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AN EXAMINATION OF
THE DRIVERS OF EXPLORATORY AND EXPLOITATIVE SEARCH

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MICHAEL F. PRICE COLLEGE OF BUSINESS

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ABSTRACT

Engaging in search behaviors is a critical activity of firms. Traditionally, the extent to which firms engage in search has been modeled as the level of R&D in which firms engage, or their patenting propensity. However, all R&D efforts and patents are not uniform in the type of search in which they are focused. Search efforts can either be directed towards gathering new knowledge and technologies (exploratory search) or better understanding the knowledge and technologies they currently possess (exploitative search). The type of search in which firms engage is related to outcomes such as technology discovery, new product launches and financial performance. Thus, the distinction between the types of search in which firms engage is an important one. However, it has largely been overlooked in studies using R&D expenses or patenting propensity as measures of search efforts.

Because of the importance of understanding the types of search in which firms engage, I sought to understand what drives each type of search. Drawing upon the Behavioral Theory of the Firm and Upper Echelons Perspective, I examined how problems firms face, slack resources, executive demographics and executive compensation drive exploratory and exploitative search. Support for my original hypotheses was poor, with only CEO age and equity ownership being statistically significant. However, post-hoc analysis revealed there are substantial differences between large and small firms in the pharmaceutical industry in what drives search, suggesting promising avenues for future research.

CHAPTER ONE:

INTRODUCTION

All firms possess unique stores of knowledge and possess varying levels of abilities to identify, acquire and exploit new knowledge (Grant, 1996). The extent to which they are able to use their stores of knowledge and learn new knowledge influences their financial performance and even their survival (Grant, 1996). As firms gain mastery over what they know, they are able to leverage it to discover new knowledge and reap gains in efficiencies by honing key routines and processes (Cohen and Levinthal, 1990).

However, over time, knowledge held by firms grows old, technologies become outdated and core competencies that once generated positive performance outcomes deteriorate into rigidities that have detrimental performance effects (Leonard-Barton, 1992). To stave off negative performance and increase the chances of long-term survival, firms must, at some point and to some degree, search for and acquire new knowledge (March, 1991). That new knowledge may come from searching internally and more fully exploiting areas of general familiarity (i.e., exploitation), or it may come from searching externally and exploring for new knowledge to incorporate into the firm (i.e., exploration) (March, 1991). Given the choice between exploration and exploitation, what determines which kind of search in which firms will engage? The primary focus of this dissertation is the investigation of how critical antecedents of firm search efforts influence the type of search in which firms engage (i.e., exploratory or exploitative).

Exploration versus exploitation

These two dominant ways of searching for knowledge were described in the seminal article by March (1991) as exploration and exploitation. Exploratory search, while not defined explicitly by March, can be conceptualized as the process of risk taking, discovery and experimentation in an effort to acquire new knowledge (March, 1991: 71, 85). While the results of exploration are "uncertain, distant, and often negative" (March, 1991: 85), exploring external to the organization may result in the discovery of new knowledge. Exploitative search, the alternative search strategy, can be conceptualized as the process of refining and more fully developing, utilizing and understanding currently held knowledge (1991: 71). Returns from exploitative search are more frequently "positive, proximate, and predictable" (1991: 85), suggesting that exploiting currently-held knowledge tends to yield consistent results.

Given the choice between exploratory and exploitative search, what do firms do? Are they able to engage in both forms of search? If so, what are the determinants of each kind of search? When firms engage in exploitative search, they develop certain processes and routines that enable them to make use of their already possessed knowledge (Leonard-Barton, 1992). Likewise, when firms engage in exploratory search, they develop alternate processes and routines to incorporate new knowledge (Levinthal and March, 1993). This dissertation examines the critical antecedents of exploratory and exploitative search and when each might be more likely to be pursued.

Problem- and Slack-based search

In their seminal work on the behavioral theory of the firm, Cyert and March (1963) described two fundamental drivers of organizational search efforts: problems and organizational slack. When firms encounter problems of various kinds they are motivated to resolve the problems. Problems frequently are generated by a lack of knowledge leading to undesirable outcomes (Chang, 1996). To resolve such problems, firms often engage in search behaviors to acquire the missing knowledge. Similarly, when firms have resources beyond that which is required for operation, they often use such resources to more fully develop knowledge they currently possess or acquire new knowledge from external sources to add to what they already possess (Greve, 2003). Often the efforts employed towards that end are searching for knowledge, either internally within the firm or externally to the firm (March, 1991).

In addition to providing a general impetus for initiating search efforts (e.g., Cyert and March, 1963; Greve, 2003, 2007), what *type* of search (i.e., exploratory or exploitative) do problems and slack encourage? Prospect theory has posited that when individuals operate from a "loss" perspective, they tend to be more risk taking. In the current application, I explore the extent to which problem-based search is analogous to operating from a "loss" perspective. Regarding slack search, I extend prior literature which has examined the impact of slack on innovation but has yet to be extended explicitly to search efforts. Moreover, in addition to the impact of problems and slack on search within firms, there are other influences at work – namely the influences of the Top Management Team (TMT). As the individuals who are able to shape much of resource allocation within firms (Daily and Dalton, 1994), investigating the central role of TMTs in determining the type of search in which firms engage is critical.

Top Management Teams

To the degree that TMTs do influence the search efforts of firms, the type of search that executives elect to pursue is strongly influenced by their underlying beliefs and cognitive frames by which they view situations (Hambrick and Mason, 1984). The psychological construct of risk preferences (e.g., Smith, Collins, and Clark, 2005) is one such underlying characteristic of TMT members that may be instrumental in understanding what kind of search managers favor. Given that exploratory search for new knowledge is generally more risky than the exploitative search of knowledge already known within firms (He and Wong, 2004; March, 1991), there is likely a connection between risk preferences and the type of search in which search firms engage. Thus, in order to better understand how problems and slack precipitate organizational search, I seek to examine how the risk preferences of executives directly affect search efforts and how they moderate the effects of problems and slack.

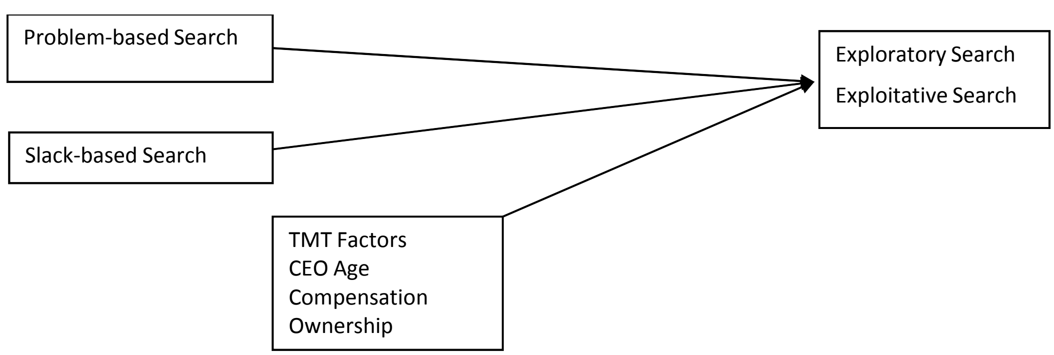
Prior work has examined the influence of CEO risk preferences on outcomes such as acquisition and divestiture propensity (Sanders, 2001), stock price variability (Coles, Daniel, and Naveen, 2006) and investments in R&D (Barker III and Mueller, 2004). However, despite the prominent role of CEOs, other work has recognized the importance of, and encouraged additional research into, the entire TMT in major firm level outcomes such as foreign expansion (Barkema and

Shvyrkov, 2007), strategic change (Boeker, 1997) and innovation (Bantel and Jackson, 1989). In this dissertation, I examine the influence of the TMT on the search efforts of firms. Taking this approach allows me to examine how dynamics within the TMT influence organizational search, whereas examining the risk preferences of only the CEO would not allow me to examine these additional interesting aspects.

Research Questions

To summarize the above introductory discussion, this dissertation seeks to examine how critical antecedents (problems, slack and top management teams) of firm search efforts influence the type of search firms engage in (i.e., exploratory or exploitative). To explore these relationships, I investigate the following questions. The constructs discussed are depicted in Figure 1.1.

Figure 1.1



1. How do problems affect the amount and type of search (i.e., exploratory or exploitative) in which firms engage?
2. How do financial slack resources affect the amount and type of search in which firms engage?
3. How does CEO age impact the type of search in which firms engage?

4. How does TMT compensation affect the amount and type of search in which firms engage?
5. How does TMT equity ownership affect the type of search in which firms engage?

Theoretical Contributions

Main Contribution

The main theoretical contribution of this dissertation is the examination of the core drivers of exploratory and exploitative search within firms. In particular, I articulate theoretical reasons why problems, slack and executive risk preferences should influence exploration and exploitation and test hypotheses towards that end.

Secondary Contribution

While prior work has examined antecedents of product innovation (e.g., Greve, 2003; 2007), there has not been such a focus on the antecedents of *search* that eventually lead to such innovation. To better understand how firms generate exploratory and exploitative innovations, it is critical to better understand the search efforts in which firms engage that ultimately lead to such innovations. This research directly focuses on such search efforts.

CHAPTER TWO:

THEORETICAL DEVELOPMENT AND HYPOTHESES

Organizational Search

At the heart of this dissertation is an examination of the key antecedents of organizational search. At its core, organizational search is the process by which firms seek knowledge (Cyert and March, 1963). Regardless of the location or motivation of the search, or the activities that comprise it, when firms seek knowledge, they engage in search. Searching for new knowledge (i.e., exploratory search) is a key way in which firms add resources that can lead to competitive advantage (Barney, 1991; Grant, 1996). Searching within currently-held knowledge not only allows firms to use more efficiently that which they already possess (March, 1991), but also enables them to more easily identify and acquire new knowledge (Cohen and Levinthal, 1989). Engaging in search activities (in general) has been linked with creating value (Eisenhardt and Martin, 2000), gaining competitive advantage (Katila and Ahuja, 2002), and facilitating innovation and change (Dougherty, 1992; Eisenhardt and Martin, 2000).

The Need for Search

The need to engage in search activities is paramount for firms. As firms utilize existing knowledge, they develop core capabilities on which they base their competitive stance (e.g., Hitt and Ireland, 1985; Leonard-Barton, 1992; Prahalad and Hamel, 1990; Snow and Hrebiniak, 1980). Without investment into such capabilities, over time, the routines and processes that allowed the firm to create efficiencies related to such capabilities become harder to change (Winter, 2000), transforming the capabilities into rigidities and preventing firms from adapting to changing industry and environmental demands (Leonard-Barton, 1992). Engaging in exploratory and exploitative search are two ways that firms can invest into such capabilities as they either bring new knowledge into the firm (via exploration) or better understand the knowledge already contained within the firm (via exploitation). However, in the absence of search, the valuable resources and capabilities of firms can erode, devolving the firm from a state of competitive advantage to competitive disadvantage (Barney, 1991; Leonard-Barton, 1992).

The Cost of Search

Despite the critical need of firms to engage in search activities, search is not free (Lant and Mezias, 1990). Indeed, the search process can be rather resource intensive, depending upon where and how firms engage in their search. Depending upon the degree to which they search in new areas, areas with immature technologies and areas distant from their core knowledge sources, new knowledge search may be difficult and, by extension, resource intensive (Ahuja and Lampert, 2001; Stuart and Podolny, 1996). Owing to the fact that exploring in previously unexplored areas is more difficult and more time consuming than exploiting currently held knowledge, exploratory search is generally more expensive and resource intensive than exploitative search. Despite the costs, however, engaging in search is important for firms to allow them to renew themselves (Zott, 2003).

Search ability

The ability to search is, itself, an ability that firms may nurture and develop as they gain skills in seeking out knowledge (e.g., Zollo and Winter, 2002). Given the different ways that firms can engage in search and the different types of knowledge available for searching within, different skills and abilities may be required to successfully search in different areas (Henderson and Cockburn, 1994; Leonard-Barton, 1992). Thus, depending on the unique skill sets of firms, they will have differing levels of success with different types of search strategies. In his seminal article, March (1991) identified two core ways in which firms learn through search activities: exploration and exploitation. These two distinct search strategies have since been conceptualized as distant and local search (Stuart and Podolny, 1996) and experimental and imitative search (Zott, 2003). Both of these conceptualizations articulate the tension within search between uncertainty and certainty, far away and close at hand, and undiscovered and previously exposed search. This tension is reflected in the fundamental differences between the exploratory search to discover new knowledge and the search to more fully exploit current stores of knowledge (Katila and Ahuja, 2002; March, 1991).

Explore and Exploit

March's (1991) construct of "exploration and exploitation" has met with increasing interest as research incorporating explore-exploit notions has flourished since its publication. The construct has found its way into numerous strategy topics (Gupta, Smith, and Shalley, 2006), such as: alliance formation (Lavie and Rosenkopf, 2006; Rothaermel and Deeds, 2004), corporate venture capital investing (Wadhwa and Kotha, 2006), interpersonal and group learning (Miller, Zhao, and Calantone, 2006; Taylor and Greve, 2006), organizational knowledge and learning (Agrawal and Henderson, 2002; Levinthal and March, 1993; Nerkar, 2003), entrepreneurship (Beckman, 2006), organizational renewal (Danneels, 2002; Dougherty, 1992), ambidexterity (He and Wong, 2004; Lubatkin *et al.*, 2006; Smith and Tushman, 2005), and innovation (Greve, 2007; Katila and Ahuja, 2002; Rosenkopf and Nerkar, 2001).

March (1991) introduces the idea of exploration as being concerned with ideas such as "search, variation, risk taking, experimentation, play, flexibility, discovery, [and] innovation" (1991: 71) and whose "returns are uncertain, distant, and often negative" (1991: 85). In contrast, exploitation focuses on such things as "refinement, choice, production, efficiency, selection, implementation, [and] execution" (1991: 71) and whose "returns are positive, proximate, and predictable" (1991: 85). In developing this construct of exploration and exploitation, March (1991) recognized the inherent conflict and paradoxical relationship between the two forms of learning activities: firms must balance a focus on risk-taking and refinement, discovery and efficiency, and experimentation with execution.

Antecedents of Search

Antecedents of search have been conceptualized in different ways. While the two original ideas of search drivers were problems facing the firm and the presence of slack resources (Cyert and March, 1963), there have been other ideas. Before exploring problem-based and slack-based search more specifically, I briefly discuss other reasons for search efforts. These reasons include arguments that search is necessary for survival (Bulow, Geanakoplos, and Klemperer, 1985) and that it is demanded by the internal (Hannan and Freeman, 1984) and environmental (Hrebiniak and Joyce, 1985) forces.

Other Types of Antecedents of Search

Bulow, Geanakoplos and Klemperer argued that in some industries search is necessary simply for survival (1985). In these industries, whether search is driven by market competition (Bulow et al., 1985) or as a result of pressures from market entry (Kadiyali, 1996), firms must engage in search or face extinction. At the other end of the "merely survive" versus "thrive" continuum, firms may engage in search from a desire to leapfrog their competitors (Ratliff, 2002; Schilling, 2003). While the leapfrog motivation is quite different than simply trying to survive within the industry, in either case, firms are engaging in search efforts to improve their likelihood of survival and increase performance.

Two other antecedents of search that have been examined play off ideas that search behaviors are constrained by internal and environmental forces. As to the former, inertia and routines within firms encourage firms to engage in search behaviors that conform with what they have done in the past (Greve, 2007; Hannan and Freeman, 1984). Inertia and routines serve as constraints within firms because processes are in place which facilitates engaging in certain types of search, in certain ways, to certain intensities. Additionally, environmental forces external to firms encourage them to act in certain ways (Hrebiniak and Joyce, 1985). In this case, to the degree that other firms within an industry are engaging in search activities, firms would feel pressure to likewise engage in search activities. This is distinguished from previously discussed antecedents in that external pressures may exist regardless of survival or leapfrogging concerns.

While these all have particular nuances, they can still be couched somewhat in terms of problem- and slack-based search. Survival and leapfrog motivated search are both tied to problem-based search in that both are trying to overcome some sort of problem. Survival-based search is attempting to overcome the problem of failure, while the leapfrog-induced searching firms are trying to overcome the perceived problem of underperformance relative to their performance goals (i.e., above their competitors).

The degrees to which firms engage in problem- and slack-based search are influenced by the broader environment in which firms are located. In particular, the search behaviors of dominant firms within the industry may influence the search behavior of other firms within the industry.

Whether stemming from survival, leapfrog or environmental conformity concerns, once the types of search behavior are in place, then the inertia and routines of firms encourage firms to maintain their particular levels of search. Once the systems and procedures are in place to engage in particular types of search, it is far easier to allow the systems to replicate themselves than to try to re-create them.

On the positive side, this allows firms to replicate themselves with minimal effort, which increases the likelihood of survival. On the flip side, if changes to search behaviors *are* needed, inertia can prevent such necessary changes from taking place. As touched on, these other types of search routines are really sub-types or secondary to the two dominant types of search: problem-based and slack-based. We turn to those next.

Problem-Based Search

When firms encounter problems of various kinds, they typically seek to address such problems (Cyert and March, 1963). Frequently, the problems encountered stem from the failure of something to perform as well as expected. Within the realm of firm operations, there are many different types of problems that firms may experience. For example, firms may experience problems related to product recalls, increased competition, resource scarcity or inadequate legitimacy. While all of these may be valid problems that lead to search efforts, they will ultimately be manifested in lower performance. Thus, I focus on problem-based search as that prompted by poor financial performance.

Generally, firms experience financial problems when their realized level of performance falls short of their potential performance (Chang, 1996; Cyert and March, 1963; Duncan and Weiss, 1979). First, it may take the form of failing to meet analyst expectations. This shortfall stems from failing to meet external expectations of performance levels, which may not have been entirely reasonable to begin with. Or, firms may realize performance lower than the industry average. This type of underperformance is also externally determined but is in relation to the firms' peers in the industry. Finally, financial failure may take the form of a decline in performance from the last relevant period (month, quarter or year). In contrast to the other two forms of failure, this form of expectation is internally determined and is based on the prior performance of the firm.

Regardless of how the benchmarks are set or which ones are unattained, when firms fail to meet their goals, several outcomes may follow. Some of the outcomes from failure include downsizing (Adhmadjian and Robinson, 2001), adherence to loosing strategies (McDonald and Westphal, 2003), top management team turnover (Boone *et al.*, 2004), new market entry (Greve, 1998), strategic reorientation (Boeker, 1997; Ketchen Jr. and Palmer, 1999; Lant, Milliken, and Batra, 1992) and an increase in innovation (Bolton, 1993; Greve, 2003).

In addition to (and often preceding) these specific outcomes, firms engage in search behaviors following performance shortfalls to determine how to respond to the problems they have encountered (Cyert and March, 1963). This perspective, as articulated by the behavioral theory of the firm, argues that managers frequently compare outcomes with pre-determined goals. When the goals are not attained, they attempt to address that problem by engaging in search behaviors to identify appropriate remedies to the problems they have encountered.

While such search efforts may result in changes to strategy and the incorporation of new ideas (e.g., Ketchen Jr. and Palmer, 1999), it does not necessarily have to do so. Given that search efforts may take the shape of exploratory or exploitative search (or some degree of both), further research is needed to explore what type of search firms select. Theory building towards specific hypotheses regarding what type of search (exploratory or exploitative) in which firms will engage is discussed in the hypotheses section, below.

