting in 2002 and new product introduction in 2006.

The next step is to examine how those moderation effects might vary depending on the type of inventions in question. To do that, we split the sample into firms that could be considered "radical inventors" and those that are "incremental inventors". The split is made by calculating the average number of backward citations across all patents applications filed by the sample companies in 2002. Companies whose average number of backward citations fall below the population average were classified as radical

inventors, and those whose average backward citations fall above the population average were classified as incremental inventors, using the same logic as was presented in the previous chapter. Results are reported in Table 3.1 below.

The saturated model for all companies in the sample, reported in the third column of results, is a significant improvement over both the base model ($p<0.001$) as well as the model containing all direct effects ($p<0.001$). This suggests that the inclusion of our moderators does make a significant contribution to our understanding of the phenomenon in question. We can see in the saturated model that there are a number of variables which significantly predict the number of new products a firm is likely to introduce in 2006. In terms of direct effects, the cumulative number of new products introduced prior to 2006, the number of new patents filed in 2002, the proportion of the executive team with science or engineering backgrounds, the diversity of company tenure within the executive team, and diversity in both cash and total compensation within the executive team are all positively correlated with the number of new products the company has introduced in 2006. Diversity of executive age and diversity of executive experience in the biomedical industry both have a negative direct correlation with new products introduced in 2006.

Table 3.1 OLS Regression Results, Dependent Variable is New Products Introduced

	All Companies			Radical Inventors	Incremental Inventors
	Base Model	Direct Effects	Fully Saturated Model	Fully Saturated Model	Fully Saturated Model
R&D intensity	0.19	-0.03	-0.08	5.34	-0.05
Turnover 2002-2006	-0.77	-0.21	0.15	-1.58	-0.28
Debt-to-equity	1.46	-0.28	0.04	5.25†	-0.18
Number of executives	0.75†	0.47	0.09	0.78*	-0.04
Cumulative number of products introduced	0.13**	0.22**	0.19**	0.24**	0.11**
Number of patents filed, 2002	0.04	0.58**	2.49*	-4.47	1.17
Ratio of Executives with Technical Backgrounds		2.10	7.30**	18.9*	3.09
Technical Background Interaction			-2.22*	-13.3**	0.83
Ratio of Executives with Mktg Backgrounds		-2.58	1.57	1.88	-0.68
Marketing Background Interaction			-1.83†	-2.42	0.02
Ratio of Executives with Masters or Doctorate Degrees		1.02	0.36	-6.87*	-0.20
Masters or Doctorate Interaction			-1.25	0.96	-2.39
Blau index of diversity		-3.80	-1.38	-13.2†	-0.91
Blau Interaction			-1.24	12.9*	0.53
S.D. of executive age		-0.11	-0.25*	-0.41	-0.06
Age Interaction			0.08*	0.04	-0.06
S.D. of years in biomed		0.00	-0.24*	-0.30	-0.01
Years in biomed interaction			0.23**	0.48**	0.04
S.D. of years outside biomed		0.08	-0.14	0.50†	-0.07
Years outside biomed interaction			0.03	-0.19	0.07
S.D. of years in company		0.24	0.34*	0.61*	0.12
Years in company interaction			-0.28**	-0.63**	-0.10
S.D. of cash compensation		0.00	0.00**	0.00	0.00**
Cash interaction			-0.00**	0.00	0.00
S.D. of total compensation		-0.00**	0.00**	-0.00†	-0.00†
Compensation interaction			0.00**	0.00†	0.00
Constant	-3.11	-3.18	-2.39	0.31	-0.65
n	87	87	87	36	51
F	24.41	19.25	35.85	95.93	6.85
Prob>F	0	0	0	0	0
Adjusted R-squared	0.62	0.78	0.91	0.99	0.75

Of special interest to us are the interaction terms. While a high proportion of executives with technical backgrounds has a positive direct effect on new product introduction, it also negatively moderates the relationship between invention and commercialization. In short, more technically oriented executive teams are associated with firms that are less efficient at turning their inventions into products. We see the same negative and significant moderation effect for firms with high proportions of marketing executives, firms with a high diversity of executive tenure within the company, and a high diversity in the level of cash compensation. We also see evidence of positive moderation. Having executive teams with a diversity of ages, a diversity of experience within the biomedical industry, and a diversity of total compensation is associated with firms that are more efficient at turning inventions into products.

The most important results are reported in the third and fourth columns. A clear pattern of contingency seems to be emerging in that executive characteristics appear to play a significant role in the transformation of radical inventions into new products but play little if any role in the transformation of more incremental inventions. We find strong evidence that in the context of a firm which tends to develop more radical inventions, executive teams with higher proportions of technical backgrounds are actually less efficient at turning patents into products. There is no such effect exhibited in the firms which invent incrementally.

We also see an interesting effect regarding diversity of functional background and experience. The significant positive coefficient on the interaction between our Blau index of diversity and the number of patents filed in 2002 for the population of radically inventive companies suggests that more diverse executive teams lead to more efficient

use of radical inventions. There is no such relationship in the population of incremental inventors. There are two other diversity measures of note which significantly moderate the invention—new product relationship in firms which invent radically but not those which invent incrementally. Executive teams which are more diverse in terms of the length of their experience in the biomedical device industry (a mix of seasoned veterans and new entrants) are associated with more efficient use of a radical portfolio of patents. However executive teams which are diverse in terms of how long they have worked for the focal company are associated with a significantly lower efficiency in turning radical inventions into new products.

While suggestive, it is very difficult to draw any statistically valid conclusions regarding the difference of coefficients across the two subsamples. One way to conclusively prove that there is in fact a difference would be to construct three-way interactions where each of our focal interactions was in turn multiplied by a dummy variable indicating whether a particular firm is a radical inventor or an incremental inventor. We could then run regressions on the entire sample together and examine the coefficients on the three-way interactions to draw conclusions. However doing so in our current model would add ten additional predictors to a model which is already suffering from a very poor ratio of observations to predictors. Another option would be to rerun a series of models in which each explanatory variable, it's interaction with the number of patents filed, and the three-way interaction between the explanatory variables, patents filed, and the radical dummy were entered one per model. This would require that we have some confidence in the fact that the correlation among the explanatory variables is low enough that significant results in one model were not due to the effect of a collinear

explanatory variable that had been excluded. Examining the table of pairwise correlations from Chapter 2, it appears that the highest correlation among our explanatory variables is a 0.46 correlation between the standard deviation of executive ages and the standard deviation of years of experience in the biomedical industry. While higher than we might like, it seems reasonable to proceed with the testing procedure.

In Table 3.2 we report the results of these three-way interaction tests for the three top management team demographic variables which appear in Table 3.1 to be significant moderators of the patent—product relationship for radical inventors but not for incremental inventors. Those variables are the proportion of executives with technical backgrounds, the diversity of executive backgrounds, and the diversity of experience in the biomedical industry. A significant coefficient on the three-way interaction would indicate that the difference in coefficients suggested by Table 3.1 is in fact a statistically supported difference.

Out of the three variables of interest, only the number of years in the biomedical industry results in a statistically significant three-way interaction. Thus despite the very suggestive results of Table 3.1, we can only claim with statistical certainty that the moderating effect of a diverse range of biomedical experience on the patent—product relationship differs across radically and incrementally inventive firms. Without a larger sample and more statistical power, the contingent nature of the moderating influence of technical backgrounds and diversity of backgrounds will remain only suggestive.