Slack-Based Search

Definitions of slack

Since its earliest formal use by Cyert and March (1963), organizational slack has been studied by many scholars in many contexts. Building off earlier work by Barnard, (1938) March and Simon (1958), and Cyert and March (1963) conceptualized slack as "payments to members of the coalition in excess of what is required to maintain the organization" (36). Since that time, numerous definitions and conceptualizations of slack have been offered. Among them include a definition by Dimmick and Murray, in which slack is described as "those resources which an organization has acquired which are not committed to a necessary expenditure. In essence, these are resources which can be used in a discretionary manner for various purposes" (Dimmick and Murray, 1978: 616).

Nohria and Gulati defined slack as "the pool of resources in an organization that is in excess of the minimum necessary to produce a given level of organizational output (Nohria and Gulati, 1996: 1246). Geiger and Cashen defined it as "the resources in or available to an organization that are in excess of the minimum necessary to produce a given level of organizational output" (Geiger and Cashen, 2002: 69). While all of the various definitions have merit and highlight certain elements of slack, I adopt the definition offered by March and paraphrased by Bourgeois (1981):

> Organizational slack is that cushion of actual or potential resources which allows an organization to adapt successfully to internal pressures for adjustment or to external pressures for change in policy, as well as to initiate changes in strategy with respect to the external environment (p30).

Kinds of slack

From this general understanding of the idea of slack, the various ways in which slack has been specifically conceptualized has evolved since its introduction (Bourgeios, 1981; Bourgeios and Singh, 1983; Nohria and Gulati, 1996; Sharfman *et al.*, 1988; Tan and Gallupe, 2006; Voss, Sirdeshmukh, and Voss, 2008). From its earliest conceptualization as the difference between what is minimally required to retain employee participation and what is actually paid them (March and Simon, 1958), differences between types of slack have been elucidated. Bourgeois (1981) summarized previous descriptions into two main camps: slack used for internal maintenance and slack used as a facilitator of strategic behavior.

Regarding internal maintenance, slack can be used as an inducement to attract individuals to the organization (Barnard, 1938; Cyert and March, 1963; March and Simon, 1958), for conflict resolution (Cyert and March, 1963; Pondy, 1967) and as a workflow buffer (Galbraith, 1973; Pondy, 1967; Thompson, 1967). In each of these cases, slack is thought of in terms of its relation to individual, sub-unit and workflow operations (Bourgeios, 1981). The buffering component of slack, described by Thompson (1967,) is particularly salient as the buffer provides firms with the ability to engage in search while still protecting their core from external threats.

Additionally, Bourgeois (1981) considers how slack is used to facilitate strategic behavior – with this focus on the firm level. In this case, slack is considered to facilitate three broad types of strategic behaviors: political behaviors (March and Simon, 1958; Simon, 1945), satisficing through bounded search (March and Simon, 1958; Simon, 1945) and search behaviors leading to innovation (Cyert and March, 1963; Hambrick and Snow, 1977). In focusing on slack as a facilitator of search behaviors, I specifically build upon the uses of slack as a buffer (Thompson, 1967) and as a facilitator of search (Cyert and March, 1963) that provides firms the security and ability to engage in search.

Available slack

Using financial indicators as measures of slack, Bourgeois and Singh (1983) expounded upon the conceptualizations of slack as a facilitator of strategic behaviors and further delineated types of slack. Digging further, they differentiate between types of slack in terms of their ease of recovery. The most easily recoverable form of slack is that of available slack, or what others have called "high discretion slack" (Sharfman et al., 1988). Available slack represents resources that are not tied to specific needs and operations of firms and can be easily allocated as firms desire (Bourgeios and Singh, 1983). Having on-hand resources available for disparate uses grants managers broad freedom in how and for what purposes they use such resources. The other two forms of slack vary somewhat in terms of their ease of use: potential and recoverable slack.

Potential Slack

Potential slack represents the level of excess resources firms could access if they so desired (Bourgeios and Singh, 1983). This is typically conceptualized in terms of firms' ability to borrow funds from external sources to create additional available slack. However, even if firms have the objective ability or capacity to borrow additional resources, actually acquiring such resources is not always entirely in their power, making this form of slack more difficult to access than available slack.

Recoverable Slack

The third and most difficult to access type of slack is recoverable slack. This type of slack is represented by the amount of excess resources within firms that can not normally be accessed by firms except when firms face adversity (Bourgeios and Singh, 1983). For example, when departments are overstaffed, have overpaid managers and have expenses that are too high, they are not using their resources in the most efficient manner (Geiger and Cashen, 2002). When times are going well, firms are not typically concerned with recovering such slack resources. However, when things go poorly and firms have to make cutbacks, these areas represent buffers that firms can attempt to access to recover additional resources. Since the recovery process entails first identifying where excess resources are located and then attempting to reduce the buffer layer, the recovery process can be uncertain and difficult to undertake.

Outcomes of Slack

Slack has been argued to have both positive and negative implications for firms. On the positive side, at a high level, slack helps firms survive environmental jolts and changes in performance that might otherwise incapacitate them (Meyer, 1982). Considering its ability as a facilitator of strategic behavior, slack can allow firms to pursue innovation even in environments with low resources (Cyert and March, 1963), relieve managers of the burden of begging for every penny when they seek to pursue opportunities (Nohria and Gulati, 1996), enter new product and geographic markets even in the face of various uncertainties such strategies might hold (Bourgeios, 1981; Hambrick and Snow, 1977; Moses, 1992) and search for new knowledge and opportunities (Levinthal and March, 1981; March, 1976; Nohria and Gulati, 1996).

However, slack can also have negative implications for firms. By its very nature, slack represents unused or ill-used resources (Leibenstein, 1969; Williamson, 1963, 1964) (also referred to as *x-inefficiency* in economics literature) (Leibenstein, 1969). Additionally, slack typically results in loosened financial controls within firms and provides ready resources for managers to pursue their own self-interests, often at the expense of the best interests of their firms (Antle and Fellingham, 1990; Jensen, 1993; Jensen and Meckling, 1976; Leibenstein, 1969). Moreover, the presence of slack may keep doomed projects on "life support" that should otherwise have been shut down, simply because resources remain to continue the projects (Staw, Sandelands, and Dutton, 1981).

Despite the association between slack and search, in general, it is unclear whether slack promotes exploratory or exploitative search, specifically. Some prior work has found that slack is positively related to activities associated with exploration, such as risk taking (Singh, 1986), adaptation (Kraatz and Zajac, 2001) and innovation (Nohria and Gulati, 1996). Alternately, other work has found evidence that slack is related to activities associated with exploitation, such as incremental adaptation (Tan and Peng, 2003) and more cautious decision making (Mishina, Pollock, and Porac, 2004).

Voss, Sirdeshmukh and Voss (2008) attempted to gain greater clarity into the impact of slack on one specific type of outcome with which slack has been related – that of product innovation. They found that slack had different effects on product innovation depending on the type of slack and the environmental context in which slack resource allocations were made. Yet even in that study, slack was not directly linked with search efforts. While search efforts and innovation are certainly related, they are different outcomes, and they should each be given full attention and examination.

While Voss and colleagues (2008) helped bring clarity to the question of the relationship between slack and product *innovation*, there remains substantial question regarding slack and *search*. In terms of the impact of slack on innovation process in the pharmaceutical industry, firms first identify slack resources, engage in search behaviors to either discover new knowledge and technologies (i.e., exploration) or more fully utilize knowledge and technologies they already possess (i.e., exploitation), and develop inventions; ultimately such inventions are developed into marketable products (Gambardella, 1995; Gassmann, Reepmeyer, and Von Zedtwitz, 2004). Thus, while the question of how slack affects product innovation has been answered with greater clarity, the question still remains as to how slack affects initial exploratory and exploitative search decisions of firms.

Top Management Teams

Thus far, I have discussed how firms react when they face problems and how they act (proactively) when slack resources are present. Of course *firms* do not make decisions and take actions, but rather it is the people within firms who do so.

Specifically, it is one particular group of individuals within firms who make such choices – the top management team (TMT) (Hambrick and Mason, 1984). Though influenced by forces such as the board of directors (Daily and Dalton, 1993; Westphal and Fredrickson, 2001) and the environment (Hannan and Freeman, 1977), the TMT is the group of individuals most directly responsible for strategy setting and execution within firms (Daily and Johnson, 1997; Daily and Schwenk, 1996; Hambrick and Mason, 1984). These groups of individuals must scan and interpret environmental signals, develop strategic plans, work with boards of directors, implement strategic plans, be held accountable for their failure or success and, in the context of the present study, decide whether to engage in exploratory or exploitative search.

The degree to which executives decide to engage in exploration or exploitation affects the fortunes of the firm and their personal wealth as well. As mentioned previously, the returns from exploration and exploitation are rather varied (March, 1991). The financial outcomes of exploration are frequently "uncertain, distant, and often negative," but when they do result in positive outcomes, they can be extremely positive; in contrast, exploitation generally results in more "positive, proximate, and predictable" returns (March, 1991: 85). Depending on the risk preferences of these executives, then, the typical outcomes from exploration and exploitation may hold very different appeal.

Executives with high risk tolerance may be particularly attracted to the "swinging for the fences" prospects that exploration provides – the search effort often either pays off dramatically well or is a complete loss (Sanders and Hambrick, 2007). Conversely, executives with low risk tolerance may be far more attracted to the "safe and steady" results that exploitation generally provides. Owing to the tremendous influence that executives have within their firms and the very real differences that engaging in one form of search over the other generates, an important part of this dissertation is the examination of risk preferences of executives on exploratory and exploitative search.

Upper Echelons Perspective

The upper echelons (UE) perspective provides an appropriate theoretical lens through which to examine the influence of executives on search behaviors. The strategies ultimately decided upon by these executives are largely influenced by their underlying beliefs and the cognitive frames by which they view situations and decide upon strategies, as described by the UE perspective (Hambrick and Mason, 1984). However, given the degree of difficulty in accessing and measuring these underlying psychological constructs, various demographic proxies such as age, tenure, functional background and education have been applied in diverse research settings (Carpenter, Geletkanycz, and Sanders, 2004). By measuring the proxies of other underlying psychological constructs such as risk preferences (e.g., Smith *et al.*, 2005), creativity (e.g., Barkema and Shvyrkov, 2007) and intelligence (e.g., Wiersema and Bantel, 1992), an impressive body of research has built a strong argument that demographic characteristics are reasonable proxies for the underlying constructs they purport to measure.

The TMT demography studies frequently take the form of looking at how various demographic characteristics relate to outcomes of interest. One of the earliest studies in this regard was by Murray (1989) who looked at TMT demographic heterogeneity and performance. He found partial support for the assertion that in more stable environments, TMTs with more homogeneity (in terms of age, tenure, functional background and education) would perform better and in less stable environments, more diverse groups would perform better. Using a similar approach, Bantel and Jackson (1989) discovered that the more diversity among TMT members, the more unique (i.e., "innovative") solutions they found.

Building on studies such as these, Pegels et al (2000) looked at TMT age, tenure, education level and functional background and found that the closer the demographic characteristics of firms resembled those of the strongest performers in an industry, the better they did. Additionally, Amason, Shrader and Tompson (2006) found that the better a TMT demographic profile fit the novelty of a venture, the better it would do – more homogenous TMTs were better suited for less novel ventures and more heterogeneous TMTs were better suited for more novel ventures.

Scholars investigating these issues have found relationships between demographic characteristics and underlying psychological constructs in terms of *average* levels as well as *heterogeneity* of characteristics (e.g., Carpenter *et al.*, 2004; Tihanyi *et al.*, 2000). Numerous studies have examined demographic characteristics in this regard and have looked at various issues influenced by TMT size, tenure, education level, education specialization, functional background, age and compensation (Bantel and Jackson, 1989; Barkema and Shvyrkov, 2007; Boone *et al.*, 2004; Bunderson, 2003; Carpenter, 2002; Carpenter *et al.*, 2004; Hambrick, Cho, and Chen, 1996; Kor, 2006; Murray, 1989; Pegels *et al.*, 2000; Rajagopalan and Datta, 1996; Simons, Pelled, and Smith, 1999; Tihanyi *et al.*, 2000; Wiersema and Bantel, 1992; Wiersema and Bird, 1993).

Despite the extensive body of work surrounding demographic research, it is not without its critics (Priem, Lyon, and Dess, 1999). Due to the coarse nature of demographic measures, scholars have argued that some measures are not necessarily accurate measures of the constructs they purport to examine (Lawrence, 1997; Pettigrew, 1992; Priem et al., 1999). However, their use can be appropriate if the measures are valid proxies of the underlying constructs they purport to represent. In this dissertation, I use executive age and compensation as indicators of executive risk preferences and discuss the appropriateness and applicability of each measure in the following sections.

Executive Age

Age as a proxy for risk preferences has the support of sound theoretical arguments and empirical findings, making its use in demography studies justified. Theorists argue that as executives age, they may have an increasingly difficult time grasping new concepts and ideas (Chown, 1960; Hambrick and Mason, 1984) because of the decreased stamina and physical and mental abilities required for the changes that often result from new ideas (Child, 1974). Additionally, executives may become more risk averse as they age because, if the risks do not pay off and they are terminated from their positions, they may have a harder time obtaining a comparable position than younger executives (Eriksson, 1991; Ward, Sonnenfeld, and Kimberly, 1995). Along these lines, executives may also feel that there is little to look forward to after their career is over and may want to minimize risks of prematurely ending it (Sonnenfeld, 1988).

Empirical studies have added support to these theoretical reasons, as prior work has found that as executives age they tend to be more risk averse, in general (MacCrimmon and Wehrung, 1986), and tend to minimize investments in risky, long-term projects, the results of which they may not be around to reap (Barker III and Mueller, 2004; Dechow and Sloan, 1991). Concurrent with the decrease in time and resources allocated towards long-term projects, executives often spend more time focused on manipulating short-term earnings (Davidson, Xie, and Ning, 2007) and pursuing more low-growth strategies (Child, 1974). Indeed, in reviewing the theoretical and empirical evidence it seems clear that "one of the most enduring findings about executive age is that older executives tend to be more conservative" (Barker III and Mueller, 2004: 785).

Age: Average and Heterogeneity

Because of its strong theoretical and empirical support, executive age has been a frequently examined variable, examined by examining both the *average* age and *heterogeneity* of ages among executives. The average age of executives has been studied in terms of innovation (Bantel and Jackson, 1989), project performance (Katz, 1982), firm performance (Pegels et al., 2000) and international diversification (Tihanyi et al., 2000). In addition to executive age as a reflection of risk preferences, executive compensation has long been studied due to the effect that compensation has on executive risk preferences.

Executive Compensation

Executive compensation has been studied in terms of its influence on aligning risk preferences between principals and agents (Fama and Jensen, 1983; Jensen and Meckling, 1976). Because shareholders have better ability to diversify their wealth among firms with varying levels of risk, they are more risk neutral with respect to the risk level of any one firm within their portfolios (Milgrom and Roberts, 1992). Managers, however, have a great deal of personal wealth (e.g., employment, salary, stock, etc.) tied up within firms and are, therefore, assumed to be risk-averse (Jensen and Meckling, 1976). Because of this difference in risk preferences, much research has investigated how to properly structure compensation systems to align the risk preferences of the agents with the principals. However, because of the human capital that executives have invested in firms, and the inability to diversify the risk associated with such an investment, it is nearly impossible to achieve perfect alignment between principals and agents (Holmstrom, 1979).

Compensation scholars have examined the relationship between compensation and various outcomes. Examples of some research includes the relationship between compensation and R&D spending (Wu and Tu, 2007), innovation (Balkin, Markman, and Gomez-Mejia, 2000; Yanadori and Marler, 2006), competitive behaviors (Vroom, 2006), technological intensiveness (Siegel and Hambrick, 2005), performance (Siegel and Hambrick, 2005; Tosi and Gomez-Mejia, 1994), monitoring and control (Beatty and Zajac, 1994b) and the capital structure of firms (John and John, 1993).

Regarding R&D spending, Wu and Tu (2007) found that stock option pay is a significant predictor of R&D spending and is even more effective when (absorbed and unabsorbed) slack resources are high or when performance is high. Balkin, Markman and Gomez-Mejia (2000) examined whether CEO compensation was based on the level of innovation (i.e., patents and R&D spending) and found that it was, with short-term compensation being a stronger predictor than long-term compensation. Similarly, Yanadori and Marler (2006) looked at the compensation policies that high-tech firms put in place for mid-level R&D managers and found that the desire of firms to pursue innovation resulted in a) higher compensation for R&D employees (as compared with non-R&D employees); b) more long-term compensation for R&D employees (as opposed to short-term pay); and c) a longer vesting period of stock options for R&D employees. These findings build strong support for the arguments that compensation affects R&D and innovation.

However, research is lacking on the link between TMT compensation and the *kind* of search (exploratory, exploitative) firms seek and the type of compensation that yields such results. For example, when stock options (one form of long-term compensation) are extremely out-of-the-money (OOTM), executives tend to be more risk seeking, but when they are extremely deep-in-the-money (DITM), executives are more risk averse (Carpenter, 2000). Devers and colleagues (2007) argue that because of how different compensation systems differentially influence executive behaviors, they should be studied in more detail than they have previously been examined. I seek to answer the call for a more detailed examination of how different compensation components influence exploratory and exploitative search.

Hypotheses

Problem-Based Search

Attempts to Search for Solutions

As stated previously, when firms encounter problems, they engage in search efforts to correct those problems (Cyert and March, 1963). As modeled in this study, problemistic search is examined in terms of financial performance below aspiration levels. Thus, when executives view their firms' financial performance to be below aspiration levels, they seek to engage in search efforts to remedy such shortcomings (Greve, 2003). However, in what type of search efforts would they engage (i.e., exploratory or exploitative) to solve the financial problems? Prospect theory addresses this question.

According to prospect theory, when individuals perceive themselves to be operating from a "loss" perspective, they become more risk seeking to make up for the losses they have incurred (Tversky and Kahneman, 1974). In the present situation, when executives view their firms to be in a loss situation, they would become more risk seeking in the search efforts that they support in their firms. Owing to the uncertain nature of exploratory search, exploration is considered more risky than exploitation (He and Wong, 2004; March, 1991). Thus, when the financial performance level of firms is below that of their aspired level, they will engage in a greater level of exploratory search (c.f., Greve, 2007). By engaging in more exploratory search, they seek to discover new knowledge or technology that would enable them to make a substantial breakthrough and reap large financial returns (He and Wong, 2004). By taking such risks, they would hope to overcome the loss situation.

By the same argument, then, since the returns from exploitation are typically more consistent but more conservative (He and Wong, 2004), engaging in exploitative search does not hold the same promise of recuperating losses that exploratory search does. When viewed from the loss perspective, generating small, consistent returns via exploitative search will not contribute towards getting firms out of their financial distress. Therefore, when firms experience greater financial performance short of their aspiration levels, they will engage in less exploitative search. Formally:

Hypothesis 1a: There is a positive association between performance below the aspiration level and exploratory search; as performance below the aspiration level increases, exploratory search increases.

Hypothesis 1b: There is a negative association between performance below the aspiration level and exploitative search; as performance below the aspiration level increases, exploitative search decreases.

Slack Search

In addition to problem-motivated search, when firms do *not* face performance shortfalls, they may still be motivated to search. This may be so when firms possess stores of slack resources. Firms can use these slack resources to engage in search activities that they might not otherwise be able to pursue (Cyert and March, 1963; Greve, 2003).

As discussed above, while recent work (e.g., Greve, 2007; Voss *et al.*, 2008) brought clarity to issues surrounding the relationship between slack and product innovation, questions still remain as to the relationship between slack and organizational search. Search is a crucial first step in the innovation cycle, deserving a separate investigation. Financial slack resources, whether they be available, potential or recoverable represent resources that can be deployed or re-deployed within firms if and when desired, although they vary in their ease of (re)deployment.