Table 3.2 Testing Three-Way Interactions

	Model 1	Model 2	Model 3
R&D intensity	0.09	0.18	0.04
Turnover 2002-2006	-0.65	-0.77	-0.35
Debt-to-equity	0.12	0.69	0.62
Number of executives	0.34	0.60	0.17
Cumulative number of products introduced	0.10**	0.10**	0.09**
Number of patents filed, 2002	1.87**	1.92**	-1.28**
Radical dummy	0.56	0.19	-1.55
Ratio of Executives with Technical Backgrounds	3.76		
Technical Background Interaction	-2.18*		
Technical Background Three-way Interaction	-0.65		
Blau index of diversity		2.67	
Blau Interaction		-2.20†	
Blau Three-way Interaction		-0.05	
S.D. of years in biomed			-0.09
Years in biomed interaction			0.25**
Years in biomed three-way interaction			0.11*
Constant	-3.07	-4.31*	0.01
n	87	87	87
F	17.36	15.88	24.10
Prob>F	0.00	0.00	0.00
Adjusted R-squared	0.66	0.64	0.73

We also explore another approach to testing the proposed relationships. In essence we are telling an efficiency story, looking at how top management team characteristics affect the proportion of patents filed in 2002 become new products in 2006. The inputs are patents, and the outputs are products. An alternative way to study the effect of top management team characteristics on that conversion is to use the ratio of new products in 2006 to new patents filed in 2002 as the dependent variable and the

management demographics as the independent variables. We can then test whether the management influence is different for radical patents versus incremental patents by interacting the management variables with the radicalness of invention. Significant coefficients on those interaction terms would then suggest that executive characteristics affect the efficiency with which new ideas become new products differently depending on the radicalness of the input patents. We conduct such an analysis, and once again unfortunately do not achieve statistical significance of our focal interaction terms.

While our small sample size and the likely small size of the effects in question prevent us from definitively proving that managers have a bigger influence over the commercialization process when the stock of patents is more radical, the results of Table 3.1 are certainly suggestive of a phenomenon which is of great importance to companies who compete based on their ability to commercialize new ideas. We can speculate on the mechanisms that might cause such a differential effect. In the case of the ratio of executives with technical backgrounds, it may be the case that more technically-minded executives are better equipped to evaluate radical inventions, improving their ability to weed out those which may not be technically or commercially viable. This skill would have less marginal effect when faced with a mundane portfolio of incremental inventions which are more easily understood and assessed by the average executive. It could also be the case that technical education and experience leads executives into competency traps (Levitt & March 1988) which prevent them from fully appreciating the potential of a radical new invention. Further study will be required to understand the specific mechanisms at play.

In terms of the findings on diversity, we can return to the argument on evaluation and opportunity recognition to suggest thatperhaps executive teams with representation from multiple functional areas are more likely to contain one or more key individuals whose unique experience and knowledge allows them to recognize the potential value in a particular invention which is radical enough to be outside the understanding of the average executive. It may also be possible that radical inventions tend to spring from the combination of ideas from disparate domains, making it necessary for there to be a diversity of backgrounds to fully grasp the significance. Again, further investigation is warranted.

3.4. Conclusions and Limitations

While exploratory in nature, the results of this study provide an interesting and valuable contribution to our understanding of radical innovation at the firm level as well as to our understanding of the upper echelons perspective. In the spirit of Salancik & Pfeffer (1977), Hambrick & Finelstein (1987) and others, we have discovered an important set of contingencies determining the extent to which top management team characteristics are likely to affect firm-level innovations. Importantly, we have added nuance to the prior literature by examining not only how executives influence the level of innovative effort, but also looking at how the influence of managerial characteristics varies across different types of innovation.

We have also added to the literature by explicitly recognizing and empirically testing a more detailed model of innovation. By separating innovation into the

component processes of invention and commercialization, we are better able to understand where in the process different forces such as executive influence come to bear. Combining the results from this chapter and the last, we begin to get a richer picture. While executive characteristics do not affect the type of inventions a firm is likely to produce, they do have a significant impact on the likelihood that a firm will be able to successfully turn those new ideas into new products.

Lacking in the present model, however, is a deeper understanding of the processes at work. The specific mechanisms through which executives exert influence over the commercialization of radical new inventions is something that we cannot ascertain within the limits of the current data. It could be that they act directly on specific projects through championing, or perhaps their impact is more diffuse through their role as symbolic leaders (Pfeffer 1981) or as the wellspring of organizational values (Miles 2007). Getting a handle on this will require much more in-depth research on specific firms and their innovative processes.

There are also potential issues with regards to our data. We have no way of knowing specifically which of the patents filed in 2002 were incorporated into new products introduced in 2006. Given that our measures of radicalness were by necessity aggregate averages over all patents filed, we cannot say for sure whether the radical patents or the incremental patents were being exploited more frequently, or how the executive characteristics affected the development of a particular kind of technological invention. We see no way to overcome this limitation.

In sum, we are extremely pleased with the results of this study. We have added to the top management team literature by discovering another element of context which

determines the extent to which executives exert influence throughout the organization. We have added to the innovation literature by offering a richer, more detailed empirical model of the innovation process. Studying only inventions or only new products as the outcome of innovative efforts does not tell the whole story. To really understand why some firms can innovate better than others, we must understand how various firm characteristics affect the likelihood that new ideas move through the development process to become new products.

LIST OF REFERENCES

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Afuah, A. 1998. ***Innovation Management: Strategies, Implementation, and Profits***. Oxford, New York: Oxford University Press.

Ahuja, G. & Lampert, C.M. 2001. Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough inventions. ***Strategic Management Journal,*** 22(6-7): 521-543.

Aldrich, H. E. & Waldinger, R. 1990. Ethnicity and Entrepreneurship. ***Annual Review of Sociology***, 16: 111-135.

Antonacopoulou, E. P. 2006. The relationship between individual and organizational learning: New evidence from managerial learning practices. ***Management Learning***, 37(4): 455-473.

Argyris, C. & Schon, D. 1978. ***Organizational learning: A theory of action perspective***. Reading, Massachusetts: Addison-Wesley Publishing Company.

Attuahene-Gima, K. & Ko, A. 2001. An empirical investigation of the effect of market orientation and entrepreneurship orientation alignment on product innovation. ***Organization Science***, 12(1): 54-74.

Bantel, K.A. & Jackson, S.E. 1989. Top management and innovations in banking: Does the composition of the top team make a difference? ***Strategic Management Journal***, 10:107-124.

Barkema, H.G., & Shvyrkov, O. 2007. Does top management team diversity promote or hamper foreign expansion? ***Strategic Management Journal***, 28(7): 663-680.

Barringer, B. R. & Bluedorn, A.C. 1999. The relationship between corporate entrepreneurship and strategic management. ***Strategic Management Journal,*** 20(5): 421-444.

Birkinshaw, J. 1997. Entrepreneurship in multinational corporations: The characteristics of subsidiary initiatives. ***Strategic Management Journal***, 18(3): 207-229.

Bower, G. H. 1981. ***Theories of Learning***. Englewood Cliffs, New Jersey: Prentice-Hall.

Burgelman, R. A. 1983. Corporate Entrepreneurship and Strategic Management - Insights from a Process Study. ***Management Science***, 29(12): 1349-1364.

Burgelman, R. A. 1983. A Process Model of Internal Corporate Venturing in the Diversified Major Firm. ***Administrative Science Quarterly***, 28(2): 223-244.

Byrne, D. 1961. Interpersonal attraction as a function of affiliation need and attitude similarity. ***Human Relations***, 14: 63-70.

Cannella, A.A., Park, J.H., & Lee, H.U. 2008. Top management team functional background diversity and firm performance: Examining the roles of team member collocation and environmental uncertainty. ***Academy of Management Journal***, 51(4): 768-784.

Carpenter, M., Narin, F., et al. 1981. Citation rates to technologically important patents. ***World Patent Information***, 3: 160-163.

Chandler, A. 1962. ***Strategy and structure: Chapters in the history of the industrial enterprise***. Cambridge, Massachusetts: The M.I.T. Press.

Chandy, R. K. & Tellis, G.J. 1998. Organizing for radical product innovation: The overlooked role of willingness to cannibalize. ***Journal of Marketing Research***, 35(4): 474-487.

Chen, M.H., Chang, Y.C., & Hung, S.C. 2008. Social capital and creativity in R&D project teams. ***R&D Management***, 38(1): 21-34.

Cho, T.S. 2006. The effects of executive turnover on top management team's environmental scanning behavior after an environmental change. ***Journal of Business Research***, 59(2006): 1142-1150.

Cho, T.S. & Shen, W. 2007. Changes in executive compensation following an environmental shift: The role of top management team turnover. ***Strategic Management Journal***, 28: 747-754.

Christensen, C. M. 1997. ***The Innovator's Dilemma***. Boston, Massachusetts: Harvard Business School Press.

Christensen, C.M. & Bower, J.L. 1996. Customer power, strategic investment, and the failure of leading firms. ***Strategic Management Journal***, 17(3): 197-218.

Cohen, J. 1988. ***Statistical Power Analysis for the Behavioral Sciences*** (2nd Edition). Hillsdale, New Jersey: Lawrence Earlbaum Associates.

Cohen, J., Cohen, P., West, S.G., & Aiken, L.S. 2003. ***Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*** (3rd edition). Mahwah, New Jersey. Lawrence Earlbaum Associates.

Cohn, J., Katzenbach, J., & Viak, G. 2008. Finding and grooming breakthrough innovators. ***Harvard Business Review***, 86(12): 62.

Cohen, W. M. & Levinthal, D.A. 1989. Innovation and Learning - the 2 Faces of R-and-D. ***Economic Journal***, 99(397): 569-596.

Cohen, W. M. & Levinthal, D.A. 1990. Absorptive-Capacity - a New Perspective on Learning and Innovation. ***Administrative Science Quarterly***, 35(1): 128-152.

Covin, J. G. & Slevin, D.P. 1989. Strategic Management of Small Firms in Hostile and Benign Environments. ***Strategic Management Journal***, 10(1): 75-87.

Cyert, R. M. & March, J.G. 1963. ***A Behavioral Theory of the Firm***. Englewood Cliffs, New Jersey: Prentice-Hall.

Dahlin, K. B. & Behrens, D.M. 2005. When is an invention really radical? Defining and measuring technological radicalness. ***Research Policy***, 34(5): 717-737.

Damanpour, F. 1991. Organizational Innovation - a Metaanalysis of Effects of Determinants and Moderators. ***Academy of Management Journal***, 34(3): 555-590.

Damanpour, F. 1992. Organizational Size and Innovation. ***Organization Studies***, 13(3): 375-402.

David, P. A. 1975. ***Technical choice, innovation and economic growth***. London: Cambridge University Press.

Denis, J.L., Lamothe, L. & Langley, A. 2001. The dynamics of collective leadership and strategic change in pluralistic organizations. ***Academy of Management Journal***, 44(4): 809-837.

Dewar, R. D. & Dutton, J.E. 1986. The Adoption of Radical and Incremental Innovations - an Empirical-Analysis. ***Management Science***, 32(11): 1422-1433.

Dierickx, I. & Cool, K. 1989. Asset Stock Accumulation and Sustainability of Competitive Advantage. ***Management Science***, 35(12): 1504-1511.

Dobrev, S. D. & Barnett, W.P. 2005. Organizational roles and transition to entrepreneurship. ***Academy of Management Journal***, 48(3): 433-449.

Dushnitsky, G. & Lenox, M.J. 2005. When do firms undertake R&D by investing in new ventures? ***Strategic Management Journal***, 26(10): 947-965.

Dyer, J. H. & Singh, H. 1998. The relational view: Cooperative strategy and sources of interorganizational competitive advantage. ***Academy of Management Review***, 23(4): 660-679.

Ellis, H. C. 1965. ***The Transfer of Learning***. New York: MacMillan.

Ettlie, J. E., Bridges, W.P., et al. 1984. Organization Strategy and Structural Differences for Radical Versus Incremental Innovation. ***Management Science***, 30(6): 682-695.

Freeman, C. & Soete, L. 1997. ***The Economics of Industrial Innovation***. Cambridge, Mass: The MIT Press.

Garcia, R. & Calantone, R. 2002. A critical look at technological innovation typology and innovativeness terminology: a literature review. ***Journal of Product Innovation Management***, 19(2): 110-132.

Gartner, W. B. 1988. "Who is an entrepreneur" is the wrong question. ***American Journal of Small Business***, 10: 696-706.

Gatignon, H., Tushman, M.L., et al. 2002. A structural approach to assessing innovation: Construct development of innovation locus, type, and characteristics. ***Management Science***, 48(9): 1103-1122.

George, G., Zahra, S.A., et al. 2002. The effects of business-university alliances on innovative output and financial performance: a study of publicly traded biotechnology companies. ***Journal of Business Venturing***, 17(6): 577-609.

Govindarajan, V. & Kopalle, P.K. 2006. Disruptiveness of innovations: Measurement and an assessment of reliability and validity. ***Strategic Management Journal***, 27(2): 189-199.

Green, S. G., Gavin, M.B., et al. 1995. Assessing a Multidimensional Measure of Radical Technological Innovation. ***IEEE Transactions on Engineering Management***, 42(3): 203-214.

Hambrick, D.C. & Finkelstein, S. 1987. Managerial discretion: A bridge between polar views of organizations. In Cummings & Staw (Eds.), ***Research in Organizational Behavior***.

Hambrick, D.C. & Mason, P.A. 1984. Upper echelons: The organization as a reflection of its top managers. ***Academy of Management Revew,*** 9(2): 193-206.

Harrison, R. & Leitch, C.M. 2005. Entrepreneurial learning: Researching the interface between learning and the entrepreneurial context. ***Entrepreneurship Theory and Practice***, 29(4): 351-371.

Hisrich, R. D. P. 1989. ***Entrepreneurship: Starting, Developing, and Managing a New Enterprise***. Irwin Professional Publishing.

Hitt, M. A., Ireland, R.D., et al. 2001. Guest editors' introduction to the special issue - Strategic entrepreneurship: Entrepreneurial strategies for wealth creation. ***Strategic Management Journal***, 22(6-7): 479-491.

Holcomb, T.R., Holmes, R.M., & Connelly, B.L. 2009. Making the most of what you have: Managerial ability as a source of resource value creation. ***Strategic Management Journal***, 30(5): 457-485.

Hult, G. T. M., Ketchen, D.J., et al. 2002. An examination of cultural competitiveness and order fulfillment cycle time within supply chains. ***Academy of Management Journal***, 45(3): 577-586.

Ireland, R. D., Hitt, M.A., et al. 2001. Integrating entrepreneurship and strategic management actions to create firm wealth. ***Academy of Management Executive***, 15(1): 49-63.

Ireland, R. D., Hitt, M.A., et al. 2003. A model of strategic entrepreneurship: The construct and its dimensions. ***Journal of Management***, 29(6): 963-989.

Itami, H. & Numagami, T. 1992. Dynamic Interaction between Strategy and Technology. ***Strategic Management Journal***, 13: 119-135.

Jensen, M. C. & Meckling, W.H. 1976. Theory of Firm - Managerial Behavior, Agency Costs and Ownership Structure. ***Journal of Financial Economics***, 3(4): 305-360.

Jewkes, J., Sawers, D., & Stillerman, R. 1959. ***The Sources of Invention***. New York: St. Martin's Press.

Kearney, E. & Gebert, D. 2009. Managing diversity and enhancing team outcomes: The promise of transformational leadership. ***Journal of Applied Psychology***, 94(1): 77-89.

Kirzner, I. M. 1997. Entrepreneurial discovery and the competitive market process: An Austrian approach. ***Journal of Economic Literature***, 35: 60-85.

Knight, G. A. 1997. Cross-cultural reliability and validity of a scale to measure firm entrepreneurial orientation. ***Journal of Business Venturing***, 12(3): 213-225.