Available slack (measured as the firm's quick ratio) represents the most easily deployable type of slack resource, since it is not tied to any specific projects (Bourgeios and Singh, 1983). Potential slack (measured as the firm's debt-to-equity ratio) is the next most easily deployable type since once acquired, potential slack becomes available slack and can then be deployed (e.g., Dierickx and Cool, 1989). Recoverable slack (SG&A-to-sales ratio) is the least easily deployable type since it is embedded within current operations and is not typically accessed except when other slack resources are unavailable, such as during times of financial hardship (Bourgeios, 1981).

However, despite the differences in the ease with which each type of financial slack resource can be (re)deployed, the basic argument for each remains the same. As financial slack resources increase, the structural constraints placed upon the use of those resources decreases (Nohria and Gulati, 1996; Voss *et al.*, 2008). These looser constraints will be associated with a decreasing concern of hoarding resources (since they are increasingly plentiful) and greater gain seeking and risk taking (Voss et al., 2008). The characteristic of greater risk taking suggests an increase in exploratory activities, consistent with prior research (Mishina *et al.*, 2004; Nohria and Gulati, 1996; Tan and Peng, 2003; Voss *et al.*, 2008).

Alternately, as slack decreases, structural controls will tighten and there will be an increased focus on making sure the projects to which resources are allocated are worthwhile (Voss et al., 2008). This focus will likely be associated with a decreased focus on gain seeking and risk taking, instead favoring more reliable returns from investments (He and Wong, 2004; March, 1991). These characteristics suggest a tendency to favor more exploitative search. Therefore,

Hypothesis 2a: There is a positive association between each type of financial slack resource (available, potential and recoverable) and exploratory search; as slack increases, exploratory search increases.

Hypothesis 2b: There is a negative association between each type of financial slack resource (available, potential and recoverable) and exploitative search; as slack decreases, exploitative search increases.

TMT Age and Search

The top management team of a firm is largely responsible for directing the search efforts of firms. These individuals make strategic decisions for firms with imperfect information and with bounded rationality (Cyert and March 1963) Thus, individual differences of these executives are important to examine when attempting to understand what drives their strategic choices (Hambrick and Mason, 1984) and by implication, the specifics of search. The types and extent of search efforts ultimately decided upon by these executives are largely influenced by their underlying beliefs and cognitive frames by which they view situations (Hambrick and Mason, 1984).

However, given the degree of difficulty in accessing and measuring these underlying psychological constructs, various demographic proxies such as age, tenure, functional background and education have been applied in diverse research settings (Carpenter et al., 2004). By measuring the proxies of other underlying psychological constructs such as risk preferences (e.g., Smith *et al.*, 2005), creativity (e.g., Barkema and Shvyrkov, 2007) and intelligence (e.g., Wiersema and Bantel, 1992), scholars have built strong arguments that demographic characteristics are reasonable proxies for the underlying constructs they purport to measure, as previously discussed.

One such underlying construct is that of executive risk tolerance. O'Brien (under review) notes that the impact of firm age on risk taking has been previously examined (Beatty and Zajac, 1994a; Fiegenbaum and Thomas, 1988; Jegers, 1991; Singh, 1986), with some other work examining how factors such as organizational slack and aspiration levels moderate such relationship (Bromiley, 1991; Cyert and March, 1963; Miller and Leiblein, 1996).

One common argument regarding firm age and risk preferences is that as executives age, they become less flexible in their cognitive patterns and increasingly resistant to change (Wiersema and Bantel, 1992). As executives age, their career window decreases, discouraging them from pursuing risky strategies (Carlsson and Karlsson, 1970). Instead, job and financial security increase in importance which places a stronger focus on maintaining the status quo and minimizing risky strategies (Carlsson and Karlsson, 1970; Vroom and Pahl, 1971). All this suggests that older executives are more likely to be risk averse, while younger executives are more likely to be risk seeking.

Risk preferences are related to organizational search in that different kinds of search are associated with different risk levels in terms of length of payoff and amount of payoff. As discussed previously, searching externally is generally regarded as more risky, given the longer time horizon and relative uncertainty in generating returns (March, 1991). In contrast, searching internally to more fully develop existing knowledge generally has a shorter time horizon and returns from such search efforts are much more likely to result in a payoff (March, 1991). Even though returns from internal exploitative search are typically less than those generated from external exploratory search, they are more consistent and hence, considered less risky. Thus, when considering age as a proxy for risk preferences and its implication for search preferences, we argue that older executives favor internal, exploitative search while younger executives favor external, exploratory search. Due to expected limitations in the data, I will likely only be able to consistently gather age data on CEOs.

Therefore:

Hypothesis 3a: There is a negative association between CEO age and exploratory search; as CEO age increases, exploratory search will decrease.

Hypothesis 3b: There is a positive association between CEO age and exploitative search; as CEO age increases, exploitative search will increase.

Compensation

This dissertation is concerned with what influences firm search efforts. As I have previously discussed, executives largely determine the search efforts in which firms will engage. Thus, it is important to examine the motivations and preferences of executives that influence the types of search efforts they direct their firms towards. I look at executive age and compensation as two core components that drive firm search efforts. While age is highly personal to executives and not subject to manipulation (except for determining the beginning and ending points of executive tenure), compensation is subject to manipulation.

Executive compensation typically consists of two components: short-term pay and long-term pay (Westphal and Zajac, 1994). Short-term pay is comprised of the executives' base salary and bonuses tied to short-term performance goals (Balkin et al., 2000). In contrast, executive long-term pay is comprised of equity-based components such as stock options and other instruments that are linked to a longer term (e.g., three-to-five year) window (Balkin et al., 2000).

Agency theory argues that executives with high levels of short-term pay (relative to long-term pay) will be more interested in maximizing the value of the firm in the short-term in order to maximize their personal wealth (Demirag, 1998). Other factors held constant, when executives with high ratios of short-term compensation decide how to allocate scarce resources, they typically invest in projects that have a greater likelihood of paying off in the short-term. In terms of search efforts, executives with a short-term focus typically promote internal search, exploiting competencies already known. This type of search is associated with higher likelihood of success, even if the eventual payoff may be less (March, 1991).

In contrast, executives with higher levels of long-term compensation (relative to short-term compensation) will be more focused in maximizing the value of the firm in the long-term to maximize their long-term wealth (c.f., Demirag, 1998). Again, when such executives must allocate scarce resources between short-term and long-term projects, I argue that those executive groups with higher levels of long-term pay will promote long-term projects. In conducting search efforts, executives with this long-term focus would typically favor external search, exploring for new information that the firm did not previously possess. Focusing on such projects is associated with higher risk, but higher variance of returns. With a higher level of long-term pay, then, executives would be willing to bear additional risk with the hope of increasing their future payoff.

As with age, compensation can differ not only on average type, but on the variance of pay among the executive members. Pay disparity has been linked with negative consequences such as a failure to work together and lower levels of innovation, due to power struggles and conflict stemming from disparate pay structures (Siegel and Hambrick, 2005). Thus, at higher levels of pay heterogeneity (disparity), exploratory search will decrease, while at lower levels of pay heterogeneity, exploitative search will increase.

These arguments lead to the following hypotheses:

Short-term compensation disparity:

Hypothesis 4a: There is a negative association between short-term compensation disparity and exploratory search; as the short-term compensation disparity increases, exploratory search will decrease.

Hypothesis 4b: There is a positive association between short-term compensation disparity and exploitative search; as the short-term compensation disparity increases, exploitative search will increase.

Long-term compensation disparity:

Hypothesis 5a: There is a negative association between long-term compensation disparity and exploratory search; as the long-term compensation disparity increases, exploratory search will decrease.

Hypothesis 5b: There is a positive association between long-term compensation disparity and exploitative search; as the long-term compensation disparity increases, exploitative search will increase.

CEO short-term compensation ratio:

Hypothesis 6a: There is a negative association between CEO short-term compensation ratio and exploratory search; as CEO short-term compensation ratio increases, exploratory search will decrease.

Hypothesis 6b: There is a positive association between CEO short-term compensation ratio and exploitative search; as CEO short-term compensation ratio increases, exploitative search will increase.

TMT short-term compensation ratio:

Hypothesis 7a: There is a negative association between TMT short-term compensation ratio and exploratory search; as TMT short-term compensation ratio increases, exploratory search will decrease.

Hypothesis 7b: There is a positive association between TMT short-term compensation ratio and exploitative search; as TMT short-term compensation ratio increases, exploitative search will increase.

Ownership

In addition to age and compensation, the amount of equity executives have in their firms has been found to have an impact on risk preferences (Sanders, 2001) (Devers *et al.*, 2008). Agency theory based arguments had long held that to the degree that the interests of executives and owners can be aligned, that executives will act in the best interest of owners (Berle Jr. and Means, 1932; Fama, 1980). Accordingly, the more of the firm that executives own (primarily in the form of stock ownership), the more they will take actions consistent with owners' desires to grow the value of the firm.

Typically, owners of firms support risk-taking measures that, while costly in the short-term, will increase the long-term value of the firm (e.g., Hoskisson *et al.*, 2002). Recent research has found support for the idea that increasing equity ownership (firm risk) interacts with the risk of job loss (employment risk) to magnify risk aversion within executives. This effect actually influences executives to take more cautious approaches to risk taking behaviors so as to not lose the value of their stock equity and possibly their job, because of a few bad decisions. Thus, executives with greater stock ownership will be more conservative, while executives with lower levels of stock ownership will be more aggressive in their risk behaviors. Accordingly:

CEO Stock Ownership:

Hypothesis 8a: There is a negative association between CEO equity ownership and exploratory search; as CEO equity ownership increases, exploratory search will decrease.

Hypothesis 8b: There is a positive association between CEO equity ownership and exploitative search; as CEO equity ownership increases, exploitative search will increase.

TMT Stock Ownership:

Hypothesis 9a: There is a negative association between TMT equity ownership and exploratory search; as TMT equity ownership increases, exploratory search will decrease.

Hypothesis 9b: There is a positive association between TMT equity ownership and exploitative search; as TMT equity ownership increases, exploitative search will increase.

CHAPTER THREE:

RESEARCH METHODOLOGY

Sample

Inclusion Requirements

To test these hypotheses, I examined a sample of U.S.-based, publicly traded firms within the pharmaceutical industry from 1994 to 2005. In order to provide a strong test for the theory and hypotheses developed herein, I needed to test the hypotheses in an industry in which the search efforts of firms could be documented in a clear and consistent manner. Additionally, I needed access to demographic and compensation data of top executives of these firms in which search happened. The pharmaceutical industry proved to be just such an industry.

Regarding the first requirement, the search efforts of pharmaceutical firms are documented extensively through patenting (Malerba and Orsenigo, 2001, 2002; Nerkar and Roberts, 2004). Patenting is not, in and of itself, organizational search. However, more so than in any other industry, patenting is an accurate reflection of knowledge search by firms (Bierly and Chakrabarti, 1996).

As to the second requirement, in order to determine the influences of demographic characteristics and compensation on firms' search efforts, I utilized only publicly traded firms. Patenting rights vary by nation depending on the intellectual property laws in place. In the United States, the intellectual property rights are stable and supportive of protecting the patent holders' rights, thus encouraging patenting. Thus, because I focused on U.S.-based firms (and patents applied for in the United States), I captured patent data in an industry and country in which patenting is extremely important and the benefits of which are legally protected.

Generalizability

Despite the appropriateness of using the pharmaceutical industry to examine the search efforts of firms and performance outcomes from such search, as with any single industry study, there were questions of generalizability. Mansfield (1986) estimated that, in the pharmaceutical industry, 60 percent of inventions would not have developed but for patent protection.[1] This suggests that while patenting activity does not account for all of the searching in which firms engage it accounts for a substantial portion. More importantly, the evidence contained within patent applications regarding the tendency of firms to explore or exploit is an indication of their search tendencies even when the search efforts are not formalized in patent applications. Thus, to the extent that patent applications serve as a reflection of the broader search behaviors of firms, the findings in this study are generalizable to other industries.

Final Sample Composition

Consistent with prior work utilizing the pharmaceutical industry, the sample consisted of United States-based, publicly traded firms that were classified as belonging to the pharmaceutical industry (SIC 2834 or NAICS 325412) (Bierly and Chakrabarti, 1996; Miller, 2008). To make sure the firms were actively and primarily engaged in the pharmaceutical industry, only those firms whose

[1] The percentage of inventions that would not have been developed but for patent protection for selected industries include: chemicals (38%); petroleum (25%); machinery (17%); fabricated metal products (12%); electrical equipment (11%) (Mansfield, 1986).

pharmaceutical sales accounted for more than half of their total sales were included (Bierly and Chakrabarti, 1996). Additionally, it was important to distinguish between pharmaceutical firms that focused on selling prescription drugs (also referred to as ethical drugs) as opposed to those that primarily focused on selling generic drugs due to the patent protection afforded prescription drugs (Gassmann et al., 2004).

Corporate Affiliations

The Lexis-Nexis Corporate Affiliations (2002) directories were referenced to determine parent/subsidiary/affiliation information for each firm, for each year. Additionally, when reviewing patent data, occasionally patents would be affiliated with a firm but the Lexis-Nexis Corporate Affiliations directory did not have them referenced as being affiliated. In such circumstances, I engaged in sufficient internet searches to determine if the firms were affiliated, the nature of their affiliation, and when their affiliation began.

Research in the pharmaceutical industry has found that the length of time from the beginning of a project until initial patent application filing is approximately two years (Gassmann *et al.*, 2004). The general framework of my arguments is that certain firm and TMT characteristics in year 0 impact search behaviors that are documented in year 2. Thus, when putting the sample together, patents by acquired firms were not included with the parents' patents until 2 years after the acquisition. This 2 year lag allows the effects I argue to be present long enough to manifest themselves.

Panel Data

Panel data, rather than cross-sectional data, will be used in an attempt to capture the causal influence of problems, slack and TMT risk preferences on search. In the pharmaceutical drug industry, this was particularly important given the length and cost of research and development needed in order to apply for a patent (Gambardella, 1995; Gassmann et al., 2004). From 1994-2003 there were 102 unique firms that met all of the above criteria to be included in the sample: U.S. owned and based, publicly traded, primarily focused in the ethical drug pharmaceutical industry, with patent applications filed two years after the availability of financial information. Collecting this data in an overlapping set of panels resulted in 449 firm-year observations. Table 3.1 summarizes the panels of data I used and the time periods at which different variables were measured.

Table 3.1

Panels of Data and Time Periods Used

Period	Performance, Slack & TMT Characteristics	Patent Application
Example	0	2
1994-1996	1994	1996
1995-1997	1995	1997
1996-1998	1996	1998
1997-1999	1997	1999
1998-2000	1998	2000
1999-2001	1999	2001
2000-2002	2000	2002
2001-2003	2001	2003
2002-2004	2002	2004
2003-2005	2003	2005

Dependent Variables

Exploratory Search

I have argued that examining patent citation references in the pharmaceutical industry provides a window into the search efforts of firms. That is, to the degree that firms incorporate new citations in their patent applications, it reflects their efforts in exploring for, and incorporating, new knowledge. On the other hand, to the degree that firms repeatedly use the same citations reflects the fact that they are exploiting currently held knowledge. To measure the degree to which firms incorporate new citations (exploration) or reuse the same citations (exploitation), I used the operationalization developed by Katila and Ahuja (2002), and I defer to their original work for a more thorough description of the development of the variables.

To measure the degree to which firms engage in exploration, I utilized the variable *exploratory search*. Exploratory search is defined as "the proportion of previously unused citations (*new citations* $_{it-1}$) in a firm's focal year's list of citations" (Katila and Ahuja, 2002: 1186). A high exploratory search score indicates that firms are utilizing a large number of previously unused patent citations, which reflects their efforts in exploring for and incorporating new knowledge (Katila and Ahuja, 2002; Rosenkopf and Nerkar, 2001).

Conversely, a low exploratory search score indicates that firms have focused their search efforts to a more narrow body of knowledge. Argote (1999) argued that the organizational memory of firms in high technology industries (such as pharmaceuticals) tends to be somewhat short-term, such that knowledge that has not been used within approximately five years is effectively forgotten (Argote, 1999). Thus, as did Katila and Ahuja (2002), I counted the number of citations referenced in each patent application that were not included in any other patent applications by a given firm in the preceding five years. This formula is formally stated as:

$$\textit{Exploratory Search}_{i\,t\text{-}1} = (\textit{new citations}_{i\,t\text{-}1} / \textit{total citations}_{i\,t\text{-}1}).$$

Exploitative Search

While exploratory search reflects the degree to which firms have incorporated new knowledge as part of their search efforts, *exploitative search* reflects the degree to which firms have reused existing knowledge in their search efforts. The more firms reuse a technology, the better acquainted they become with it (Katila and Ahuja, 2002). As with exploratory search, I utilized the measure for exploitative search from that put forth by Katila and Ahuja (2002). Exploitative search is "measured as the average number of times a firm repeatedly used the citations in the patents it applied for" (Katila and Ahuja, 2002: 1187).

A high value for exploitative search indicates that firms have frequently used a given set of citations in prior patent applications, while a low value indicates they have not made frequent use of such citations in prior applications.[2] Exploitative search is calculated by taking "the number of items that, on the average, each citation in the year *t*-1 was repeatedly used during the past five years" (Katila and Ahuja, 2002: 1187). Formally stated:

$$\textit{Exploitative Search}_{it\text{-}1} = \left(\sum_{y=t-6}^{t-2} \textit{repetition count}_{iy} / \textit{total citations}_{i\,t\text{-}1} \right).$$

[2] One alternate explanation for a low exploitative search value is that the firm has not applied for many prior patents. Thus, as discussed later, I control for prior patent applications.

Patent and citation data was collected entirely from Delphion (a Thomson-Reuters firm) (http://www.Delphion.com).

Independent Variables

Problem-Based Search

As previously discussed, of all of the different types of problems that firms can face (e.g., product recalls, increased competition, resource scarcity, inadequate legitimacy), the end result is that such problems ultimately result in financial difficulties. Generally, problems related to financial performance can be described by firms failing to perform up to their desired level of performance (Chang, 1996; Cyert and March, 1963; Duncan and Weiss, 1979). Greve (2003), following Cyert and March (1963: 123), examined the extent to which the actual performance of firms compares with their aspiration level. I utilized Greve's (2003: 691) formulation in this study and created the variable *actual-to-aspired performance*. The formulas by which to examine aspiration level in comparison with actual performance are:

$$A_{ti} = a_1 SA_{ti} + (1 - a_1) HA_{ti}.$$

$$SA_{ti} = (\Sigma_{j \neq i} P_{tj}) / (N - 1).$$

$$HA_{ti} = a_2 HA_{t-1,\, i} + (1 - a_2) P_{t-1.}$$

In these formulas, *A* is the aspiration level, which is a combination of social and historical aspiration levels. *SA* is the social aspiration level, which is the average performance (*P*) of the other firms in the sample. *HA* is the historical aspiration level, which is a combination of prior period historical aspiration level and the focal firm's prior performance. Overall, utilizing this measure for (under-)performance incorporated performance in relation with peer firms, as well as historical and expected performance for the firm. Prior research has supported the assertion that this measure is an appropriate one for examining financial problems that would induce firms to search for solutions.

Slack-Based Search

As previously discussed, I examined the impact of three different types of financial slack on the search efforts of firms. *Available slack* represents uncommitted resources that can be deployed at the discretion of executives and is represented by a firm's quick ratio (Palmer and Wiseman, 1999). *Potential slack* is the level of additional resources firms could appropriate from external sources if needed (Bourgeios and Singh, 1983). This form is slack is represented by the firm's ratio of debt-to-equity (Bourgeios and Singh, 1983; Bromiley, 1991; Hitt *et al.*, 1991; Palmer and Wiseman, 1999). The third aspect of slack that was examined is that of recoverable slack, which represents excess resources that can usually only be accessed when firms face adversity and must seek ways to reduce the budget. *Recoverable slack* is measured as the ratio of sales, general and administrative expenses, to sales (Bourgeios and Singh, 1983; Bromiley, 1991). The data for the slack variables were obtained from COMPUSTAT.