Kurtzberg, T.R. 2005. Feeling creative, being creative: An empirical study of diversity and creativity in teams. ***Creativity Research Journal***, 17(1): 51-65.

Lane, P. J., Koka, B.R., et al. 2006. The reification of absorptive capacity: A critical review and rejuvenation of the construct. ***Academy of Management Review***, 31(4): 833-863.

Lane, P. J. & Lubatkin, M. 1998. Relative absorptive capacity and interorganizational learning. ***Strategic Management Journal***, 19(5): 461-477.

Levitt, B. & March, J.G. 1988. Organizational learning. ***Annual Review of Sociology***, 14: 319-338.

Ling, Y., Simsek, Z., Lubatkin, M.H., & Veiga, J.F. 2008. Transformational leadership's role in promoting corporate entrepreneurship: Examining the CEO-TMT interface. ***Academy of Management Journal***, 51(3): 557-576.

Lounsbury, M. & Glynn, M.A. 2001. Cultural entrepreneurship: Stories, legitimacy, and the acquisition of resources. ***Strategic Management Journal***, 22(6-7): 545-564.

Lumpkin, G. T. & Dess, G.G. 1996. Clarifying the entrepreneurial orientation construct and linking it to performance. ***Academy of Management Review***, 21(1): 135-172.

Lyon, D. W., Lumpkin, G.T., et al. 2000. Enhancing entrepreneurial orientation research: Operationalizing and measuring a key strategic decision making process. ***Journal of Management***, 26(5): 1055-1085.

Mackey, A. 2008. The effect of CEOs on firm performance. ***Strategic Management Journal***, 29(12): 1357-1367.

Malerba, F. 1992. Learning by Firms and Incremental Technical Change. ***Economic Journal***, 102(413): 845-859.

March, J. 1991. Exploration and exploitation in organizational learning. ***Organization Science***, 2(1): 71-87.

McKee, D. 1992. An Organizational Learning Approach to Product Innovation. ***Journal of Product Innovation Management***, 9(3): 232-245.

McKelvey, B. 2004. Toward a complexity science of entrepreneurship. ***Journal of Business Venturing***, 19(3): 313-341.

McMullen, J. S. & Shepherd, D.A. 2006. Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur. ***Academy of Management Review***, 31(1): 132-152.

Meeus, M. T. H., Oerlemans, L.A.G., et al. 2001. Patterns of interactive learning in a high-tech region. ***Organization Studies***, 22(1): 145-172.

Miles, R.E. 2007. Innovation and leadership values. ***California Management Review***, 50(1): 192.

Miller, D. & Friesen, P.H. 1982. Innovation in Conservative and Entrepreneurial Firms - 2 Models of Strategic Momentum. ***Strategic Management Journal***, 3(1): 1-25.

Morris, M. H. & Paul, G.W. 1987. The Relationship between Entrepreneurship and Marketing in Established Firms. ***Journal of Business Venturing***, 2(3): 247-259.

Morris, M. H. & Sexton, D.L. 1996. The concept of entrepreneurial intensity: Implications for company performance. ***Journal of Business Research***, 36(1): 5-13.

Naiberg, R. 2003. Patent attorney with Goodmans Law LLP in Toronto, Canada. I. b. K. Dahlin.

Nelson, R. R. & Winter, S.G. 1982. ***An Evolutionary Theory of Economic Change***. Belknap.

O'Brien, J. P. 2003. The capital structure implications of pursuing a strategy of innovation. ***Strategic Management Journal***, 24(5): 415-431.

Penrose, E. 1995. ***The Theory of the Growth of the Firm***. Oxford University Press.

Pfeffer, J. 1981. Management as symbolic action: The creation and maintenance of organizational paradigms. In Cummings and Staw (Eds.), ***Research in Organizational Behavior***.

Pfeffer, J. 1983. Organizational demography. In Cummings and Staw (Eds.), ***Research in Organizational Behavior.***

Porter, M.E. 1990. ***The Competitive Advantage of Nations***. New York: The Free Press.

Rice, M. P., Kelley, D., et al. 2001. Radical innovation: triggering initiation of opportunity recognition and evaluation. ***R & D Management***, 31(4): 409-420.

Roberts, E.B. 1988. What we've learned: Managing invention and innovation. ***Research Technology Management,*** 31(1): 11-29.

Roberts, K.H. & O'Reilly, C.A. 1979. Some correlates of communication roles in organizations. ***Academy of Management Journal***, 22:42-57.

Rosenberg, N. 1976. ***Perspectives on Technology***. Armonk: M. E. Sharpe, Inc.

Rosenberg, N. 1982. ***Inside the black box: Technology and economics***. Cambridge: Cambridge University Press.

Rosenkopf, L. & Nerkar, A. 2001. Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. ***Strategic Management Journal***, 22(4): 287-306.

Rousseau, D. M. & Parks, J.M. 1992. The Contracts of Individuals and Organizations. ***Research in Organizational Behavior***, 15: 1-43.

Salancik, G.R. & Pfeffer, J. 1977. Constraints on administrator discretion: The limited influence of mayors on city budgets. ***Urban Affairs Quarterly***, 12(4): 475-498.

Sansone, C. & Harackiewicz, J.M. 2000. ***Intrinsic and extrinsic motivation: The search for optimal motivation and performance***. US: Academic Press.

Sarkar, M. B., Echambadi, R.A.J., et al. 2001. Alliance entrepreneurship and firm market performance. ***Strategic Management Journal***, 22(6-7): 701-711.

Schumpeter, J. A. 1950. ***Capitalism, Socialism, and Democracy***. New York: Harper & Brothers Publishers.

Shane, S. 2001. Technological opportunities and new firm creation. ***Management Science***, 47(2): 205-220.

Shane, S. & Venkataraman, S. 2000. The promise of entrepreneurship as a field of research. ***Academy of Management Review***, 25(1): 217-226.

Sharma, P. & Chrisman, J. 1999. Toward a reconciliation of the definitional issues in the field of corporate entrepreneurship. ***Entrepreneurship Theory and Practice***, 23.

Shin, S.J. & Zhou, J. 2007. When is educational specialization heterogeneity related to creativity in research and development teams? Transformational leadership as a moderator. ***Journal of Applied Psychology***, 92(6): 1709-1721.

Shipton, H. 2006. Cohesion or confusion? Towards a typology for organizational learning research. ***International Journal of Management Reviews***, 8(4): 233-252.

Silverberg, G. 1991. Adoption and Diffusion of Technology as a Collective Evolutionary Process. ***Technological Forecasting and Social Change***, 39(1-2): 67-80.

Somech, A. 2006. The effects of leadership style and team process on performance and innovation in functionally heterogeneous teams. ***Journal of Management***, 32(1): 132-157.

Stevenson, H. H. & Jarillo, J.C. 1990. A Paradigm of Entrepreneurship - Entrepreneurial Management. ***Strategic Management Journal***, 11: 17-27.

Stopford, J. M. & Badenfuller, C.W.F. 1994. Creating Corporate Entrepreneurship. ***Strategic Management Journal***, 15(7): 521-536.

Subramaniam, M. & Youndt, M.A. 2005. The influence of intellectual capital on the types of innovative capabilities. ***Academy of Management Journal***, 48(3): 450-463.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. ***Strategic Management Journal***, 17: 27-43.

Taylor, A. & Greve, H.R. 2006. Superman or the Fantastic Four? Knowledge combination and experience in innovative teams. ***Academy of Management Journal***, 49(4): 723-740.

Thornton, P. H. 1999. The sociology of entrepreneurship. ***Annual Review of Sociology***, 25: 19-46.

Tsai, W. P. 2001. Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. ***Academy of Management Journal***, 44(5): 996-1004.

Tushman, M. L. & Anderson, P. 1986. Technological Discontinuities and Organizational Environments. ***Administrative Science Quarterly***, 31(3): 439-465.