CEO Age

As argued previously, the importance of executive ages has been examined in various studies in terms of average age (e.g., Bantel and Jackson, 1989; Katz, 1982; Pegels *et al.*, 2000; Tihanyi *et al.*, 2000). Values for the variable *CEO age* were obtained from annual proxy statements.

TMT Compensation

Executive compensation is an important variable and has been used in studying various firm outcomes of interest, as discussed above (Balkin *et al.*, 2000; Beatty and Zajac, 1994b; John and John, 1993; Siegel and Hambrick, 2005; Tosi and Gomez-Mejia, 1994; Vroom, 2006; Wu and Tu, 2007; Yanadori and Marler, 2006). Short-term compensation is comprised of annual salary and bonuses awarded to executives for a given year (Balkin et al., 2000). Long-term compensation generally represents the equity component of executives' pay and was calculated as twenty-five percent of the value of options awarded, which is consistent with recent research and yields similar results as that generated from the Black-Scholes options-pricing model (Balkin *et al.*, 2000; Lambert, Larcker, and Weigelt, 1993). The variable *short-term ratio* is the ratio of short-term compensation to total compensation, with total compensation being the sum of short-term and long-term compensation.

I calculated two sets of variables for use from executive compensation: disparity of short-term and long-term salaries between the CEO and other TMT members, as well as a short-to-long term compensation ratio of the CEO and other TMT members. The disparity variable will be the disparity of salaries between the CEO and the rest of the TMT members, for annual compensation (*short-term disparity*), as well as for long-term compensation (*long-term disparity*). All executive compensation data were obtained from annual proxy statements filed by firms.

Equity Ownership

Equity ownership is another important variable that has been frequently examined by strategy scholars for its impact on executive risk preferences (Devers *et al.*, 2008). Equity ownership was calculated for CEOs and TMTs as the ratio of common stock each executive owns to all outstanding common stock of the firm to create the variables *CEO equity* and *TMT equity*. Stock ownership data were gathered from annual proxy statements filed by firms.

Control Variables

Firm size

Owing to their larger size and potentially larger resource base, large firms frequently have the ability to engage in more R&D, and size is frequently controlled for in studies that include patents and/or innovation (Cohen and Klepper, 1996). It was particularly important to control for firm size given the rather mixed findings related to the relationship between size and factors generally related to search efforts (e.g., innovation, invention, R&D). Some of the divergent research includes findings that R&D expenditures do not increase proportionally as firms grow (Fritsch and Meschede, 2001), and that innovativeness tends to decrease as firms grow (Chandy and Tellis, 2000), that larger firms can spread the costs of R&D across a broader research platform (Cohen and Klepper, 1996) but that the impact of each patent tends to decrease in larger firms (Sorensen and Stuart, 2000).

Size is commonly operationalized as sales or assets. Given that some of the firms in the sample were quite small and given how long it takes to bring products to market in this industry, assets was deemed a more appropriate measure of size than sales, so *assets* is utilized herein. Additionally, given the disparity in size of many of the firms, the log of assets is typically used instead of the raw value. Data transformations are discussed below in Chapter Four.

Prior Patenting Propensity

In addition to their size, firms differed in their patenting propensity. While larger firms tend to patent more, they are not required to do so. Likewise, smaller firms may engage in a disproportionately high level of patenting, given their size. Because of this uncertainty and potential disparity in the amount of patenting, I controlled for the total number of patents for which firms applied in the prior five years with the variable *prior patents*. Again, due to the wide range of number of patents, I took the log of *prior patents*.

R&D Intensity

Complementing prior patenting propensity (the "output" of invention efforts), I also controlled for the "input," which is the amount of resources firms allocate towards their search efforts (Katila and Ahuja, 2002). I have previously argued that the history of citations used in firms' patenting activities in the pharmaceutical industry represents a high proportion of the search efforts of firms. While this may be the case, there are still some general search efforts of firms that are not reflected in patent applications. Thus, by controlling for R&D intensity, I control for such additional search efforts and create a more conservative test of my hypotheses. *R&D intensity* was calculated as R&D expenditures divided by sales.

Capital Structure

Owing to the theoretical arguments that financial returns from exploration are distant and uncertain, while returns from exploitation are proximate and more certain, the overall financial position of firms may influence the type of search in which firms engage (March, 1991; Miller and Bromily, 1990). Accordingly, I accounted for this possibility by controlling for the capital structure of firms (i.e., total assets / total shareholders' equity), with the variable *capital structure*.

TMT Size

The size of TMTs has been linked with various outcomes (Carpenter *et al.*, 2004). Because of this, Carpenter and colleagues (Carpenter *et al.*, 2004) argued that any study involving top management teams ought to include the size of the TMT as a control variable. Accordingly, I included *TMT size* as a control.

Growth Opportunities

The growth opportunity of firms is also a common control variable, and Tobin's Q is a frequently used measure for it. Tobin's Q is a measure of "the ratio of a firm's market value to the replacement cost of its assets" (Barney, 2007). Firms with values above 1 are performing well and those below 1 are not performing as well. There are many ways to calculate Tobin's Q. Per Barney (Barney, 2007), I calculated the variable *Tobin's Q* as :

$$\textit{Firm Market Value} = \frac{[\textit{market value of common stock} + \textit{market value of preferred stock} + \textit{book value of short-term debt} + \textit{book value of long-term debt}]}{\textit{Book Value of Total Assets}}$$

Citations

Because I solved for two dependent variables at the same time (exploratory and exploitative search), I needed to include instrumental variables for each of the DVs in the equations. The number of unique citations (cites) a firm used should be related to exploratory search, but not as strongly related to exploitative search. Likewise, the number of cites a firm has repeatedly used should be related to exploitative search, but not as strongly related to exploratory search. Thus, the variables *unique cites* and *repeated cites* were included as instrumental variables for exploratory search and exploitative search, respectively. A summary list of variables is included below in Table 3.2:

Table 3.2

Variables for Study

DEPENDENT VARIABLES	**MEASUREMENT**	**SOURCE**
Exploratory Search	The degree to which firms cite patents which they have not cited in other patent applications in the preceding five years	Delphion
Exploitative Search	The average number of times that each citation was repeatedly used in the prior five years	Delphion

Table 3.2 (cont'd)

INDEPENDENT VARIABLES	MEASUREMENT	SOURCE
Actual-to-aspired performance	Underperformance as a comparison of actual performance with aspiration level	COMPUSTAT
Available slack	Available slack is measured as the current ratio	COMPUSTAT
Potential slack	Potential slack is measured as the ratio of debt-to-equity	COMPUSTAT
Recoverable slack	Recoverable salck is measured as the ratio of SG&A expenses to sales	COMPUSTAT
CEO Age	The present age of the CEO	Proxy Statements
Short-term disparity	The disparity between the CEO and other members of the TMT as to the level of short-term compensation	Proxy Statements
Long-term disparity	The disparity between the CEO and other members of the TMT as to the level of long-term compensation	Proxy Statements
CEO short-term ratio	Ratio of short-term to total compensation for the CEO	Proxy Statements
TMT short-term ratio	Average ratio of short-term to total compensation for the other members of the TMT	Proxy Statements
CEO equity	Ratio of common stock owned by the CEO to all outstanding common stock of the firm	Proxy Statements
TMT equity	Average ratio of common stock owned by the TMT to all outstanding common stock of the firm	Proxy Statements

CONTROL VARIABLES	MEASUREMENT	SOURCE
Firm size	Firm assets	COMPUSTAT
Prior patents	Total patent applications filed in the previous 5 years	Delphion
R&D intensity	R&D expenditures / sales	COMPUSTAT
Capital structure	Total assets / total shareholders equity	COMPUSTAT
TMT Size	Number of TMT members included per firm-year	Proxy Statements
Tobin's Q	Firm market value [market value of common stock + market value of preferred stock + book value of short-term debt + book value of long-term debt] / Book value of total assets	Proxy Statemetns and COMPUSTAT
Repeated Cites	The number of repeated citations in the last 5 years	Delphion
Unique Cites	The number of unique citations in the last 5 years	Delphion

Analytical Approach

As previously discussed, I examined the U.S.-based, publicly traded firms from the pharmaceutical industry. These 102 firms were examined (subject to the number of panels in which they were included) from the period 1994 to 2005, which resulted in a total sample of 449 firm-year observations. Relationships that are observable over time are not generally discernable in a one-year window. However, longitudinal data allows for a better examination of causal relationships (Bergh, 1993). Because this study attempts to examine the causal relationships between variables, a longitudinal panel data set was most appropriate.

Analyzing longitudinal data using ordinary least squares (OLS) regression was used for a long time by scholars examining longitudinal data sets. However, researchers had to test and correct for heteroskedasticity (non-constant variance of error terms) and autocorrelation (when the covariance between error terms is not equal to zero) when using OLS regression (Bergh, 1993). To increase the chances of avoiding these problems, an alternate analytical technique was required.

Therefore, instead of OLS regression, fixed- or random-effects models are now typically used, with the difference between which modeling technique depending upon the type of data and goals of the research (Certo and Semadeni, 2006). Fixed-effects models are frequently used when the goal is generalization of the results to other firms that have the same values for key variables (e.g., number of patents, degree of exploration or exploitation). However, random-effects models are usually used when the goal is generalization to other firms (or industries) that may differ on the values of key variables (http://www.upa.pdx.edu/IOA/newsom/mlrclass/ho_randfixd.doc).

Hausman Specification Test

However, beyond logical arguments for choosing between fixed- and random-effects models, a Hausman specification test (Hausman, 1978) indicates which test should be done. The null hypotheses for the Hausman test is that the coefficients estimated by both the random and fixed effects estimators are the same (Park, 2005). If the test is not significant, then random effects should be used. If it is significant, then fixed effects should be used (Hausman, 1978; Park, 2005). I ran the test twice, setting both exploratory search and exploitative search as the dependent variables, and in both cases, the test was significant. Accordingly, fixed effects were used.

Regression Models

The .reg3 regression is a three-stage estimation technique, specifically designed to handle simultaneous equations. This regression technique allows researchers to examine the impact of a set of independent variables upon two dependent variables at the same simultaneously (http://www.stata.com/help.cgi?reg3, Last Accessed June 9, 2009). Since that is the present situation, .reg3 is an appropriate estimation tool. This technique may be used for fixed-effects panel data by including the dummy variables for years, as I have done.

For comparison sake, I also utilized the .xtivreg command which is specifically designed for handling panel data in which one or more “right-hand-side” variables are endogenous variables (http://www.stata.com/help.cgi?xtivreg, Last Accessed June 9, 2009). Endogenous variables were identified, along with the instrumental variable that was related with the endogenous variable but not related with the other endogenous variable(s). This technique was modeled as fixed-effects with the “fe” option.

CHAPTER FOUR:

ANALYSIS AND RESULTS

After collecting the data in the manner discussed in Chapter Three, I analyzed the structure of the data to determine their appropriateness for testing my hypotheses. After reviewing univariate statistics for the data and performing several transformations to decrease their non-normality, I analyzed the data using the .reg3 and .xtivreg techniques just discussed. This chapter reports the results of the data structure examination and the hypotheses tests.

Before analyzing data with sophisticated analytical techniques, Hair et al. (1998) lay out four steps for initial data examination that provide the researcher an opportunity to first understand the data. Those four steps include examinations of descriptive statistics and data distribution, checking for missing data, checking for outliers and testing the underlying assumptions of multivariate analysis (Hair Jr. *et al.*, 1998).

Descriptive Statistics

The first step included an examination of the descriptive statistics, data distribution and correlation tables of all dependent, control and independent variables. Reviewing the raw data in this fashion helps researchers gain a better understanding of the nature of the data and the degree to which they conform to normality. Descriptive statistics are reported below in Table 4.1 and are discussed next.

Table 4.1

Full Panel Descriptive Statistics Prior to Transformation

Variable	N	N Missing	Min	Max	Mean	Variance	Std Dev	Skewness	Kurtosis
Dependent Variables:									
Exploratory search	449	0	0.00	1	0.09	0.02	0.14	3.03	10.83
Exploitative search	449	0	0.00	1	0.28	0.05	0.23	0.65	-0.38
Independent Variables:									
Actual-to-aspired performance	447	2	-15.21	1	0.03	0.80	0.89	-11.77	191.12
Available slack	195	254	0.17	453	4.20	1,077.44	32.82	13.38	183.48
Potential slack	449	0	0.26	37	6.31	35.51	5.96	1.83	4.33
Recoverable slack	447	2	-36.50	113	0.62	58.99	7.68	11.83	168.66
CEO Age	432	17	34.00	73	53.06	43.42	6.59	-0.25	0.29
CEO short-term ratio	449	0	0.00	1	0.61	0.07	0.27	-0.13	-1.03
TMT short-term ratio	449	0	0.11	1	0.68	0.03	0.18	-0.30	-0.53
Short-term disparity	449	0	0.00	8	1.86	0.48	0.70	1.37	10.58
Long-term disparity	449	0	0.00	1708	6.25	6,499.05	80.62	21.09	446.20
CEO equity	449	0	0.00	1	0.02	0.01	0.07	13.50	229.72
TMT equity	449	0	0.00	2	0.01	0.01	0.08	20.86	439.40
(Theoretical) Control Variables:									
Firm size	449	0	0.22	116775	3,443.82	92,106,736.97	9,597.23	5.40	46.89
R&D intensity	445	4	0.01	8	0.36	0.26	0.51	9.24	128.87
Capital structure	449	0	-47.40	126	2.27	82.47	9.08	10.15	138.24
Tobin's Q	447	2	0.42	41	5.17	18.47	4.30	4.30	27.20
TMT Size	449	0	3.00	8	4.73	0.66	0.81	-0.55	0.80
Repeated cites	449	0	0.00	14476	1,065.24	4,148,196.23	2,036.71	2.73	8.82
Unique cites	449	0	0.00	1971	130.10	96,949.59	311.37	3.80	15.43
Prior patents	449	0	1.00	1934	166.43	102,867.73	320.73	2.64	7.08

Missing Variables

Missing variables, skewness and kurtosis are of particular interest in initial examinations. When a substantial number of variables are missing for a specific variable, the appropriateness of its use becomes questionable. In the present case, Table 4.1 reveals that all of the variables except for available slack and CEO age are nearly fully present. Compustat provided values for less than half of the observations for sales, general and administrative Expenses (the key variable in available slack), and the data did not appear to be present in 10-K reports. Various methods exist for filling in values for missing values, such as imputation or mean-substitution; however, each method has drawbacks. In the present case, because two other suitable measures for financial slack are present (potential slack and recoverable slack), I elected to simply drop available slack from the model.

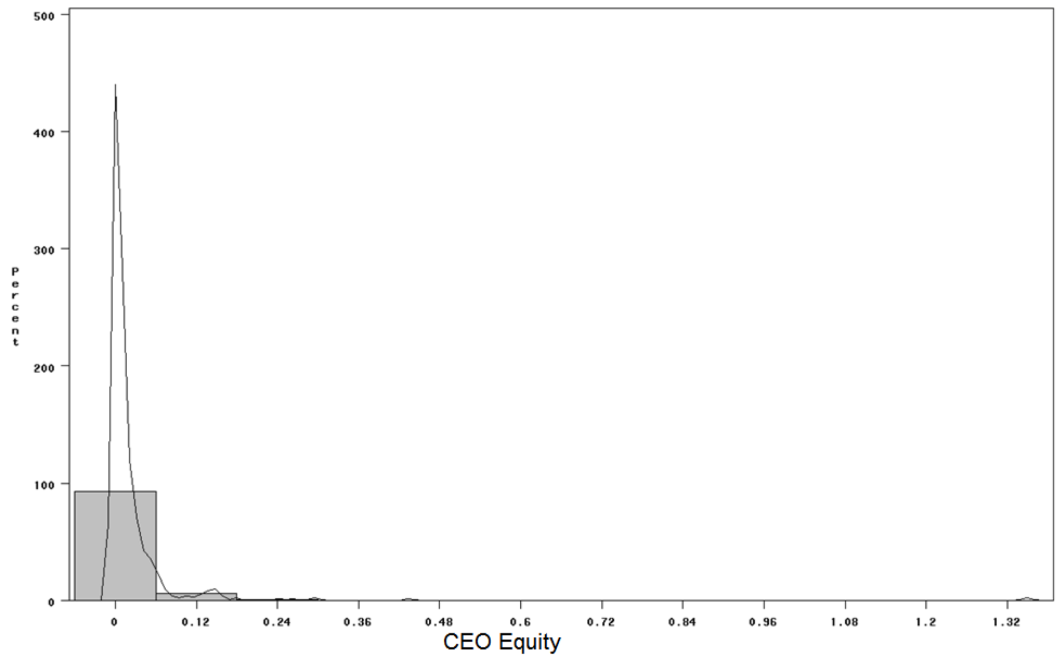
The only other variable with double-digit missing values is CEO age (the present age of CEOs of the firms). However, at 432/449, this variable is only missing in 3.8% of the observations, so I took no corrective action with it. Next, I examined the skewness and kurtosis of the data.

Skewness

The skewness of data represents the degree to which the data are bunched either towards or away from the y-axis of an x-y plot. The normal range for skewness is approximately +/- 2 (Hair Jr. *et al.*, 1998). The (untransformed) data revealed that many variables were above this standard level. In fact, many of these variables had skewness measuring above +/- 10, representing extremely skewed data. As an example of the skewness of one of these variables, a graphical representation of CEO equity is provided below in Figure 4.1.

Histograms with normal distribution overlays for all variables (before and after applicable transformations and outlier removal) in this study are included in Appendix A. Additionally, plots of exploratory search with each other variable in this study and exploitative search with each other variable are included in Appendix B.

Figure 4.1



While it is difficult to see due to the scale of the graph, the data were skewed so severely because of the high number of variables close to the "0" value and the presence of one value to the right of the "1.32" value. Because this value may have represented an outlier, I examined it and discuss my findings below in the outlier examination section.

Kurtosis

Kurtosis, also of importance to examine at this stage, represents the degree of "peakedness" or "flatness" of the data and again, according to Hair Jr., *et al.* (1998), should be less than two. Many of the variables in the data examined as part of this dissertation were extremely (positively) peaked. Table 4.1, above, of CEO equity is also a good example of highly kurtotic data.

Data Transformations

Applying appropriate transformations to data can minimize skewness and kurtosis – bringing the data within acceptable ranges – and allowing for accurate data analysis. To correct for positively skewed data, Hair, Jr. *et al.* (1998) recommend taking the logarithm of skewed or kurtotic values, which I did. Table 4.2, below, shows the results of logarithmic transformations of appropriate variables.

After applying these transformations (see Table 4.2 below), the skewness and kurtosis of all of the independent and control variables was reduced to acceptable levels except for that of capital structure which was still above 2 for both values.