Van den Bosch, F. A. J., Volberda, H.W., et al. 1999. Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. ***Organization Science***, 10(5): 551-568.

Wasserman, S. & Faust, K. 1999. ***Social Network Analysis***. Cambridge: Cambridge University Press.

Zahra, S. A. 1996. Governance, ownership, and corporate entrepreneurship: The moderating impact of industry technological opportunities. ***Academy of Management Journal***, 39(6): 1713-1735.

Zahra, S. A. 2005. Entrepreneurial risk taking in family firms. ***Family Business Review***, 18(1): 23-40.

Zahra, S. A. & George, G. 2002. Absorptive capacity: A review, reconceptualization, and extension. ***Academy of Management Review***, 27(2): 185-203.

Zahra, S. A., Neubaum, D.O., et al. 2000. Entrepreneurship in medium-size companies: Exploring the effects of ownership and governance systems. ***Journal of Management***, 26(5): 947-976.

APPENDICES

Appendix A. Purdue Research Park Companies

- Company
- 2K Corporation
- ABAQUS Central
- ACE Learning, LLC
- Advanced Digital Imaging
- Advanced Process Combinatorics, Inc.
- Aerial Image
- Akina, Inc.
- Ameriprise Financial
- Arlington Counseling
- Arxan Technologies, Inc.
- Arxan Research
- B.L. Anderson Co.
- Banc Tech
- Banker Investment Group
- Batch Process Technologies, Inc.
- Bernardin – Lochmueller & Associates, Inc.
- Bioanalytical Systems, Inc.
- BioVitesse
- Bose McKinney & Evans
- Butler International, Inc.
- Center for the Advancement of Transportation Safety (CATS)
- Central Indiana Development Corp. & Mortgage Corp.
- CERIS (Center for Environmental & Regulatory Information Systems)
- ChromCraft Revington
- Connie Davis, CPA
- Conservation Technology Information Center
- Cook Biotech Inc.
- Copient Technologies
- Crop Production Services, Inc.
- Cruise Software
- C-SPAN Archives
- CST/Berger
- Daniel Z. Blomeke
- Delphi-D Test Lab
- Dennmark Homes
- Diesslin & Associates
- EITAC Solutions Group
- Endocyte, Inc.

- Engineering Communications
- En'Urga, Inc.
- Executive Home Builders
- Ezra Manufacturing
- FAVORED, Inc.
- FuturaGene, Inc.
- Gerald P. Murphy Cancer Foundation
- gh llc
- Green Tech America, Inc.
- Human Performance & Safety Consultants, Inc
- Icx Griffin Analytical Technologies, Inc.
- Imaginestics
- IN Space, LLC
- Indiana Agricultural Statistics
- Indiana Clean Manufacturing Technology & Safe Materials Institute
- Indiana Department of Transportation – Division of Research
- Indiana LTAP
- Industrial Federal Credit Union
- Innovar
- International Sports Club
- Invivo Ventures
- Johnson Realty Co., Inc.
- Kumon Learning Center
- L.S. Technology, Inc.
- L-3 Communications
- Lafayette Community Bank
- Life Plus
- Lite Machines Corporation
- Magic Wand Midwest
- Mascouten Associates
- MatrixBio, LLC
- Mattern, Dr. James & Kriebel, Dr. Mary
- MB Investments
- Med Institute, Inc.
- Micro Systems Technologies LLC
- mPlexus LLC
- Mudawar Thermal Systems, Inc.
- Nanovis
- Netlink Technologies
- New York Life Insurance Co.
- Nissan Chemical America Corp.
- North Central Superpave Center (NCSC)

- NOX Technologies
- OfficeScape
- Omega Wireless
- OnePurdue
- PC Krause & Associates, Inc.
- Pets and Vets as Partners
- Prophet One Solutions
- Purdue Department of Industrial Pharmacy
- Purdue IT Training
- Purdue Research Foundation/Purdue Research Park
- Purdue Technical Assistance Program
- QSIIC PharmTech
- Quadraspec, Inc.
- R.E. Moulton, Inc.
- Reliable Insurance Solutions
- River Valley Wireless, LLC
- Riverside Covenant Church
- S3CRL – Spread-Spectrum & Satellite Communications Research Laboratory.
- Sagamore Village Estates Corp.
- SAGE Intellectual Property
- Schneider Corporation
- Seyet LLC
- Simulex Inc.
- Specialty Hybrids
- SpectraCode, Inc.
- Spectraline, Inc.
- SSCI Inc.
- State Farm Insurance
- State Farm Insurance Agent (Jim Clapper)
- Steradian Technologies
- Steve Nelson, MD
- Sunny Ritchie Counseling Services
- Swift Enterprises, Ltd.
- The Chao Center for Industrial Pharmacy & Contract Manufacturing
- Thermophysical Properties Research Laboratory, Inc.
- TIAA Cref
- USDA
- Utility Test Equipment Co
- VASC Alert, LLC
- W.L. Area Testing Lab – INDOT
- W.L. Postal Carrier Annex
- WGLM 106.7 FM (KVB Broadcasting)

- WLFI – TV 18
- Zeeko Technologies, Ltd.
- APIMBA
- BenchmarkPortal LLC
- BioServices Group, LLC
- Cyberkinetics, Inc.
- Enabling Innovations
- Environmental Engineering and Contracting, Inc.
- Green Tech America, Inc.
- InMass Technologies, Inc.
- InfoComm Systems Inc.
- Janus Biosystems Inc.
- Kylin
- M4 Sciences Corporation
- MagSense Life Sciences, Inc.
- MatrixBio LLC
- Micro Machinists
- Moerae Matrix Inc./MMI Matrix Inc.
- PowerSys LLC
- Prima Specialty Vectors
- Quansor Corporation
- Risk Management Security Group
- Savitar Corporation
- Sensory Ventures LLC
- Seyet LLC
- Theme Work Analytics Limited
- VANCOE

Appendix B. Initial Letter of Invitation

[Insert Date]

Dear [Insert Name]:

We would like to request your company's participation in a survey designed to explore the processes behind organizational learning.

The ability of a firm to recognize and learn from changes in its business environment is critical to achieving competitive advantage, especially for smaller firms which rely on their agility and ability to innovate to compete. Bart Sharp, a 5th year Ph.D. student in the Krannert School of Management at Purdue University, is conducting his dissertation research investigating how the characteristics of individual employees interact with the firm's management practices to influence the kinds of knowledge the firm is able to absorb and utilize. The way firms use employees to track and take advantage of new knowledge is likely to be especially important to the firm's ability to be entrepreneurial and to innovate. This link should be of special interest to the firms associated with the Illinois Technology Development Alliance.

Participation in this research is completely voluntary. However, we feel that these topics should be of great interest both to us as well as to your company. If you agree to participate, you will be asked to pass along a brief survey to all employees of your firm. There will be one survey that all executives will be asked to complete as well as a separate survey for lower level managers and employees. Completing the survey will take no more than 30 minutes. Responses will be used for research purposes only and will be kept strictly confidential. You will be given the opportunity to receive summary statistics and analysis results based on all respondents should you be interested.

If you would be willing to participate, please contact Mr. Sharp by e-mail at sharpb@purdue.edu or by telephone at 765-532-1888. Also feel free to contact Mr.

Sharp if you have any questions or need any additional information to help you decide whether or not to take part. Thank you for taking the time to consider being a part of this interesting and important study.

Sincerely,
Gregory W. Deason
Vice President - Real Estate and Research Park Development
Director - Purdue Research Park

Appendix C. Letter of Instruction for Participating Executives

[Your Name]
[Street Address]
[City, ST ZIP Code]
[Date]

[Recipient Name]
[Title]
[School Name]
[Street Address]
[City, ST ZIP Code]

Dear [Recipient Name]:Thank you for agreeing to participate in the current exciting research on organizational learning! We expect that the results of this study will have important implications for firms seeking to get an edge on the competition through innovation.