Table 4.2

Full Panel Descriptive Statistics Prior after Transformation

Variable	**N**	**N Missing**	**Min**	**Max**	**Mean**	**Variance**	**Std Dev**	**Skewness**	**Kurtosis**
Dependent Variables:									
Exploratory search	449	0	0.00	0.93	0.09	0.02	0.14	3.03	10.83
Exploitative search	449	0	0.00	0.97	0.28	0.05	0.23	0.65	-0.38
Independent Variables:									
Actual-to-aspired performance (log)	308	141	-5.83	0.20	-1.51	0.84	0.92	-1.27	2.45
Available slack (log)	449	0	-1.36	3.61	1.40	1.01	1.00	-0.22	-0.76
Potential slack (log)	321	128	-10.48	4.73	-2.24	5.20	2.28	-0.39	0.68
CEO Age	432	17	34.00	73.00	53.06	43.42	6.59	-0.25	0.29
CEO short-term ratio	449	0	0.00	1.00	0.61	0.07	0.27	-0.13	-1.03
TMT short-term ratio	449	0	0.11	1.00	0.68	0.03	0.18	-0.30	-0.53
Short-term disparity (log)	449	0	-12.07	2.03	0.48	0.85	0.92	-8.19	91.18
Long-term disparity (constant + log)	449	0	0.00	7.44	0.91	0.66	0.81	1.79	9.00
CEO equity (log)	435	14	-13.67	0.30	-5.46	4.49	2.12	-0.45	0.19
TMT equity (log)	447	2	-12.49	0.57	-7.04	3.38	1.84	-0.01	0.33
(Theoretical) Control Variables:									
Firm size (log)	449	0	-1.53	11.67	5.23	5.78	2.40	0.74	-0.13
R&D intensity (log)	445	4	-4.83	2.10	-1.46	0.86	0.93	-0.17	0.78
Capital structure (log)	426	23	0.02	4.83	0.57	0.38	0.61	2.88	13.37
Tobin's Q (log)	447	2	-0.86	3.71	1.44	0.37	0.61	0.27	1.38
TMT Size	449	0	3.00	8.00	4.73	0.66	0.81	-0.55	0.80
Repeated cites	409	40	0.00	9.58	5.08	5.69	2.38	-0.11	-0.95
Unique cites	422	27	0.00	7.59	3.22	3.53	1.88	0.32	-0.59
Prior patents	449	0	0.00	7.57	3.53	3.34	1.83	0.37	-0.70

However, upon closer inspection, the number of missing values dramatically increased for many variables. Looking at the raw data, the presence of many negative and zero values was detected. Such values are not capable of being log transformed. Thus, a constant was added to those variables to bring the minimum value to 1and log transforms were re-run.

After applying constants and re-running the log transformations, there are two things of note. First, short-term disparity had higher (worse) values after adding a constant and re-transforming than as originally examined. As such, I reverted to the un-transformed values for that variable. Second, most of the variables were close to the +/- 2 for skewness and kurtosis values, with potential slack, actual-to-aspired performance and capital structure as notable exceptions. To try and get these three variables closer to normality, additional transformations were conducted.

Square Root Transformation

In addition to logarithmic transformations, square root transformations can be helpful. As with log transformations, the addition of a constant was required to bring the lowest value to 1 so that all values would react the same way to a square-root transform. Specifically, this is because negative values cannot be squared, the values 1 and 0 remain constant, values above 1 become smaller and numbers below 0 and 1 become larger (http://pareonline.net/getvn.asp?v=8&n=6, Last accessed: June 2, 2009).

Inverse Transformation

Additionally, inverse transformations were examined. As with other transformations, inverse transforms (e.g., 1 / Y) also require the minimum value be brought up to 1 for consistent effects. Without knowing which method would produce the best transformed results for potential slack, actual-to-aspired performance and capital structure, a series of transformations were undertaken and are presented below in Table 4.3 for easy comparison.

Table 4.3

Additional Transformations

Variable	N	N Missing	Min	Max	Mean	Variance	Std Dev	Skewness	Kurtosis
Actual-to-aspired performance (log)	308	141	-5.83	0.20	-1.51	0.84	0.92	-1.27	2.45
Actual-to-aspired performance (constant+log)	447	2	0.00	2.86	2.78	0.02	0.14	-19.20	391.42
Actual-to-aspired performance (log base 10)	447	2	0.00	1.24	1.21	0.00	0.06	-19.20	391.42
Actual-to-aspired performance (constant+sq rt)	447	2	1.00	4.18	4.03	0.03	0.16	-15.94	300.02
Actual-to-aspired performance (constant+inverse)	447	2	-1.00	-0.06	-0.06	0.00	0.04	-21.06	444.64
Capital structure (log)	426	23	0.02	4.83	0.57	0.38	0.61	2.88	13.37
Capital structure	449	0	0.00	5.16	3.91	0.05	0.21	-12.93	256.46
Capital structure (log base 10)	449	0	0.00	2.24	1.70	0.01	0.09	-12.93	256.46
Capital structure (constant+sq rt)	449	0	1.00	13.19	7.10	0.30	0.55	2.77	96.36
Capital structure (constant+inverse)	449	0	-1.00	-0.01	-0.02	0.00	0.05	-21.14	447.65
Potential Slack (log)	321	128	-10.48	4.73	-2.24	5.20	2.28	-0.39	0.68
Potential Slack (constant+log)	447	2	0.00	5.02	3.63	0.04	0.20	-11.54	235.45
Potential Slack (log base 10)	447	2	0.00	2.18	1.57	0.01	0.09	-11.54	235.45
Potential Slack (constant+sq rt)	447	2	1.00	12.28	6.15	0.25	0.50	4.85	113.16
Potential Slack (constant+inverse)	447	2	-1.00	-0.01	-0.03	0.00	0.05	-21.06	444.66

For each of these variables, the transformation with the most appropriate skewness and kurtosis variables was only accomplished by dropping many negative and zero values. Since negative and zero values are valid values, these log transforms were unacceptable. The next best results in each case were those generated by the SQRT of the values. However, those values were still rather high.

Outlier Examination

Because of the inability to bring the skewness and kurtosis values of potential slack, actual-to-aspired performance and capital structure within normal ranges, I examined the Z-scores of these values to scan for potential outliers. The examination for outliers is an important step in data preparation as outliers have the potential to unduly influence the data. A value may technically be considered an outlier if it is +/- 2.5 standard deviations away from the variable mean (Hair Jr. *et al.*, 1998). However, simply being +/- 2.5 standard deviations away from the mean is not sufficient evidence to remove a valid value.

In addition to objective criteria, the value should be examined to determine why it appears to be an outlier. For example, a firm that is substantially larger than other firms in the sample should not necessarily be removed from the sample simply because it is large. However, a value reported in billions instead of millions (i.e., inaccurately reported data) should clearly be fixed or removed. Generally, though, if the value causes undue influence on the rest of the data, perhaps a good case could be made for removal, but this should only be done in the most extreme circumstances (Hair Jr. *et al.*, 1998).

For potential slack, there were 444 values between -3.62 and 3.95 standard deviations, 2 missing values and 3 extreme outliers of -10.37, +11.24, and +12.32. For actual-to-aspired performance, there were 446 values between -3.56 and +0.93 standard deviations, 2 missing values and 1 extreme outlier of -19.10. For the third variable, capital structure, there were 446 values between -3.61 and +4.03 standard deviations, 0 missing values and 3 extreme outliers of -12.19, +10.18 and +10.65.

Digging deeper into the reasons for why these values were generated, I found that the same three firms were causing an undue influence on potential slack and capital structure: Columbia Laboratories (1999), Isis Pharmaceuticals (1999) and Sepracor (1998). All three of these firms had low equity, low assets and high debt, creating a lethal combination on these calculated variables. The other value, actual-to-aspired performance, was generated by Vyrex (1998) because of a particularly poor financial year and no prior year ROA to help smooth out the poor performance.

In looking at the big picture of the dataset (449 firm-year observations), it seemed imprudent to allow four small firm-year observations with low assets, high debt and/or poor performance to have such a negative impact on two important independent variables and one important control variable. Also, given that these extreme values were between 6.15 – 15.54 standard deviations away from the next closest value, it seemed quite reasonable to consider these values as outliers. Accordingly, I deleted these values and re-ran the above transformations for these three values, resulting in the next table, Table 4.4.

Table 4.4

Transformations of troublesome variables AFTER outlier removal

Variable	N	N Missing	Min	Max	Mean	Variance	Std Dev	Skewness	Kurtosis
Actual-to-aspired performance	446	3	-4.23	1.22	0.06	0.28	0.53	-3.26	19.18
Actual-to-aspired performance (constant+log)	446	3	0.00	1.86	1.66	0.02	0.14	-6.80	68.03
Actual-to-aspired performance (log base 10)	446	3	0.00	0.81	0.72	0.00	0.06	-6.80	68.03
Actual-to-aspired performance (constant+sq rt)	446	3	1.00	2.54	2.30	0.02	0.13	-4.69	36.37
Actual-to-aspired performance (constant+inverse)	446	3	-1.00	-0.16	-0.19	0.00	0.05	-12.08	170.48
Capital structure	448	1	-22.95	125.61	2.38	77.12	8.78	11.62	155.96
Capital structure (constant+log)	448	1	0.00	5.01	3.25	0.05	0.23	-4.84	105.07
Capital structure (log base 10)	448	1	0.00	2.17	1.41	0.01	0.10	-4.84	105.07
Capital structure (constant+sq rt)	448	1	1.00	12.23	5.10	0.35	0.59	6.73	92.22
Capital structure (constant+inverse)	448	1	-1.00	-0.01	-0.04	0.00	0.05	-20.23	420.11
Potential Slack	444	5	-18.57	28.39	0.23	5.01	2.24	2.33	77.28
Potential Slack (constant+log)	444	5	0.00	3.87	2.97	0.03	0.19	-11.34	169.35
Potential Slack (log base 10)	444	5	0.00	1.68	1.29	0.01	0.08	-11.34	169.35
Potential Slack (constant+sq rt)	444	5	1.00	6.93	4.44	0.08	0.28	-4.65	81.79
Potential Slack (constant+inverse)	444	5	-1.00	-0.02	-0.05	0.00	0.05	-18.81	371.40

After removing the outliers, two of the three variables (actual-to-aspired performance and potential slack) had the best results on the raw values for skewness and kurtosis – no manipulation was necessary beyond removing the outliers. For the third variable, capital structure, a square-root transformation yielded the best results, with the fewest number of missing values. Interestingly, however, doing this same procedure on the variable with outliers included actually resulted in lower skewness but slightly higher kurtosis (2.77 and 96.36, respectively, compared with 6.73 and 92.22).

Because the data best resembled normality with the all observations for capital structure, removing a valid (even if extreme) value from capital structure did not seem warranted. However, the sacrifice of a few observations for actual-to-aspired performance (Columbia 1998) and potential slack (Sepracor 1998, Columbia 1999 and Isis 1999), to achieve substantial improvement to the normality of the data, did appear justified. Taking these steps resulted in the final descriptive statistics, shown below in Table 4.5.

Table 4.5

Final Full Panel Descriptive Statistics After Transformations

Variable	N	N Missing	Min	Max	Mean	Variance	Std Dev	Skewness	Kurtosis
Dependent Variables:									
Exploratory search (constant + log)	449	0	0.00	0.66	0.08	0.01	0.11	2.53	7.08
Exploitative search	449	0	0.00	0.97	0.28	0.05	0.23	0.65	-0.38
Independent Variables:									
Actual-to-aspired performance (constant + sq rt)	446	3	-4.23	1.22	0.06	0.28	0.53	-3.26	19.18
Available slack (log)	449	0	-1.36	3.61	1.40	1.01	1.00	-0.22	-0.76
Potential slack (constant + sq rt)	444	5	-18.57	28.39	0.23	5.01	2.24	2.33	77.28
CEO Age	432	17	34.00	73.00	53.06	43.42	6.59	-0.25	0.29
CEO short-term ratio	449	0	0.00	1.00	0.61	0.07	0.27	-0.13	-1.03
TMT short-term ratio	449	0	0.11	1.00	0.68	0.03	0.18	-0.30	-0.53
Short-term disparity	449	0	0.00	7.58	1.86	0.48	0.70	1.37	10.58
Long-term disparity (constant + log)	449	0	0.00	7.44	0.91	0.66	0.81	1.79	9.00
CEO equity (log)	435	14	-13.67	0.30	-5.46	4.49	2.12	-0.45	0.19
TMT equity (log)	447	2	-12.49	0.57	-7.04	3.38	1.84	-0.01	0.33
(Theoretical) Control Variables:									
Firm size (log)	449	0	-1.53	11.67	5.23	5.78	2.40	0.74	-0.13
R&D intensity (log)	445	4	-4.83	2.10	-1.46	0.86	0.93	-0.17	0.78
Capital structure (log)	448	1	1.00	12.23	5.10	0.35	0.59	6.73	92.22
Tobin's Q (log)	447	2	-0.86	3.71	1.44	0.37	0.61	0.27	1.38
TMT Size	449	0	3.00	8.00	4.73	0.66	0.81	-0.55	0.80
Repeated cites (constant + log)	449	0	0.00	9.58	4.67	7.00	2.65	-0.14	-0.99
Unique cites (constant + log)	449	0	0.00	7.59	3.14	3.51	1.87	0.37	-0.55
Prior patents (log)	449	0	0.00	7.57	3.53	3.34	1.83	0.37	-0.70

Heteroskedasticity

One of the key assumptions of regression, is that the residual terms have equal variance for all predicted values of the dependent variable(s), otherwise known as *homoskedasticity* (Cohen *et al.*, 2003). To test this assumption, I used the *.hettest* command in STATA. This test sets the null hypotheses to be that the variables have constant variances. With both exploratory and exploitative search as dependent variables, the test was significant (0.000), meaning that the null is rejected and suggesting that the data may be heteroskedastic (and not homoskedastic), violating one of the key assumptions of regression.

As thoroughly discussed in the preceding pages, the structure of the data was extensively analyzed and numerous data transformations were performed. It seemed unlikely that further transformations would result in changes substantial enough to remove heteroskedasticity.

Autocorrelation

Autocorrelation, the degree to which panel data variables are correlated with themselves (Parr and Phillips, 1999) and multicollinearity, the degree to which variables are correlated with each other (Hair Jr. *et al.*, 1998), were also important to examine. I tested for autocorrelation in STATA with the command *.findit xtserial*. The Wooldridge test for autocorrelation sets the null hypotheses to be that there is no first-order autocorrelation. With exploitative search set as the dependent variable, the test was not significant (0.2774), indicating the null cannot be rejected, lending support to the assertion that there is no autocorrelation in that model.

However, with exploratory search set as the dependent variable, the test was significant (0.0000), indicating autocorrelation as related to the dependent variable.

Collinearity

Multicollinearity, a related issue, can be gauged, in part, by examining the Variance Inflation Factors (VIFs), shown below in Table 4.6. The VIFs indicate the amount that correlation amongst the predictor variables causes the variance of each regression coefficient to increase (Cohen *et al.*, 2003). Among all variables, firm size had the highest VIF, nearing a 10 – much higher than any other variable. Cohen *et al.* (2003) have said that when VIFs reach 10 or higher, serious multicollinearity may be present (423). Yet even at levels as low as 2, variance inflation can cause instability in the data (Neter, Wasserman, and Kutner, 1985). To gain a better understanding of whether the variance inflation and multicollinearity was causing instability in the data, I next examined the correlation matrix.

Table 4.6

Variable	VIF	1/VIF
Firm size	9.6	0.104
Long-term disparity	6.6	0.151
CEO short-term ratio	6.5	0.153
Prior patents	4.7	0.213
Capital structure	4.3	0.231
Potential slack	4.3	0.231
R&D intensity	3	0.331
TMT short-term ratio	2.5	0.396
Actual-to-aspired performance	2.3	0.435
Available slack	2	0.509
Short-term disparity	1.6	0.630
CEO equity	1.5	0.657
Tobin's Q	1.4	0.709
TMT equity	1.3	0.746
TMT Size	1.3	0.756
CEO Age	1.3	0.793

To get a better picture of the degree of instability of the coefficients, I examined the correlation matrix for two items. First, I made note of variables that seemed to be highly correlated with other variables in the correlation matrix, shown below in Table 4.7.

The initial correlation table shows high, statistically significant correlations between many variables (correlations at .4 or higher are indicated in bold). Variables that are correlated with other variables at levels of .4 or higher are included in Table 4.8.

Table 4.8

Variable	Number of variables the focal variable is correlated with at .4 or higher
Exploratory search	2
Exploitative search	1
Potential slack	1
Actual-to-aspired performance	2
CEO short-term ratio	3
TMT short-term ratio	3
Long-term disparity	3
Firm size	10
R&D intensity	4
Capital structure	1
CEO equity	3
TMT equity	1
Repeated cites	3
Unique cites	5
Prior patents	6

The two variables that were highly correlated with the most number of other variables are firm size (assets) and prior patents (which could also be a reasonable proxy for firm size). Given that the assets variable is included as a control for size, and that it is correlated with prior applications at .82 level, it may be unnecessary.

Table 4.7

Variable	MEAN	STD	N	Explora-tory search	Exploit-ative search	Available slack	Potential slack	Actual-to-aspired perf	CEO short-term ratio	TMT short-term ratio	Short-term disparity
Exploratory search	0.080	0.112	449	1.000							
Exploitative search	0.284	0.226	449	-0.329*	1.000						
				0.00							
Available slack	1.395	1.005	449	0.004	0.1512*	1.000					
				0.94	*0.00*						
Potential slack	0.227	2.237	444	-0.026	-0.058	0.005	1.000				
				0.59	*0.22*	*0.93*					
Actual-to-aspired performance	0.064	0.528	446	-0.085	0.045	0.108*	0.078	1.000			
				0.07	*0.34*	*0.02*	*0.10*				
CEO short-term ratio	0.606	0.271	449	0.083	-0.033	0.102*	-0.010	-0.222*	1.000		
				0.08	*0.48*	*0.03*	*0.83*	*0.00*			
TMT short-term ratio	0.677	0.176	449	0.087	-0.037	0.108*	-0.030	-0.276*	**0.678***	1.000	
				0.07	*0.43*	*0.02*	*0.52*	*0.00*	*0.00*		
Short-term disparity	1.865	0.696	449	0.021	-0.029	-0.201*	0.016	0.127*	-0.049	-0.278*	1.000
				0.66	*0.54*	*0.00*	*0.74*	*0.01*	*0.30*	*0.00*	
Long-term disparity	0.908	0.811	449	-0.064	0.027	-0.118*	0.014	0.239*	**-0.894***	**-0.708***	0.259*
				0.18	*0.56*	*0.01*	*0.76*	*0.00*	*0.00*	*0.00*	*0.00*
Firm size	5.226	2.404	449	-0.218*	0.027	-0.388*	0.055	**0.500***	**-0.471***	**-0.498***	0.340*
				0.00	*0.57*	*0.00*	*0.25*	*0.00*	*0.00*	*0.00*	*0.00*
R&D intensity	-1.463	0.927	445	0.074	-0.023	0.076	-0.084	**-0.650***	0.277*	0.295*	-0.267*
				0.12	*0.63*	*0.11*	*0.08*	*0.00*	*0.00*	*0.00*	*0.00*
Capital structure	5.097	0.595	448	-0.025	0.024	-0.052	**0.855***	-0.037	-0.023	-0.059	0.010
				0.60	*0.61*	*0.27*	*0.00*	*0.44*	*0.63*	*0.21*	*0.83*
Tobin's Q	1.441	0.607	447	0.032	0.065	0.005	-0.129*	-0.123*	-0.049	-0.140*	-0.021
				0.49	*0.17*	*0.91*	*0.01*	*0.01*	*0.30*	*0.00*	*0.66*
CEO Age	53.063	6.590	432	0.111*	-0.228*	-0.303*	-0.053	0.023	0.075	-0.034	0.148*
				0.02	*0.00*	*0.00*	*0.27*	*0.64*	*0.12*	*0.48*	*0.00*
TMT Size	4.735	0.815	449	-0.171*	0.047	-0.071	-0.066	0.172*	-0.149*	-0.091	0.120*
				0.00	*0.32*	*0.13*	*0.17*	*0.00*	*0.00*	*0.05*	*0.01*
CEO equity	-5.463	2.119	435	-0.008	0.074	0.378*	-0.031	-0.140*	0.220*	0.222*	-0.190*
				0.87	*0.12*	*0.00*	*0.52*	*0.00*	*0.00*	*0.00*	*0.00*
TMT equity	-7.042	1.838	447	0.129*	0.000	0.259*	0.016	-0.113*	0.201*	0.240*	-0.213*
				0.01	*1.00*	*0.00*	*0.74*	*0.02*	*0.00*	*0.00*	*0.00*
Repeated cites	4.673	2.645	449	**-0.476***	**0.666***	-0.205*	-0.021	0.253*	-0.282*	-0.318*	0.215*
				0.00	*0.00*	*0.00*	*0.65*	*0.00*	*0.00*	*0.00*	*0.00*
Unique cites	3.142	1.873	449	0.099*	0.190*	-0.379*	-0.008	0.296*	-0.320*	-0.360*	0.293*
				0.04	*0.00*	*0.00*	*0.87*	*0.00*	*0.00*	*0.00*	*0.00*
Prior patents	3.527	1.827	449	**-0.441***	0.214*	-0.352*	-0.008	0.325*	-0.358*	-0.386*	0.224*
				0.00	*0.00*	*0.00*	*0.87*	*0.00*	*0.00*	*0.00*	*0.00*

Table 4.7 (cont'd)

Variable	Long-term disparity	Firm size	R&D intensity	Capital structure	Tobin's Q	CEO Age	TMT Size	CEO equity	TMT equity	Repeat-ed cites	Unique cites
Exploratory search											
Exploitative search											
Available slack											
Potential slack											
Actual-to-aspired performance											
CEO short-term ratio											
TMT short-term ratio											
Short-term disparity											
Long-term disparity	1.000										
Firm size	**0.489***	1.000									
	0.00										
R&D intensity	-0.292*	**-0.691***	1.000								
	0.00	*0.00*									
Capital structure	0.034	0.044	-0.025	1.000							
	0.47	*0.35*	*0.61*								
Tobin's Q	0.036	-0.213*	0.332*	-0.037	1.000						
	0.45	*0.00*	*0.00*	*0.43*							
CEO Age	-0.066	0.136*	-0.142*	0.018	0.014	1.000					
	0.17	*0.00*	*0.00*	*0.70*	*0.77*						
TMT Size	0.166*	0.374*	-0.183*	-0.010	-0.122*	-0.061	1.000				
	0.00	*0.00*	*0.00*	*0.84*	*0.01*	*0.20*					
CEO equity	-0.225*	**-0.475***	0.245*	-0.024	-0.018	-0.193*	-0.037	1.000			
	0.00	*0.00*	*0.00*	*0.62*	*0.71*	*0.00*	*0.44*				
TMT equity	-0.226*	**-0.447***	0.263*	-0.011	0.089	-0.117*	-0.054	0.326*	1.000		
	0.00	*0.00*	*0.00*	*0.82*	*0.06*	*0.02*	*0.25*	*0.00*			
Repeated cites	0.298*	**0.609***	-0.324*	0.052	-0.027	-0.033	0.265*	-0.273*	-0.237*	1.000	
	0.00	*0.00*	*0.00*	*0.27*	*0.57*	*0.49*	*0.00*	*0.00*	*0.00*		
Unique cites	0.345*	**0.665***	**-0.409***	0.061	0.007	0.146*	0.208*	**-0.419***	-0.248*	**0.647***	1.000
	0.00	*0.00*	*0.00*	*0.20*	*0.89*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	
Prior patents	0.364*	**0.816***	**-0.419***	0.054	-0.082	0.073	0.356*	**-0.426***	-0.356*	**0.786***	**0.700***
	0.00	*0.00*	*0.00*	*0.25*	*0.08*	*0.13*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Firm size also generated the highest VIF value, the only value coming close to 10. In light of these factors, I considered dropping firm size (assets) and just keeping prior patents. Before doing that, I wanted to also check the stability of the variables.

Variables may be unstable if signs (+/-) are different as between the correlation matrix and regression coefficients. To determine this, I entered each of the variables in the .reg3 regression equation and compared the signs with those from the correlation matrix. The results are shown in Table 4.9. In each case, the constant and predictor variable returned the same coefficient sign as that indicated in the correlation matrix. This consistency in signs suggests that the coefficients are stable and multicollinearity is not too problematic. Thus, firm size was not dropped as a variable; I next ran the regressions.

Regression Models

I ran the data using two regression routines in STATA: .reg3 and .xtivreg. As previously discussed, .reg3 allows two or more dependent variables to entered in the same model, while .xtivreg runs them separately, while controlling for the other DV. Both are appropriate given the current data (unbalanced panel data with continuous DVs).

Table 4.9

Variable	Exploratory search	Sign in .reg3	Exploitative search	Sign in .reg3
Exploratory search	1.000			
Exploitative search	-0.329*		1.000	
	0.00			
Available slack	0.004	pos	0.1512*	pos
	0.94		*0.00*	
Potential slack	-0.026	neg	-0.058	neg
	0.59		*0.22*	
Actual-to-aspired performance	-0.085	neg	0.045	pos
	0.07		*0.34*	
CEO short-term ratio	0.083	pos	-0.033	neg
	0.08		*0.48*	
TMT short-term ratio	0.087	pos	-0.037	neg
	0.07		*0.43*	
Short-term disparity	0.021	pos	-0.029	neg
	0.66		*0.54*	
Long-term disparity	-0.064	neg	0.027	pos
	0.18		*0.56*	
Firm size	-0.218*	neg	0.027	pos
	0.00		*0.57*	
R&D intensity	0.074	pos	-0.023	neg
	0.12		*0.63*	
Capital structure	-0.025	neg	0.024	pos
	0.60		*0.61*	
Tobin's Q	0.032	pos	0.065	pos
	0.49		*0.17*	
CEO Age	0.111*	pos	-0.228*	neg
	0.02		*0.00*	
TMT Size	-0.171*	neg	0.047	pos
	0.00		*0.32*	
CEO equity	-0.008	neg	0.074	pos
	0.87		*0.12*	
TMT equity	0.129*	pos	0.000	0 (neg)
	0.01		*1.00*	
Repeated cites	**-0.476***	**neg**	**0.666***	**pos**
	0.00		*0.00*	
Unique cites	0.099*	pos	0.190*	pos
	0.04		*0.00*	
Prior patents	**-0.441***	**neg**	0.214*	pos
	0.00		*0.00*	

REG3 Model

I first ran the data with .reg3, entering the control and dummy variables first, then slack, performance and TMT effects in separate models to show their individual effects, and then a full model of all variables was run. For the dummy variables, the year 2000 was removed since that year had the most number of observations (http://dss.princeton.edu/online_help/analysis/dummy_variables.htm, Last Accessed: June 5, 2009.). Confidence Intervals (CIs) are included for the full model. The results are presented in Tables 4.10 and 4.11, below.

Table 4.10

reg3 DV: Exploratory Search	Model 1 Controls	Model 2a Main Effects: Slack	Model 2b Main Effects: Perfor-mance	Model 2c Main Effects: TMT	Model 3 Main Effects: Full	Confidence for Full	Intervals Model
Controls:							
R&D intensity (log)	-0.017*				-0.005	-0.020	0.009
Capital structure (log)	0.000				-0.001	-0.016	0.013
Tobin's Q (log)	0.009				-0.007	-0.026	0.012
TMT Size	0.002				0.005	-0.007	0.017
Prior patents (log)	-0.028*				-0.035	-0.042	-0.028
1994	0.017				-0.014*	-0.076	0.049
1995	0.006				0.003	-0.046	0.051
1996	-0.018				-0.008	-0.044	0.027
1997	-0.014				-0.011	-0.047	0.024
1998	0.005				0.004	-0.038	0.045
1999	-0.005				-0.003	-0.039	0.033
2001	-0.031 t				-0.039*	-0.073	-0.006
2002	-0.038*				-0.046**	-0.085	-0.009
2003	-0.071				-0.075**	-0.113	-0.037
Independent Variables:							
Available slack (log)		-0.016*			-0.001	-0.013	0.011
Actual-to-aspired performance (constant + sq rt)			-0.041		-0.006	-0.101	0.088
CEO Age				0.002**	0.002**	0.001	0.004
Short-term disparity				0.008	0.009	-0.007	0.024
Long-term disparity (constant + log)				0.014	0.014	-0.014	0.043
CEO short-term ratio				0.016	0.014	-0.070	0.098
TMT short-term ratio				-0.017	-0.023	-0.103	0.057
CEO equity (log)				-.012**	-0.011**	-0.016	-0.006
TMT equity (log)				0.003	0.003	-0.003	0.008
Model Statistics:							
R Square	0.249**	.265**	0.255**	.314**	.3185**		
R Square Change	-	+.016	+.006	0.065	+.070		
Chi-Sq	146.580	159.66	150.44	188	190.640		
Chi-Sq Change	-	13.080	3.860	41.420	44.060		

Table 4.11

reg3 DV: **Exploitative Search**	Model 1 Controls	Model 2a Main Effects: Slack	Model 2b Main Effects: Perfor-mance	Model 2c Main Effects: TMT	Model 3 Main Effects: Full	Confidence for Full	Intervals Model
Controls:							
R&D intensity (log)	0.015				-0.008	-0.041	0.026
Capital structure (log)	0.007				0.009	-0.024	0.041
Tobin's Q (log)	0.015				0.041 t	-0.002	0.084
TMT Size	-0.005				-0.016	-0.043	0.012
Prior patents (log)	0.033*				0.056**	0.040	0.071
1994	-0.088				-0.017	-0.157	0.123
1995	-0.056				-0.036	-0.145	0.074
1996	0.013				-0.007	-0.088	0.073
1997	0.016				-0.003	-0.083	0.078
1998	0.012				0.032	-0.061	0.126
1999	-0.001				0.016	-0.065	0.098
2001	0.026				0.012	-0.064	0.087
2002	-0.022				-0.019	-0.105	0.067
2003	-0.078 t				-0.091*	-0.177	-0.007
Independent Variables:							
Available slack (log)		0.066**			0.048**	0.022	0.075
Actual-to-aspired performance (constant + sq rt)			0.066		-0.072	-0.284	0.141
CEO Age				-0.007**	-0.006**	-0.009	-0.002
Short-term disparity				-0.013	-0.006	-0.041	0.029
Long-term disparity (constant + log)				-0.011	0.015	-0.050	0.079
CEO short-term ratio				0.065	0.070	-0.120	0.260
TMT short-term ratio				0.053	0.070	-0.111	0.251
CEO equity (log)				0.017**	0.012*	0.001	0.024
TMT equity (log)				0.002	0.001	-0.011	0.013
Model Statistics:							
R Square	0.077**	0.142**	0.255**	.314**	0.183**		
R Square Change	-	+.065	+.178	+.237	+.106		
Chi-Sq	36.900	73.13	38.32	76.89	91.540		
Chi-Sq Change	-	36.230	1.420	39.990	54.640		

XTIVREG Model

Next, I ran the models using .xtivreg. With this procedure, each dependent variable is entered separately, but the other (secondary) endogenous variable is indicated within the equation. Additionally, an indicator variable is entered for each of the secondary endogenous variables that is related to the secondary variable but not the primary one. For example, for the exploratory search equation, exploitative search was the secondary equation. Repeated cites was strongly positively correlated with exploitative search (since it reflects the number of cites the firm has repeatedly used over the prior 5 years) but was negatively correlated with exploratory search. For exploratory search, unique cites was a key variable in calculating the exploratory search value. While it did not appear to be as strongly correlated with exploratory search as repeated cites was with exploitative search, it was still theoretically the most appropriate instrumental variable and was used.

Taken together, these analyses reveal somewhat consistent findings. The results of the hypotheses tests are discussed next. In some instances, the result was not statistically significant but was within the estimated CI. In situations where the CI does not overlap 0, it can be inferred that 95% of the CIs drawn from the population would contain the true value. This is not a probability statistic, *per se*, but does provide some support for the range of values that likely contain the population parameter (Hinkle, Wiersma, and Jurs, 2003). However, when the CI overlaps zero, the interpretability of the CI decreases. Because of the potential importance of the CI, I make note of it, as well. Findings from this model are presented in Tables 4.12 and 4.13 A summary of the findings for the hypotheses is included in Table 4.14.

Table 4.12

xtivreg DV: Exploratory Search	Model 1 Controls	Model 2a Main Effects: Slack	Model 2b Main Effects: Perfor-mance	Model 2c Main Effects: TMT	Model 3 Main Effects: Full	Confidence for Full	Intervals Model
Controls:							
R&D intensity (log)	0.005				0.010	-0.014	0.033
Capital structure (log)	-0.006				-0.007	-0.019	0.006
Tobin's Q (log)	0.028*				0.012	-0.010	0.035
TMT Size	-0.007				-0.009	-0.025	0.007
Prior patents (log)	-0.109**				-0.082**	-0.104	-0.061
1994	0.014				0.017	-0.041	0.074
1995	-0.004				-0.004	-0.051	0.044
1996	-0.015				-0.008	-0.044	0.028
1997	-0.008				0.000	-0.035	0.035
1998	0.005				0.012	-0.026	0.051
1999	-0.010				0.010	-0.023	0.043
2001	-0.012				-0.019	-0.048	0.011
2002	0.006				-0.004	-0.042	0.033
2003	-0.036				-0.036 t	-0.075	0.002
Independent Variables:							
Available slack (log)		.023*			0.022*	0.004	0.041
Actual-to-aspired performance (constant + sq rt)			0.006		-0.019	-0.120	0.081
CEO Age				0.000	0.000	-0.002	0.003
Short-term disparity				-0.006	-0.008	-0.031	0.014
Long-term disparity (constant + log)				0.040 t	0.04 t	-0.007	0.089
CEO short-term ratio				0.058	0.063	-0.068	0.194
TMT short-term ratio				0.056	0.050	-0.034	0.135
CEO equity (log)				-0.003	-0.003	-0.012	0.005
TMT equity (log)				0.000	-0.001	-0.007	0.006
Model Statistics:							
R Square	0.180	0.165	0.187	0.196	0.181		
R Square Change		-0.015	0.007	0.016	0.001		
Chi-Sq	475.500	484.99**	473.02**	539.13**	549.71**		
Chi-Sq Change		9.490	-2.480	63.630	74.210		

Table 4.13

xtivreg	Model 1	Model 2a	Model 2b	Model 2c	Model 3		
DV:							
Exploitative Search	Controls	Main Effects: Slack	Main Effects: Perfor-mance	Main Effects: TMT	Main Effects: Full	Confidence for Full	Intervals Model
Controls:					-0.008	-0.059	0.043
R&D intensity (log)	-0.007				0.010	-0.018	0.038
Capital structure (log)	0.008				0.023	-0.025	0.071
Tobin's Q (log)	0.010				0.013	-0.020	0.047
TMT Size	0.007				0.06*	0.006	0.123
Prior patents (log)	0.065				-0.039	-0.163	0.085
1994	-0.023				0.012	-0.091	0.114
1995	0.029				0.033	-0.045	0.111
1996	0.053				0.007	-0.069	0.082
1997	0.050				0.014	-0.069	0.096
1998	0.025				-0.003	-0.075	0.069
1999	0.009				-0.009	-0.073	0.055
2001	0.004				-0.098**	-0.175	-0.023
2002	-0.079				-0.120**	-0.196	-0.045
2003	-0.113						
Independent Variables:							
Available slack (log)		0.015			0.010	-0.032	0.051
Actual-to-aspired performance (constant + sq rt)			0.066		0.041	-0.176	0.257
CEO Age				0.002	0.002	-0.003	0.007
Short-term disparity				-0.023	-0.091	-0.374	0.192
Long-term disparity (constant + log)				-0.059	-0.071	-0.253	0.110
CEO short-term ratio				-0.100	-0.025	-0.073	0.023
TMT short-term ratio				-0.077	-0.058	-0.163	0.048
CEO equity (log)				0.008	0.008	-0.011	0.026
TMT equity (log)				-0.001	-0.001	-0.015	0.013
Model Statistics:							
R Square	0.02	0.029	0.022	0.016	0.021		
R Square Change		0.009	0.002	-0.004	0.001		
Wald Chi-Sq	1429.86**	1438.16**	1412.1**	1349.42**	1328.35**		
Wald Chi-Sq Change		8.300	-17.760	-80.440	-101.510		

Table 4.14

Summary of Hypotheses

Hypothesis (with brief summary)	reg3 Model	xtivreg Model
1a (greater performance shortfall, more exploration)	NS	NS
1b (greater performance shortfall, less exploitation)	NS	NS
2a (more slack, more exploration)	NS	**0.05**
2b (less slack, more exploitation)	NS	NS
3a (higher age, less exploration)	**0.01 (opp)**	NS
3b (higher age, more exploitation)	**0.01 (opp)**	NS
4a (greater short-term disparity, less exploration)	NS	NS
4b (greater short-term disparity, more exploitation)	NS	NS
5a (greater long-term disparity, less exploration)	NS	**0.10 (opp)**
5b (greater long-term disparity, more exploitation)	NS	NS
6a (higher CEO current ratio, less exploration)	NS	NS
6b (higher CEO current ratio, more exploitation)	NS	NS
7a (lower TMT current ratio, more exploration)	NS	NS
7b (higher TMT current ratio, more exploitation)	NS	NS
8a (more CEO equity, less exploration)	**0.01**	NS
8b (more CEO equity, more exploitation)	**0.05**	NS
9a (more TMT equity, less exploration)	NS	NS
9b (more TMT equity, more exploitation)	NS	NS

Hypotheses Results

Hypothesis 1a and 1b

Hypothesis 1a argued that as the performance gap increases, that firms would be more inclined to engage in exploratory search. No support was found for this hypothesis. Likewise, hypothesis 1b, which argued that as the performance gap increases, that exploitative search would increase, was not found to be statistically significant. The coefficient was within the CI (-0.175 to +0.257) but the interval overlapped zero.

Hypothesis 2a and 2b

The hypotheses that argued financial slack would be positively associated with exploitation and negatively associated with exploitation found some support. I initially planned to examine all three financial slack variables (potential, available and recoverable). However, recoverable slack had too many missing values and recoverable slack did not transform as well as available slack, so I only examined the relationships between available slack and search. Both models showed significant, positive, relationship between available slack and exploratory search (at the .05 level) in "Model 2a" which looked at the control variables and slack.

However, in the .reg3 model, the relationship lost its significance for the full model. Thus, hypothesis 2a is confirmed (in the .xtivreg model), which argued that as financial slack increased, top executives would have more flexibility in directing more exploratory search. However, hypothesis 2b, which argued that as slack increased, exploitative search would decrease, found no support in the .reg3 model. The coefficient was within the CI on the .xtivreg model, but again, the interval spanned zero, undermining the interpretability of the result.

Hypothesis 3a and 3b

Just as with the problem-based search and slack-based search hypotheses, the findings related to the CEO and top managers were also mixed. Hypotheses 3a and 3b argued that as CEOs aged, they would become less risk tolerant and, thus, prefer exploitative search to exploratory search. Hypothesis 3a (as CEOs aged, they would direct less exploratory search) had strong support (at the .01 level) under the .reg3 model and in the .xtivreg model, the coefficient was within the CI.

However, the results were in the opposite direction from that hypothesized. Specifically, the results indicated that as CEOs age, they direct more exploratory search. Likewise, hypotheses 3b was supported at the .01 level (in the .reg3 model), lending support for the argument that as CEOs age, they direct less exploitative search. In the .xtivreg model, the coefficient was within the CI, but again, the CI included zero.