We are collecting data using two different survey instruments, one for all top executives (President, CEO, Vice Presidents, General Managers, or similar) and a second for all other employees (including lower level managers, functional employees, etc). The executive survey consists primarily of questions about the innovation and entrepreneurial activities with which your organization is involved. The employee survey is concerned primarily with organizational learning activities. Ideally we will receive responses from everyone in your organization. Neither survey should take more than 30 minutes to complete.

We have gone to great lengths in the design of this research to ensure the highest level of anonymity and confidentiality. At no point will anyone be required to provide personally identifiable information. Executives will have the option of providing an e-mail address should they be interested in receiving summary results from the study, and employees will have the option of providing an e-mail address to enter for a chance to win one of five $100 cash prizes. In the case of the employees the raffle drawing will be handled by the independent company which is hosting the online survey and the e-mail addresses will never be provided to any of us involved in the research. Rather than asking for the company name on the surveys, the attached instructions contain a random six-digit number for respondents to use on the survey. This will allow us to combine all the responses from a given company without knowing which company it is.

The next step is to spread the word to the rest of the organization. You will find attached to this letter two messages, one for executives and one for everyone else. The messages

contain information about the study and instructions on how to complete the surveys. **Please e-mail the file entitled "Executive Instructions" to anyone with the title of President, CEO, Vice Presidents, General Managers, or similar, and send the file entitled "Employee Instructions" to everyone else.**

Your help with this project is very much appreciated. If you have any questions, please do not hesitate to contact Bart Sharp by e-mail at sharpb@purdue.edu or by telephone at 765-532-1888.

Sincerely,

Dr. Thomas Brush, Associate Professor
Bart Sharp, PhD Candidate
Krannert School of Management
Purdue University
403 West State Street
West Lafayette, IN 47907-2056

Appendix D. Executive Instructions

Dear Sir/Madame:

Your company has agreed to participate in an exciting new research project being conducted by the Krannert School of Management at Purdue University. The goal of this study is to explore the ways in which individual employees contribute to organizational learning, and how the knowledge acquired affects innovation and entrepreneurship. Our goal is to develop a set of guidelines and recommendations which will help you maximize your firm's ability to beat the competition through innovative and entrepreneurial initiatives.

Please go to www.executivesurvey.com and complete our brief survey. It will take you no more than 30 minutes maximum. In order to ensure your anonymity, you are not required to provide any personally identifiable information. You have the option at the end of the survey to provide an e-mail address if you are interested in receiving summary results of the study. *You are not required to provide an e-mail address.* If you do choose to give one, that information will be stripped from the data such that it will never be associated with your actual responses.

Further supporting anonymity, you will never be asked the name of your company. Instead, you will enter a six-digit code number on the first question of the survey. **Your company code is XXXXXX**. Your responses will at no point be associated with your company name.

Participation in this survey is completely voluntary, and only people age 18 or older are eligible to participate. If you choose to begin the survey, you are free to withdraw at any time without penalty.

Thank you for taking the time to consider being involved! If you have any questions, feel free to contact Bart Sharp at sharpb@purdue.edu.

Sincerely,
Dr. Thomas Brush, Associate Professor
Bart Sharp, PhD Candidate
Krannert School of Management
Purdue University
403 West State Street
West Lafayette, IN 47907-2056

Appendix E. Employee Instructions

Dear Sir/Madame:

Your company has agreed to participate in an exciting new research project being conducted by the Krannert School of Management at Purdue University. The goal of this study is to explore the ways in which individual employees contribute to organizational learning, and how the knowledge acquired affects innovation and entrepreneurship. Our theory is that the independent activities of individual employees like you are an important but possibly unrecognized source of new knowledge which may become valuable to the firm. This study represents our effort to explore that phenomenon.

Please go to www.employeesurvey.com and complete our brief survey. It will take you no more than 30 minutes maximum. In order to ensure your anonymity, you are not required to provide any personally identifiable information. You have the option at the end of the survey to provide an e-mail address to **enter a drawing to win one of five $100 cash prizes**. *You are not required to provide an e-mail address.* If you do choose to give one, that information will be retained by the independent company handling the survey and will never be passed along to the researchers or associated with your responses. Odds of winning depend on the number of responses we get, but the worst case would be odds of approximately 5 in 1000. We expect the odds to be significantly better than that.

Further supporting anonymity, you will never be asked the name of your company. Instead, you will enter a six-digit code number on the first question of the survey. **Your company code is XXXXXX**. Your responses will at no point be associated with your company name.

Participation in this survey is completely voluntary, and only people age 18 or older are eligible to participate. If you choose to begin the survey, you are free to withdraw at any time without penalty.

Thank you for taking the time to consider being involved! If you have any questions, feel free to contact Bart Sharp at sharpb@purdue.edu.

Sincerely,
Dr. Thomas Brush, Associate Professor
Bart Sharp, PhD Candidate
Krannert School of Management
Purdue University

403 West State Street
West Lafayette, IN 47907-2056

Appendix F. Executive Survey (President, CEO, Vice Presidents, General Managers, or similar)

Hello, and thank you for your time. As a dissertation-stage PhD student in Strategic Management at the Krannert School of Management, I am currently conducting research on organizational learning, innovation, and entrepreneurship. We know from experience that organizations learn from the external environment through a variety of channels, including management-directed efforts such as monitoring competitors as well as the self-directed efforts of employees. I believe that the self-directed activities of individual employees, even when not obviously related to their duties, can pay enormous benefits to their organizations in terms of broadening the scope of knowledge which is available for use in the development of new products, processes, and markets. The following survey is designed to help us test that belief by measuring firm-level outcomes of innovation and entrepreneurship. Your voluntary participation would be most appreciated.

In today's environment, firms must be able to quickly innovate and effectively pursue opportunities in order to maintain a competitive advantage. Our hope is that this study will result in a set of concrete recommendations regarding important managerial decisions such as personnel selection, incentives, and company structure which can help firms maximize their ability to gain that advantage.

In pre-testing, no subject has required more than 25 minutes to complete this survey. Please be assured that your responses to the following questions will be used for research purposes only and will remain strictly confidential. In order to test theories on firm-level outcomes, there is a code associated with each survey which will allow us to connect your responses to your organization. However, we do not ask for your name or any other unique identifier and no individual responses will ever be reported. Rather, your responses will be aggregated with those of other participants for the purpose of conducting statistical analyses. If you are interested in seeing the summary statistics and results of those analyses, please indicate that on the last question of the survey and provide an e-mail address where the report can be sent.

Once again, thank you for your time and participation!

Sincerely,

Bart Sharp

Krannert School of Management

Purdue University

403 West State Street

West Lafayette, IN 47907-2056

sharpb@purdue.edu

Please enter your six-digit company code:					
Entrepreneurship In this section you will be asked a series of questions regarding your firm's entrepreneurial activities					
1. In the past three years, has your company introduced any new products or services which were the result of internal development efforts?		Yes		No	
2. If so, how many?	1	2	3	4 or more	N/A
3. In the past three years, has your company entered any new markets (new geographical markets, product markets, etc.) as a result of internal development efforts?		Yes		No	
4. If so, how many?	1	2	3	4 or more	N/A
5. In the past three years, has your company introduced any new products as the result of an unexpected discovery or opportunity?		Yes		No	
6. If so, how many?	1	2	3	4 or more	N/A
7. In the past three years, has your company entered any new markets as a result of unexpected discoveries or opportunities?		Yes		No	
8. If so, how many?	1	2	3	4 or more	N/A
9. In the past three years, has your company introduced any new products as the result of imitating other firms?		Yes		No	
10. If so, how many?	1	2	3	4 or more	N/A
11. In the past three years, has your company entered any new markets as a result of imitating other firms?		Yes		No	
12. If so, how many?	1	2	3	4 or more	N/A
13. In the past three years, has your company introduced any new products as a result of purchasing other firms?		Yes		No	
14. If so, how many?	1	2	3	4 or more	N/A
15. In the past three years, has your company entered any new markets as a result of purchasing other firms?		Yes		No	
16. If so, how many?	1	2	3	4 or more	N/A
17. In the past three years, has your company introduced any new products as a result of investments in new ventures (start-up companies outside of your own)?		Yes		No	
18. If so, how many?	1	2	3	4 or more	N/A
19. In the past three years, has your company entered any new markets as a result of investment in new ventures (start-up companies outside of your own)?		Yes		No	

20. If so, how many?	1 2 3 4 or more N/A
21. How entrepreneurial is your firm?	Not At All Extremely 1 .....2 ..... 3 ..... 4.....5
22. My company is more active in the pursuit of external opportunities than the typical firm in our industry.	Strongly Disagree Strongly Agree 1 .....2 ..... 3 ..... 4.....5
23. My company excels at exploiting opportunities in the environment.	Strongly Disagree Strongly Agree 1 .....2 ..... 3 ..... 4.....5
24. Approximately how many new products has your company began producing in the past year?	
25. Approximately how many new markets has your company entered in the past year (new geographical markets, product markets, etc.)?	
Innovation In this section you will be asked a series of questions regarding your firm's innovative activities	
26. Innovations we introduce tend to be minor improvements over the previous technology	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
27. Innovations we introduce tend to be based on a revolutionary change in technology	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
28. Innovations we introduce tend to be breakthrough innovations (significantly advance the state-of-the-art)	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
29. Innovations we introduce tend to lead to products that are difficult to replace or substitute using older technology	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
30. Innovations we introduce tend to be based on science or technology which was previously unfamiliar to us.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
31. Innovations we introduce tend to be very costly in terms of the investment required for us to become familiar with the underlying science or technology.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
32. Innovations we introduce tend to build on our previous business experience with other products.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
33. Innovations we introduce tend to require that we change the way we think about our business operations.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
34. Innovations we introduce tend to disrupt the markets in which we introduce them by significantly changing the way consumers or competitors operate.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
35. Innovations we introduce tend to create new markets where there were none before.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5
36. Innovations we introduce tend to fulfill needs or wants which the customers were previously unaware of.	Does Not Apply Strongly Applies 1 .....2 ..... 3 ..... 4.....5

37. Approximately how many patents does your company own (patents either applied for or granted)?	
38. Of those patents, how many represent internally developed inventions rather than patents which were obtained from outside sources?	
Organizational Learning In this section you will be asked a series of questions regarding your firm's ability to learn knowledge from sources outside of the organization	
39. My firm as a whole excels at recognizing potentially useful information outside firm boundaries	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
40. My firm has highly effective systems in place for the identification of external knowledge which may be of use to us	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
41. My firm becomes aware of most useful external information in a timely manner	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
42. My firm as a whole excels at internalizing potentially useful information which originates outside the firm	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
43. My firm has highly effective systems in place for the internalization of external knowledge which may be of use to us	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
44. My firm is able to absorb most useful external information	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
45. My firm as a whole excels at exploiting potentially useful information which originates outside the firm	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
46. My firm has highly effective systems in place for the application of knowledge which originates outside the firm	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
47. My firm is able to apply most potentially useful external information in a valuable way	Strongly Disagree 1 .....2 .....3 ..... 4.....5 Strongly Agree
Demographics In this section you will be asked a series of general questions about your firms operations, structure, etc.	
48. Compared on your knowledge of other firms in your industry which are of similar size and age to your company, how would you characterize your annual R&D expenditures?	Far Below Average 1 .....2 .....3 ..... 4.....5 Far Above Average
49. How many employees does your company currently have?	
50. In what year was your firm founded as a legal entity?	
51. In what year did your firm hire its first employees?	

52. In what year did your firm record its first sales?	
53. What is the ownership structure of your firm?	Private Public
54. Approximately what percentage of the company is owned by the top management team?	
55. Approximately what percentage of the company is owned by the company founders?	
56. Is at least one of the founders still a part of the top management team?	Yes No
57. Does your firm have a board of directors?	Yes No
58. If yes, is the Chairman of the Board also the CEO or other top executive?	Yes No N/A
59. Does your firm have a scientific or technical advisory board?	Yes No
60. How would you characterize your organizational structure?	Functional Divisional Other
61. What is the average span of control for your managers? (Span of control is defined as the number of employees reporting to a manager)	
62. Briefly describe the primary industry in which your firm operates	
63. How would you characterize your firm's operations?	All Service 1 .....2 .....3 ..... 4.....5 All Manufacturing
64. How would you characterize your firm's debt situation relative to other firms of similar size in your industry?	Highly Leveraged 1 .....2 .....3 ..... 4.....5 No Debt
65. How would you characterize your firm's cash situation relative to other firms of similar size in your industry?	No Cash Reserve 1 .....2 .....3 ..... 4.....5 Large Cash Reserves
Would you like to see summary results from this study? Please note that for your confidentiality, any e-mail address you provide will be stripped from your responses and stored in a separate file.	
66. I would like to receive a summary of the analyses resulting from this survey	Yes No
67. If yes, please indicate an e-mail address where the summary can be sent	

Appendix G. Employee Survey

Hello, and thank you for your time. As a dissertation-stage PhD student in Strategic Management at the Krannert School of Management, I am currently conducting research on organizational learning, innovation, and entrepreneurship. We know from experience that organizations learn from the external environment through a variety of channels, including management-directed efforts such as monitoring competitors as well as the self-directed efforts of employees. I believe that the self-directed activities of individual employees, even when not obviously related to their duties, can pay enormous benefits to their organizations in terms of broadening the scope of knowledge which is available for use in the development of new products, processes, and markets. The following survey is designed to help us test that belief by measuring the relative levels of directed and independent learning. Your voluntary participation would be most appreciated.

To make it worth your time, I will be holding a drawing at the end of the survey period to give away five $100 cash prizes. Everyone who completes the survey will be eligible to win.

In pre-testing, no subject has required more than 25 minutes to complete this survey. Please be assured that your responses to the following questions will be used for research purposes only and will remain strictly confidential. In order to test theories on firm-level outcomes, there is a code associated with each survey which will allow us to connect your responses to your organization. However, we do not ask for your name or any other unique identifier and no individual responses will ever be reported. Rather, your responses will be aggregated with those of other participants for the purpose of conducting statistical analyses.

Once again, thank you for your time and participation!

Sincerely,

Bart Sharp

Krannert School of Management

Purdue University

403 West State Street

West Lafayette, IN 47907-2056

sharpb@purdue.edu

Please enter your six-digit company code:	
Independent Learning In this section you will be asked questions regarding activities which you undertake of your own interest and which contribute to organizational learning	
1. How many clubs or other organizations do you belong to which are **NOT** related to your current job (hobbies, personal interest, etc)?	0 1 2 3 4 or more
2. Of the organizations in Question 16, how many do you belong to because you feel your employer expects you to?	None All 1 ..... 2.....3.....4 5
3. On average, how many hours per day do you spend reading magazines, journals, newspapers, websites, or other literature **NOT** related to your current job?	0 1 2 3 4 or more
4. Of the reading in Question 21, how much do you do because you feel your employer expects you to?	None All 1 ..... 2.....3.....4 5
5. I am good at finding information from outside the organization when that information is of personal interest to me.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5
6. I am likely to notice information outside my company when it is information about something which I feel passionately about.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5
7. There are strong informal communication channels at my firm.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5
8. When I learn something that I feel has value in another part of the organization, I am comfortable sharing that knowledge directly with those who can most benefit without going through the formal chain of command.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5
9. I am comfortable seeking new knowledge directly from other employees outside the formal chain of command.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5
10. When I am looking for information within my company, I can use an informal network of contacts to find it.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5
11. Employees at my company share information with each other well through informal conversations or contacts.	Strongly Disagree Strongly Agree 1 ..... 2.....3.....4 5