Hypothesis 4a and 4b

The next two sets of hypotheses looked at the relationship between pay disparity and search. In the first set, I hypothesized that as the disparity of annual salary compensation between the CEO and the rest of the TMT decreased that exploratory search would increase (4a) but that as the disparity increased, that exploitative search would increase (4b). No support was found for hypotheses 4a or 4b (although the .reg3 model for hypothesis 4a included the coefficient within its zero-spanning CI; additionally, the coefficient was positive instead of negative as I hypothesized).

Hypothesis 5a and 5b

In the second set of hypotheses related to disparity and search, I made similar arguments – that as disparity of option compensation increased, that exploratory search would decrease (5a) and exploitative search would increase (5b). Hypothesis 5a was significant at the .10 level under the .xtivreg model (and within the zero-spanning CI of the .reg3 model), but in the opposite direction. This result suggests that exploratory search may increase as the disparity of option compensation between the CEO and other TMT members increases. Hypothesis 5b was not significant under either model but under the .reg3 model, the coefficient was within the zero-spanning CI.

Hypothesis 6a, 6b, 7a and 7b

Hypotheses 6 and 7 explored the relationships between current (versus long-term) compensation and search preferences, generally arguing that long-term compensation would be associated with exploration and short-term compensation would be related with exploitation. I found no support for hypothesis 6a (lower CEO annual salary would encourage more exploratory search), although in both models, the coefficient was within the zero-spanning CI (although in a direction opposite to what I argued). Likewise, for hypothesis 6b, no support was found but the coefficient was within the CIs (with the .reg3 model in the direction I hypothesized and the .xtivreg model in the opposite direction). Hypotheses 7a and 7b likewise produced no statistically significant results, with one model (.reg3) finding the coefficient within a zero-spanning CI.

Hypothesis 8a, 8b, 9a and 9b

Hypotheses 8 and 9 examined how stock ownership affected search. I found strong results (significant at the .01 level) in the .reg3 model for hypothesis 8a, in which I argued that less stock ownership by the CEO would encourage greater risk taking and facilitate more exploratory search. The .xtivreg did not produce statistically significant results, however. For hypothesis 8b, I also found significant results (at the .05 level) in the .reg3 model and a coefficient within the zero-spanning CI for the .xtivreg model. I found no significant results for either hypotheses 9a or 9b, in which I argued that greater stock ownership by the TMT (minus the CEO) would encourage greater risk taking and encourage more exploratory search. I did find coefficients within zero-spanning CIs in both models in partial (though perhaps poor) support of both hypothesis 9a and 9b.

Post-Hoc Analysis

Given the very few statistically significant results, I wanted to further analyze the data to try and determine what the cause might be. My chief suspicion was based on observations of the pharmaceutical industry in which there seem to be a few large firms and many small ones. If there was somewhat of a clear distinction between the large and small firms, then examining them altogether may obscure the results that either large or small sets of firms might otherwise reveal. Thus, I examined the panels to see if there was such a clean break between large and small firms.

Total assets and total patent applications seemed like two likely variables that would show a clear distinction between the relative size and patenting power of the firms. To look at the impact of the large firms over the entire data sets, I summed the total assets and total patent applications, per firm, over the entire ten panels, took the log of those numbers and then calculated the Z-score of each.

The rank ordering of these scores showed a reasonable distinction between small and large firms, with a few firms somewhat in the middle. The six largest firms (Merck, Pfizer, Bristol-Myers, Eli Lilly, Wyeth and Abbott (in descending order)) all had Z-scores above 1 for both assets and total patent applications. Conversely, the numerous small firms all had negative Z-scores for both of those variables. Four firms were in the middle. Isis and Allergan had positive total patent applications but negative asset values. Warner-Lambert and Schering-Plough both had positive total patent application and total asset scores between 0 and 1. This rough estimate suggests that the six firms with assets and total patents above 1 may be the "big" firms in the pharmaceutical industry, Schering-Plough, Isis, Allergan and Warner-Lambert are (or were) medium-sized players and all the other firms are small firms.

For purposes of initial post-hoc investigation, I looked at the large firms and the small firms to see what differences would arise, if any (ignoring the "middle" firms for now). The full model using the .reg3 command for the six large firms is immediately below in Table 4.15 (the .xtivreg model was also examined and the results were similar, except that the .xtivreg model had slightly fewer significant relationships). The full model, also using the .reg3 command for the smaller firms is presented below that in Table 4.16. Below, Table 4.17, summarizes the relationships for both the "large" and "small" firms. The findings from this post-hoc analysis are discussed in the Chapter Five, along with the discussion of the results from the full sample.

Table 4.15

reg3	"Large" firms		
DV: Exploratory Search			
	Main Effects: Full	Conf for Full	Interval Model
Controls:			
R&D intensity (log)	0.017	0.001	0.034
Capital structure (log)	0.061 t	-0.007	0.130
Tobin's Q (log)	0.000	-0.022	0.022
TMT Size	-0.006	-0.017	0.006
Prior patents (log)	-0.011 t	-0.024	0.002
1994	0.070*	0.010	0.126
1995	0.044**	0.013	0.076
1996	0.030 t	-0.001	0.062
1997	0.040**	0.009	0.071
1998	0.036**	0.010	0.062
1999	0.010	-0.006	0.027
2001	0.028*	-0.001	0.058
2002	0.016	-0.022	0.054
2003	-0.012	-0.042	0.018
Independent Variables:			
Available slack (log)	0.005	-0.012	0.023
Actual-to-aspired performance (constant + sq rt)	0.131**	0.035	0.227
CEO Age	0.002**	0.001	0.003
Short-term disparity	-0.010	-0.025	0.005
Long-term disparity (constant + log)	0.055*	0.008	0.103
CEO short-term ratio	0.145 t	-0.010	0.301
TMT short-term ratio	0.041	-0.011	0.094
CEO equity (log)	-0.018**	-0.025	-0.012
TMT equity (log)	0.005	0.002	0.009
Model Statistics:			
R Square	.747**		
Chi-Sq	162.500		

reg3	"Large" firms		
DV: Exploitative Search			
	Main Effects: Full	Conf for Full	Interval Model
Controls:			
R&D intensity (log)	0.067	-0.029	0.162
Capital structure (log)	0.258	-0.141	0.657
Tobin's Q (log)	-0.058	-0.186	0.071
TMT Size	0.067*	0.001	0.133
Prior patents (log)	-0.024	-0.099	0.051
1994	-0.332*	-0.670	0.005
1995	-0.167 t	-0.347	0.013
1996	-0.146	-0.331	0.038
1997	-0.117	-0.297	0.062
1998	-0.073	-0.226	0.080
1999	-0.003	-0.099	0.093
2001	-0.082	-0.252	0.088
2002	-0.199 t	-0.419	0.020
2003	-0.297**	-0.470	-0.123
Independent Variables:			
Available slack (log)	0.158**	0.056	0.261
Actual-to-aspired performance (constant + sq rt)	-0.321	-0.878	0.237
CEO Age	0.002	-0.003	0.008
Short-term disparity	0.107**	0.020	0.195
Long-term disparity (constant + log)	-0.364**	-0.640	-0.088
CEO short-term ratio	-1.208**	-2.109	-0.307
TMT short-term ratio	0.382**	0.078	0.685
CEO equity (log)	-0.012	-0.051	0.027
TMT equity (log)	0.006	-0.016	0.028
Model Statistics:			
R Square	.603**		
Wald Chi-Sq	83.480		

Table 4.16

reg3	"Small" Firms		
DV: Exploratory Search			
	Main Effects: Full	Conf for Full	Interval Model
Controls:			
R&D intensity (log)	-0.003	-0.021	0.014
Capital structure (log)	-0.004	-0.024	0.017
Tobin's Q (log)	-0.006	-0.028	0.016
TMT Size	0.009	-0.005	0.023
Prior patents (log)	-0.050**	-0.060	-0.041
1994	-0.045	-0.165	0.074
1995	-0.015	-0.080	0.050
1996	-0.017	-0.059	0.025
1997	-0.016	-0.058	0.025
1998	0.003	-0.047	0.053
1999	-0.001	-0.043	0.041
2001	-0.045*	-0.084	-0.006
2002	-0.049*	-0.094	-0.004
2003	-0.074**	-0.119	-0.030
Independent Variables:			
Available slack (log)	0.015*	0.000	0.030
Actual-to-aspired performance (constant + sq rt)	-0.012	-0.040	0.017
CEO Age	0.001 t	0.000	0.003
Short-term disparity	0.006	-0.012	0.024
Long-term disparity (constant + log)	0.008	-0.023	0.040
CEO short-term ratio	0.005	-0.087	0.097
TMT short-term ratio	-0.030	-0.125	0.065
CEO equity (log)	-0.009	-0.015	-0.003
TMT equity (log)	0.005 t	-0.001	0.011
Model Statistics:			
R Square	.350**		
Chi-Sq	175.680		

reg3	"Small" Firms		
DV: Exploitative Search			
	Main Effects: Full	Conf for Full	Interval Model
Controls:			
R&D intensity (log)	-0.013	-0.051	0.025
Capital structure (log)	0.001	-0.044	0.045
Tobin's Q (log)	0.046*	-0.002	0.094
TMT Size	-0.014	-0.045	0.016
Prior patents (log)	0.062**	0.040	0.083
1994	0.000	-0.262	0.263
1995	0.004	-0.139	0.147
1996	0.005	-0.088	0.097
1997	0.013	-0.078	0.104
1998	0.033	-0.077	0.142
1999	0.012	-0.080	0.105
2001	0.021	-0.065	0.107
2002	0.008	-0.090	0.107
2003	-0.055	-0.154	0.043
Independent Variables:			
Available slack (log)	0.030 t	-0.003	0.064
Actual-to-aspired performance (constant + sq rt)	-0.013	-0.075	0.049
CEO Age	0.006**	-0.010	-0.002
Short-term disparity	0.003	-0.038	0.043
Long-term disparity (constant + log)	0.019	-0.050	0.088
CEO short-term ratio	0.061	-0.142	0.263
TMT short-term ratio	0.044	-0.164	0.253
CEO equity (log)	0.005	-0.008	0.017
TMT equity (log)	0.002	-0.011	0.016
Model Statistics:			
R Square	.175**		
Wald Chi-Sq	69.370		

Table 4.17

Summary of Post-Hoc Analysis Results for... Hypothesis (with brief summary)	**"Large" Firms Reg3 Model**	**"Small" Firms Reg3 Model**
1a (greater performance shortfall, more exploration)	**0.01**	NS
1b (greater performance shortfall, less exploitation)	NS	NS
2a (more slack, more exploration)	NS	**.05 (opp)**
2b (less slack, more exploitation)	**0.01**	**0.01**
3a (higher age, less exploration)	**.01 (opp)**	**0.10 (opp)**
3b (higher age, more exploitation)	NS	**0.01 (opp)**
4a (greater short-term disparity, less exploration)	NS	NS
4b (greater short-term disparity, more exploitation)	**0.01**	NS
5a (greater long-term disparity, less exploration)	**0.05 (opp)**	NS
5b (greater long-term disparity, more exploitation)	**0.01 (opp)**	NS
6a (higher CEO current ratio, less exploration)	**0.10 (opp)**	NS
6b (higher CEO current ratio, more exploitation)	**0.01 (opp)**	NS
7a (lower TMT current ratio, more exploration)	NS	NS
7b (higher TMT current ratio, more exploitation)	**0.01 (opp)**	NS
8a (more CEO equity, less exploration)	**0.01**	NS
8b (more CEO equity, more exploitation)	NS	NS
9a (more TMT equity, less exploration)	NS	**0.10**
9b (more TMT equity, more exploitation)	NS	NS

CHAPTER FIVE:

DISCUSSION AND CONCLUSION

In this dissertation, I sought to examine the drivers of exploratory and exploitative search. Beginning with the behavioral theory of the firm (Cyert and March, 1963), I investigated how exploration and exploitation were driven by financial slack and problemistic search. Also, realizing that it is the individuals within firms that ultimately determine the search behaviors in which firms engage, I explored how demographic characteristics and compensation of top management team members influenced search behaviors.

The driving force behind this dissertation was the recognition that "search" is not the uni-dimensional construct it has typically been associated with, but is rather a bi-dimensional construct that requires a more fine-grained analysis. More specifically, prior research has frequently looked at how slack, problems and executive demographics and compensation have affected search in a broad sense (usually by looking at R&D or patenting intensity) (e.g., Cohen and Levinthal, 1989). However, given that search can be categorized along lines such as broad or narrow, deep or shallow or near or far (Ahuja and Lampert, 2001; Katila and Ahuja, 2002), it was important to examine how these drivers affect each type of search differently. Some recent research has begun to make in-roads into this research, but much work remains to be done.

Thus, in this dissertation, I tested a number of hypotheses focused on predicting exploratory and exploitative search. My hypotheses and results, summarized in Table 4.14, were not well supported. In the .reg3 model, only 3 of my hypotheses were statistically significant in the direction I hypothesized (and one more was significant in the opposite direction). The .xtivreg model yielded even less supportive results. Given that the results were so poor, I conducted post-hoc analyses in which I split the largest firms out of the sample and re-ran two sets of analysis, one with the larger firms and the other with the smaller firms. For greater parsimony, the discussion of the results will incorporate a discussion of the full sample, as well as the larger and smaller firm samples.

Problem-Based Search

The first driver of search I examined was that of "problems." In this study, I operationalized "problems" as the degree to which firms failed to attain financial performance aspirations. The rationale of these hypotheses was that when firms are achieving close to their target financials goals, they will engage in exploitative search behaviors (since they seem to be doing satisfactorily). However, as performance worsens, there is a perceived need to search beyond usual sources of information and engage in exploratory search.

Despite these reasonable arguments, I did not find significant results for the hypotheses that problems firms faced affected the type of search in which they engaged. Since most of the smaller firms had negative performance and most of the larger firms had tremendously positively performance, this result is perhaps, in retrospect, not surprising. However, even after splitting out the large/small samples, the results were similarly non-significant. Only in the large firms did increasingly poor performance lead to greater exploratory search. One possible explanation for these findings is that the calculation for the *Aspiration Level* for the large and small firms is still calculated based on all of the firms. A next step to take would be to recalculate *Aspiration Level* only for the firms of the same size and reanalyze the data.

Slack-Based Search

I also looked at how slack affected the type of search in which firms engaged. The arguments here were that at low levels of slack, firms would prefer to engage in the types of search they had previously engaged in to make the best use of their slack resources. As slack increased, they would be able to take more risks and engage in more exploratory search. As with the problem-based search, I found no significant results for slack-based search in the full model.

In the large/small analyses, however, some significant findings were found. In both large and small firms, exploitative search increases with greater financial slack resources, as hypothesized. Additionally, exploratory search was shown to be positively affected by financial slack resources. While these results could be encouraging when looked at individually, their meaning is somewhat watered down when looked at as a whole. The results could lend some support to my hypotheses, but could just as well reflect the notion that firms with greater financial slack resources engage in *more* overall search than firms with less financial slack resources. Thus, the ultimate implication of these findings is, as yet, undetermined.

TMT Demography, Compensation and Ownership

These first two groups of hypotheses attempted to explore firm-level characteristics of search drivers and almost no significant results were found. I next built upon the notion that it is not firms *per se* that engage in search behaviors, but rather executives in firms that lead and direct firms into which type of search behaviors they will engage. Recognizing this, I next looked at certain demographic characteristics and compensation characteristics of top executives within firms to see how those factors impacted search. Generally, similarly poor results were found, with but a few exceptions.

Demography

The only demographic characteristic I examined was *CEO Age*. I had originally planned to also include the ages of top managers but was unable to do so due to data limitations. Significant results were found for *CEO age* and search in the .reg3 model, though opposite to those hypothesized. Prior research suggests that as individuals (including CEOs) age, they become more conservative and less risk seeking (e.g., Child, 1974; Chown, 1960; Hambrick and Mason, 1984). Based on these results, I hypothesized that older CEOs would favor greater exploitation and less exploration – but found just the opposite. That is, I actually found that older executives tended to be engaged in more exploitation and younger executives in more exploration. While contrary to my stated hypotheses, this result has been found in other research as well (e.g., March and Sharpira, 1987). These findings were largely supported in the "large" and "small" samples, as well – the only hypotheses generally supported across all three samples.

These findings are consistent with other literature that makes a different argument than the one I adopted. This other research has argued that younger executives, instead of being more risk seeking, are actually greatly averse to taking risks because of inexperience and insecurity. Younger executives may be concerned that they do not have the ability to effectively manage broad reaching, bold new initiatives. Thus, they may seek to stick with what has been working to develop a strong track record and build a strong financial position for themselves, personally. In this case, then, younger executives favor exploitative search and only as they age, would they favor more exploratory search behaviors. My findings support this line of thought and may help add another lens to how age and search behaviors are related.

Compensation

Compensation Disparity

In addition to demographic characteristics, I also examined how compensation and equity ownership influence search behaviors. In the full sample and in the sample with smaller firms, no significant findings were found but in the sample with the large firms, 6 of the 8 hypotheses were significant. These results generally indicate that in large (but not in small) pharmaceutical companies that executive compensation influences the type of search behaviors in which executives engage. Why is this result seen in large firms but not small? Further study is required, to be sure, but one reason may be that large firms have sufficient resources to compensate executives to such a degree that the amount and type of compensation actually matters.

However, in the smaller firms, none of the compensation variables were significant. Thus, in small pharmaceutical firms, executive compensation did not appear to be driving search behaviors. That could be because the firm-level factors such as financial slack are too dominant of factors for small firms. Or, since compensation is typically lower at smaller firms, compensation may not be large enough to be sufficiently motivating to the executives. Whatever the reasons, in large firms, compensation does seem to make a difference (at least in the small sample I examined).

In the first set of hypotheses (4 and 5), I argued that compensation disparity between the CEO and the other TMT members would reduce collaboration and teamwork, which would put a damper on the search for new ideas, decreasing exploratory search. However, this compensation disparity would encourage executives to look out for their own interests, which would ultimately lead to exploitative search patterns. This line of reasoning was in keeping with prior research (Siegel and Hambrick, 2005); however, I found only partial support for it. For short-term pay disparity, greater disparity did lead to more exploitation but less disparity did not lead to more exploration.

Interestingly, for long-term pay disparity, I found significant results but in the opposite direction from that hypothesized. That is to say, greater long-term pay disparity was not associated with greater exploitation as prior theory would argue, but was, instead, associated with greater exploration. The converse was also true, that lower levels of disparity were associated with greater exploitation. These results may be telling us that as long-term pay disparity increases, executives are individually motivated to increase exploratory search to increase their odds of making a major breakthrough. But, perhaps, at lower levels of pay disparity, executives are equally motivated to work together to make sure they capitalize on their options, which leads to more exploitative search behaviors. These findings seem to contradict much of the current findings and, therefore, require further investigation.

Compensation Structure

Two sets of hypotheses examined the impact that compensation structure had on search behaviors. Specifically, I examined how the ratio of current salary to option compensation for CEOs and the other TMT members affected search. The basic logic was that current compensation (annual salary and bonus) would encourage a short-term focus by the executives and lead to exploitative search behaviors, whereas option-compensation would encourage a long-term focus and lead to exploratory search. Three of the four hypotheses were supported, but similar to the findings regarding compensation disparity, these results were all in the opposite direction from that hypothesized.

For both CEOs and TMT members, a higher ratio of option compensation to salary compensation led to greater exploitative search. For CEO (but not TMT) compensation, a higher ratio of current compensation led to more exploration. These results, though completely opposite to what I argued, are not beyond the scope of reason. Given the long lead time for products in this industry (10-16 years from patent application to prescription-drugs) (Gassmann *et al.*, 2004), executives are forced to have a long-term focus regardless of their compensation structure.