12. People in my firm tend to be very accepting of new knowledge which is learned through the independent efforts of other employees	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
13. New knowledge collected through undirected initiatives of individual employees is generally well accepted	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
14. People in my firm tend to accept new knowledge whether or not that knowledge is likely to be acceptable to management	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
15. New knowledge gained as the result of the independent initiatives of employees is frequently applied to our operations.	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
16. As an organization, my firm excels at implementing new knowledge that is learned through undirected activities of employees	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
17. There is an efficient link between learning which employees do on their own initiative and the way in which we design and produce products, organize our firm, or conduct our business	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
Directed Learning In this section you will be asked questions regarding activities which you undertake as part of your job and which contribute to organizational learning	
18. How many associations, trade groups, or other organizations (not counting your employer) do you belong to which are directly related to your current job?	0 1 2 3 4 or more
19. Of the organizations in Question 1, what proportion do you belong to because you feel your employer expects you to?	None 1 ..... 2 .....3.....4 ..... All 5
20. On average, how many hours per day do you spend reading magazines, journals, newspapers, websites, or other literature directly related to your current job?	0 1 2 3 4 or more
21. Of the reading in Question 8, what proportion do you do because you feel your employer expects you to?	None 1 ..... 2 .....3.....4 ..... All 5
22. What proportion of your social contacts are with people related to your current job (people from your firm, competing firms, suppliers, customers, etc.)?	None 1 ..... 2 .....3.....4 ..... All 5
23. I am good at finding information from outside the organization when asked to by my supervisors.	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5

24. I am likely to notice information outside my company when I feel that it is information that might be important to my company.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
25. There are strong formal communication channels at my firm.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
26. When I learn something that I feel has value in another part of the organization, I am comfortable sharing that knowledge through the formal chain of command.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
27. I am comfortable seeking new knowledge through the formal chain of command.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
28. When I am looking for information within my company, there is a well established structure that I can use to find it.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
29. My company has a structured process by which we share information.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
30. People in my firm tend to be very accepting of new knowledge when the knowledge is learned through activities directed by managers	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
31. New knowledge collected through manager-sponsored initiatives is generally well accepted	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
32. People in my firm tend to accept new knowledge when they feel that knowledge is acceptable to management	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
33. New knowledge gained as the result of initiatives championed by management is frequently applied to our operations.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
34. As an organization, my firm excels at implementing new knowledge that is learned through management-led activities	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
35. There is an efficient link between management-led learning initiatives and the way in which we design and produce products, organize our firm, or conduct our business	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
Proactive Learning In this section you will be asked questions regarding activities which are not related to your current position, but which you feel will contribute to learning which will be important to your organization in the future	

36. How many associations, trade groups, or other organizations (not counting your employer) do you belong to which are not related to your current job, but which you feel might be related to what your company will do in the future?	0 1 2 3 4 or more
37. Of the organizations in Question 3, what proportion do you belong to because you feel your employer expects you to?	None All 1 ..... 2 .....3.....4 5
38. On average, how many hours per day do you spend reading magazines, journals, newspapers, websites, or other literature which is not related to your current job, but which you feel might be related to what your company will do in the future?	0 1 2 3 4 or more
39. Of the reading in Question 10, what proportion do you do because you feel your employer expects you to?	None All 1 ..... 2 .....3.....4 5
Learning Motives In this section you will be asked to answer a series of questions which explore why you choose to undertake learning activities	
40. I choose which organizations to join based on a desire to please my supervisors at work.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
41. I choose to belong to certain organizations because doing so improves my prospects for advancement or recognition at work.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
42. I join organizations which will expose me to knowledge which the management of my company has identified as being important.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
43. I choose which publications to read based on a desire to please my supervisors at work.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
44. I choose to read certain publications because doing so improves my prospects for advancement or recognition at work.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
45. I read publications which will expose me to knowledge which the management of my company has identified as being important.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
46. I choose which organizations to join based on the pleasure I get from them.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5
47. I join organizations which expose me to new knowledge that I find interesting.	Strongly Disagree Strongly Agree 1 ..... 2 .....3.....4 5

48. I use membership in organizations as a way to access knowledge on subjects about which I feel passionately.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
49. I choose which publications to read based on the pleasure I get from them.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
50. I read publications which expose me to new knowledge that I find interesting.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
51. I read certain publications in order to access knowledge on subjects about which I feel passionately.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
52. The ability to notice new knowledge outside my company is important when it comes to recognition and advancement.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
53. I am rewarded by my company when I learn something new from outside the company.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
54. My ability to advance my career depends on my ability to learn from outside my company.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
55. My managers appreciate it when I bring new knowledge into the organization.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
56. I get a lot of pleasure out of noticing new information outside my organization	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
57. I find it personally rewarding when I learn something new from outside the company.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
58. My happiness depends on my ability to learn from outside my company.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
59. Management at my company encourages employees to share information.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
60. My ability to communicate with other employees is important to my recognition and advancement.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
61. I share information with other employees because I enjoy doing so.	Strongly Disagree 1 ..... 2 .....3.....4 ..... 5 Strongly Agree
Demographics In this question you will be asked general questions regarding your background and experience	

62. What is the highest level of education which you have achieved?	High school ☐ Some college ☐ Associates degree ☐ Bachelors degree ☐ Masters degree ☐ Doctorate ☐ Other ☐
63. How relevant was the material learned at your highest level of education to your current position at work?	Completely Irrelevant 1 ..... 2 .....3.....4 ..... Very Relevant 5
64. How many years of experience do you have working in your current industry?	
65. How many years of experience do you have working in other industries?	
66. How many years of experience do you have working in your current functional area (engineering, accounting, etc.)?	
67. How many years of experience do you have working in other functional areas?	
Organizational Learning In this section you will be asked general questions regarding your organization's ability to learn	
68. My firm as a whole excels at recognizing potentially useful information outside firm boundaries	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
69. My firm has highly effective systems in place for the identification of external knowledge which may be of use to us	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
70. There is little useful external information which goes unnoticed by my firm	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
71. My firm as a whole excels at absorbing potentially useful information outside firm boundaries	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
72. My firm has highly effective systems in place for the internalization of external knowledge which may be of use to us	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
73. There is little useful external information which my firm is unable to absorb	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
74. My firm as a whole excels at exploiting potentially useful information which is learned from outside firm boundaries	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5
75. My firm has highly effective systems in place for the application of knowledge which is absorbed from the environment	Strongly Disagree 1 ..... 2 .....3.....4 ..... Strongly Agree 5

76. There is little useful external information which my firm is unable to apply in a potentially valuable way	Strongly Disagree 1 ..... 2.....3.....4 ..... Strongly Agree 5
In order to be entered to win one of five $100 cash prizes which will be randomly awarded to respondents, please provide your e-mail address below. Please note that your e-mail address will be stripped from your response. The drawing will be held by an independent party. The researchers will never be provided with your e-mail address.	
77. Please indicate an e-mail address where you can be notified if you win one of the five $100 prizes to be raffled away	

VITA

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Bart Sharp was born in Marion, Indiana and lived in and around Upland, Indiana for the first fifteen years of his life. After attending the Eastbrook school system through his sophomore year, he finished the last two years of high school as part of the inaugural class of the Indiana Academy for Science, Mathematics, and Humanities. He earned a Bachelor's degree in Aerospace Engineering from Purdue University and went to work in research in development at The Aerostructures Corporation in Nashville, Tennessee. During his time there he earned an MBA from Middle Tennessee State University. He began his teaching career as an adjunct professor of management at Middle Tennessee State, teaching operations management and principles of management in the evening and online undergraduate programs while still working as an engineer during the day. In 2004 he returned to Purdue to pursue a PhD in management at the Krannert Graduate School.