Borrowing my arguments regarding compensation disparity, it could be that executives with large option components want to make sure they keep their options. Since the industry is risky by nature, having a higher level of option compensation might actually encourage risk aversion in the executives. Bringing these ideas together, greater option compensation in a risky industry may encourage exploitative search among the executives. Continuing with this somewhat backwards rationale, a higher ratio of current compensation may lead executives to want to try and take more risks, to potentially earn greater options. Despite these plausible explanations, this reasoning seems somewhat tenuous and further research is required.

Equity Ownership

Previous arguments regarding equity ownership and top executives focused on the implications flowing from the alignment of interests between managers with those of owners (Berle Jr. and Means, 1932). It was argued that owners are typically more interested in the long-term success of the firm than in short-term gains, since they can diversify their risk portfolios by owning shares of numerous firms (Fama, 1980). Under this line of argument, then, increasing the equity ownership of executives would align their interests with those of owners and encourage more risk-seeking behaviors.

However, a new line of reasoning has re-examined these previous notions. Executives in firms already have a great deal of risk stemming from their employment risk, which cannot be diversified away. When this risk is coupled with the down-side risk of equity ownership, recent research has argued that increasing equity ownership actually works to reduce risk-seeking behaviors in executives and create more conservative tendencies. Thus, I argued that less equity ownership would be predictive of more exploration and more equity ownership would be predictive of more exploitation.

These results were present in the full sample for CEO equity ownership – but not for TMT equity ownership. In the sample of large firms, less CEO equity ownership did lead to more exploratory search (but more CEO equity ownership did not lead to more exploitative search). In the sample of small firms, CEO equity ownership was not associated with either type of search behavior, but less TMT equity ownership was associated with greater exploratory search. I was pleased to find that the results that were found related to these hypotheses were in the direction hypothesized. Somewhat comically though, these hypotheses were developed using the "alternate" logic which positioned them in contrast with typical arguments in prior work.

Non-Significant Findings

Overall, my dissertation has many more non-significant findings than significant ones. Given the large window of time examined and number of panels explored, these non-findings were somewhat surprising. There are several possible explanations for these non-findings which I will discuss next.

Explanations of Non Significant Findings

The Findings May Not Exist

First, the fact that most of the hypotheses were not supported may mean that the relationships I proposed simply do not exist. What drives firms to do the things that they do is not as simple as researchers might hope it is. I proposed numerous main effects and, given the various complexities involved in search behaviors, the phenomenon may not be that simply explained. There may be complex moderated or mediated relationships. There may be other drivers of search that I did not examine. Or, there could be other reasons still that account for these non-findings.

Theoretical Issues

Alternately, the relationships may exist after all, but the study may be flawed. There are competing theories on what drives search, and I may have sided with theories that are not as strong as the alternate theories. The discussion regarding executive age is a good example of how competing theories may account for some of the results.

Operationalization Issues

Or, if the theories are articulated correctly, it could be that the measures have been operationalized incorrectly. I measured exploration and exploitation based on patent citation counts, following Katila and Ahuja (2002). However, other work has explored different ways of measuring exploration and exploitation, such as the technological class in which patents are filed (Ahuja and Lampert, 2001). Thus, it could be that using alternate, or simply additional, measures would have enabled a more appropriate test of my hypotheses.

Separately, there could be a problem with the explore/exploit measure of Katila and Ahuja (2002). As currently calculated, there tends to be a bias against exploratory search, artificially lowering that value. For example, if a small firm used 10 new citations in a given year, its exploratory search score would be high if it filed very few patents. In contrast, a large firm that used 10 new citations but had filed thousands of patents would have a very low exploratory search score. Yet, is it accurate to infer that the large firm is that much less exploratory in its search behavior simply because it had much more "non-new" search as compared with the small firm? Perhaps, or perhaps not. Either way, this issue requires further examination.

Sample Issues

Another explanation for the non-findings may be that, given the disparity of the size of the firms, that the findings are cluttered. It was for this potential reason that I ran the post-hoc analysis in which I split the six largest firms from the smallest firms in the sample and re-ran the analysis. Additional post-hoc analysis may be appropriate to help further understand these findings.

Limitations

Generalizability

Every empirical study has limitations and this one is no exception. Since the study was conducted in a single industry, there are questions of generalizability. I have argued that a single industry examination was appropriate given the questions I was trying to answer, yet any significant findings that are ultimately found must be interpreted with some caution.

Alternate Explanations

Another limitation is that, even had significant results been found, I have not accounted for every possible alternate explanation. For example, boards of directors have an influence on setting executive compensation and have at least some influence on the strategic direction of firms. By not controlling for board effects, I have not ruled out the role that they may play. This may be worth examining in the future.

Alternate Conceptualizations

Along the lines of the previous limitation are that there are various ways to operationalize different constructs, but I have just chosen one way for each item. For example, I operationalized "problems" as being financial problems experienced when firms fall short of their financial aspirations. However, as I previously discussed, firms can certainly experience many other types of problems, particularly in the pharmaceutical industry. Lawsuits, failed clinical trials, competitor products – all of these issues that firms deal with are "problems" that firms face and could very well be more directly impactful on the search behaviors in which firms engage (i.e., than is failing to meet financial projections). Since I have only chosen one way to conceptualize this construct, I have not closed the door to the possibility that other operationalizations are more meaningful.

Future Directions

Further Post-Hoc Analysis

Given that no conclusive significant results were found, there are many future directions for this study. The immediate focus will be to continue to tease apart the sample into appropriate sub-samples (such as the large/small split) to give the data a chance to speak. There may be other effects such as the age of firms, or years since they went public, that may be playing into the results. Additionally, there are other measures of search that could be employed, some of those revolving around the technological class in which the patents are filed (e.g., Ahuja and Lampert, 2001). All of these avenues have potential for further digging into this data along the current trajectory.

Alternate Theory Consideration

Additionally, the large number of significant findings in the opposite direction from what I hypothesized deserves serious consideration. These results, taken as a whole, really tell quite a different picture about risk tolerance and risk preferences of executives than what has currently been articulated. It is possible that any number of mistakes on my part has generated erroneous results. However, if the study has been executed properly (as I believe it has been), then additional theoretical and empirical work is called for to further explore these results.

Acquisition Likelihood

Another extension seeks to capitalize on the large number of small firms present in the sample. One positive outcome for small, new firms, particularly in the bio-tech/ pharmaceutical industry is to be acquired by large, established pharmaceutical firms. Typically, such acquisitions are made at a premium and the founders and top managers tend to reap great financial benefits from the buy-out. One interesting angle in this vein of research might be to examine how the degree to which firms engage in exploration and exploitation lead to acquisition likelihood and the premium paid for such acquisition.

Searching and Finding

Another direct extension of this dissertation could be investigating the relationship between exploratory and exploitative *searching* with ultimate exploratory and exploitative "finding." Prior work involving exploration and exploitation has focused on categorizing end products as being either exploratory or exploitative in nature (e.g., He and Wong, 2004). This dissertation focused on drivers of exploratory and exploitative search behaviors.

A next step in this stream could be to look at the relationship between the search behaviors firms take and how those search behaviors translate into finished products. It is likely that exploratory search leads to products that are viewed as exploratory. However, it is also possible that as firms dig more deeply into areas of expertise, they are able to gain greater depth of understanding into the technologies they possess and truly make major breakthroughs in those areas of expertise.

Outcomes of Exploration and Exploitation

More distally related to this study could be work related to possible outcomes of focusing on exploration or exploitation. One pre-conception is that large pharmaceutical companies tend to not develop new, breakthrough drugs themselves, but rather acquire the companies that do. Thus, it may be that the small pharmaceutical firms that engage in exploration tend to be purchased, or purchased at a higher premium. On the other hand, given that small firms have limited resources, it may be that they have to focus on one core technology and exploit it to the best of their abilities to garner the interest of suitors. Or, following the ambidexterity hypothesis – that finding a balance between exploration and exploitation yields the greatest performance (He and Wong, 2004) – perhaps those small firms that are able to do both become the best acquisition targets. Whatever the case, such an examination seems interesting and warranted.

Exploration and Exploitation in Academia

Another interesting study, while moving away from the pharmaceutical industry, but building on the idea of examining citations to determine a level of exploration and exploitation, would explore the degree to which research professors explore new knowledge or exploit currently possessed knowledge. Recent work identified the most prolific authors in management (Podsakoff *et al.*, 2008). It might prove interesting to examine whether they have achieved such distinction through exploration, exploitation or both. Empirical tools of bibliometric analysis would be available to make such a determination (Ramos-Rodriguez and Ruiz-Navarro, 2004).

Conclusion

Over the past few decades, scores of articles have examined the risk preferences of firms and executives by employing coarse measures such as R&D expenditures or patenting propensity. To some degree, these measures capture the extent to which firms are searching for new knowledge. However, research utilizing measures such as these have left researchers with only a partial picture of what kind of knowledge these firms are seeking. Are their R&D dollars all being funneled into further refining products they have been selling for a generation? Or are they focusing their R&D budget on exploring new areas that could propel them *into* the next generation? Or some balance of both?

This research has sought to help address these questions by taking a more fine-grained approach as to why firms engage in search. I have endeavored to do this by analyzing the record contained in patent applications that documents the knowledge firms have relied upon in filing their patents. Utilizing measures developed by professors Katila and Ahuja (2002), I explored how problems, financial slack and TMT demographic characteristics and compensation systems influence the degree to which firms engage in exploratory and exploitative search.

While the results I have obtained have not shed much light on this subject yet, the groundwork has been laid to hopefully make contributions to theory, research and practice that are both interesting and practical. By seeking to supplement coarse-grained "R&D" and "patenting propensity" research with finer-grained measures such as I have done, I hope that future research can continue to make strides in painting a clearer picture of what drives search behaviors within firms.

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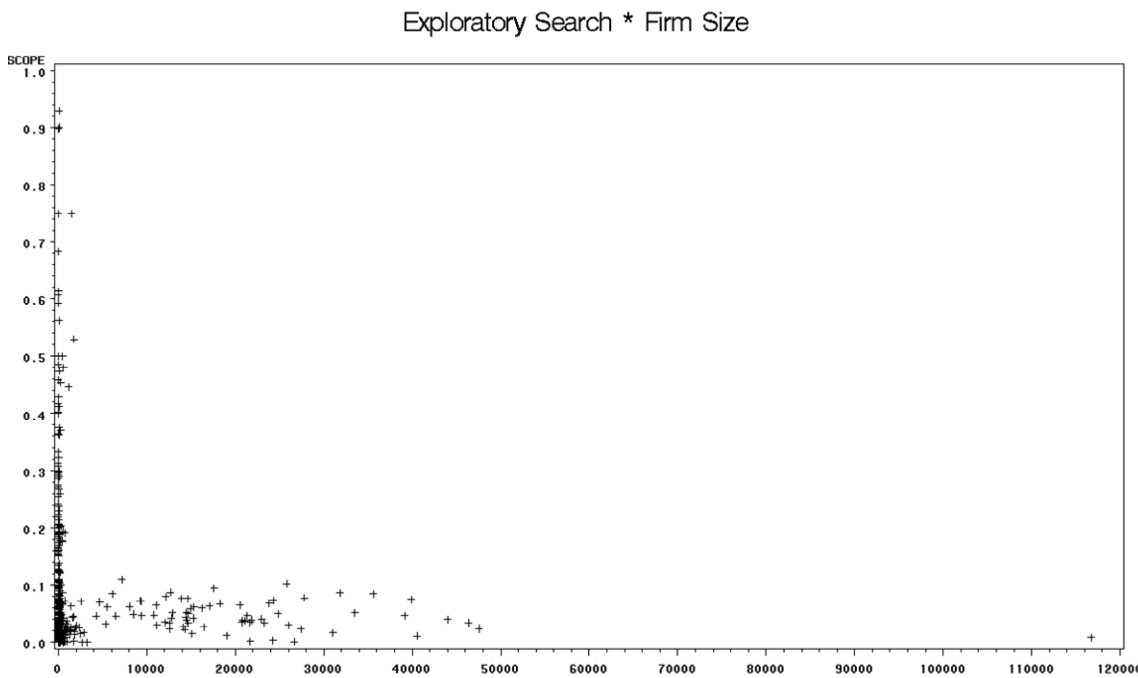
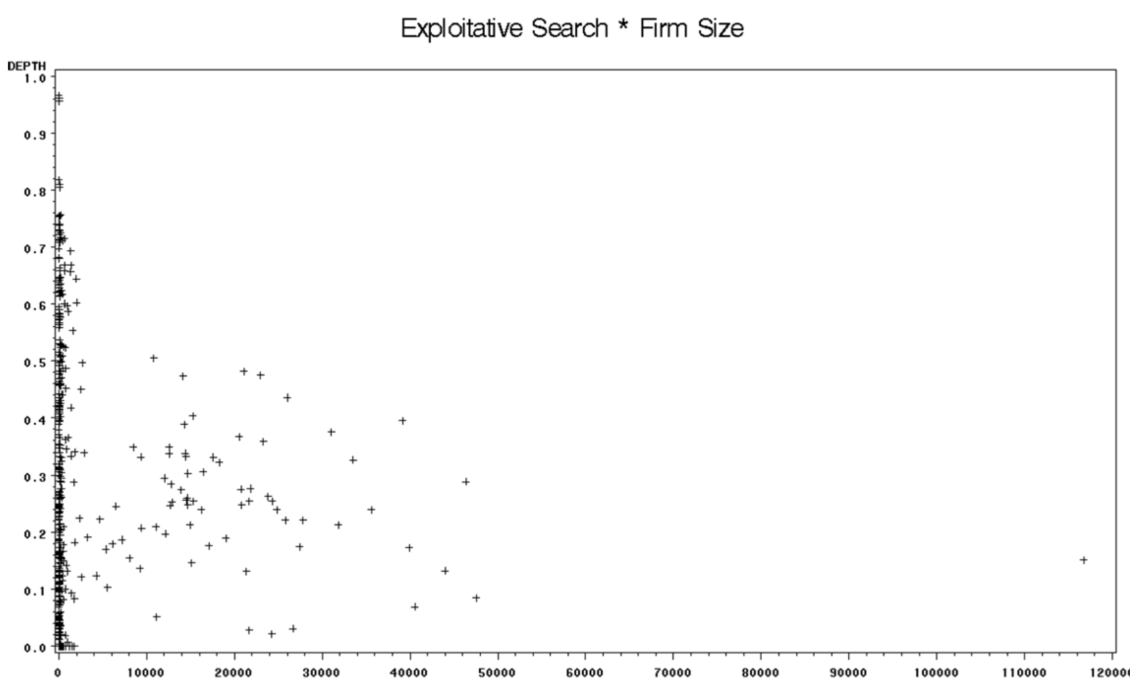
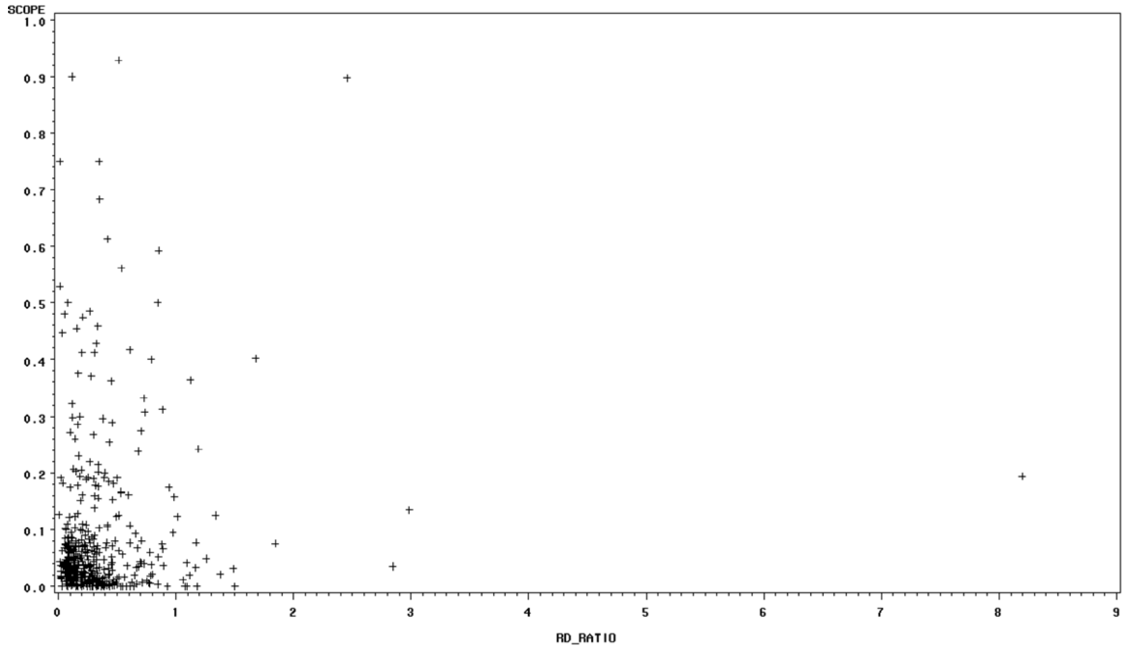
APPENDIX A:

PLOTS OF ALL INDEPENDENT AND CONTROL VARIABLES ON EXPLORATORY AND EXPLOITATIVE SEARCH

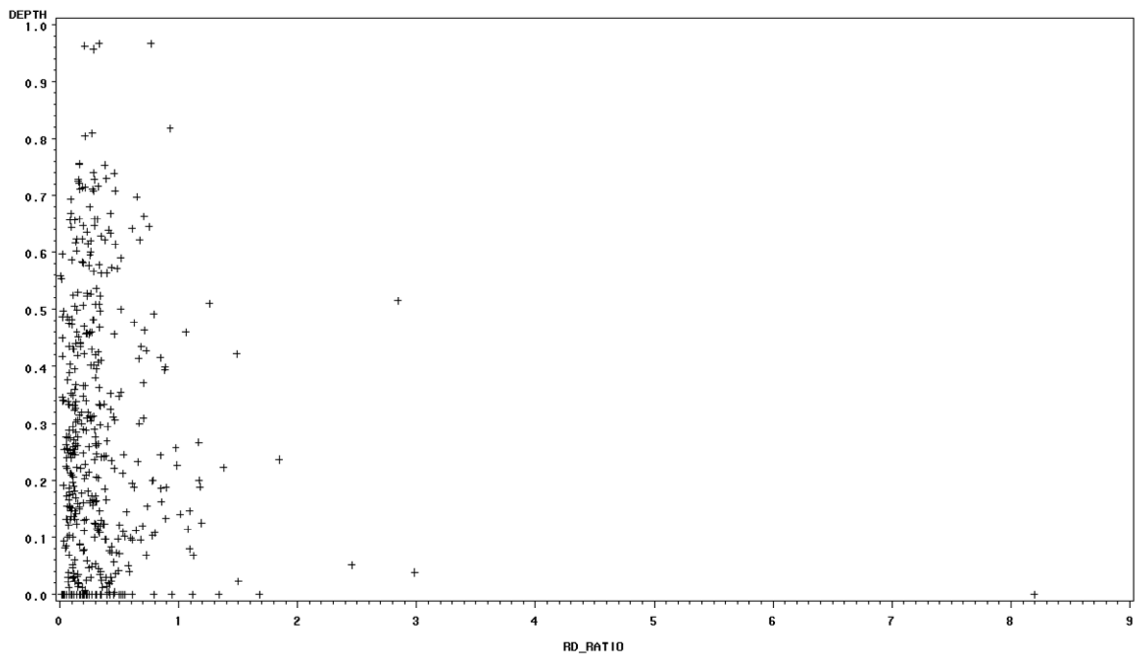




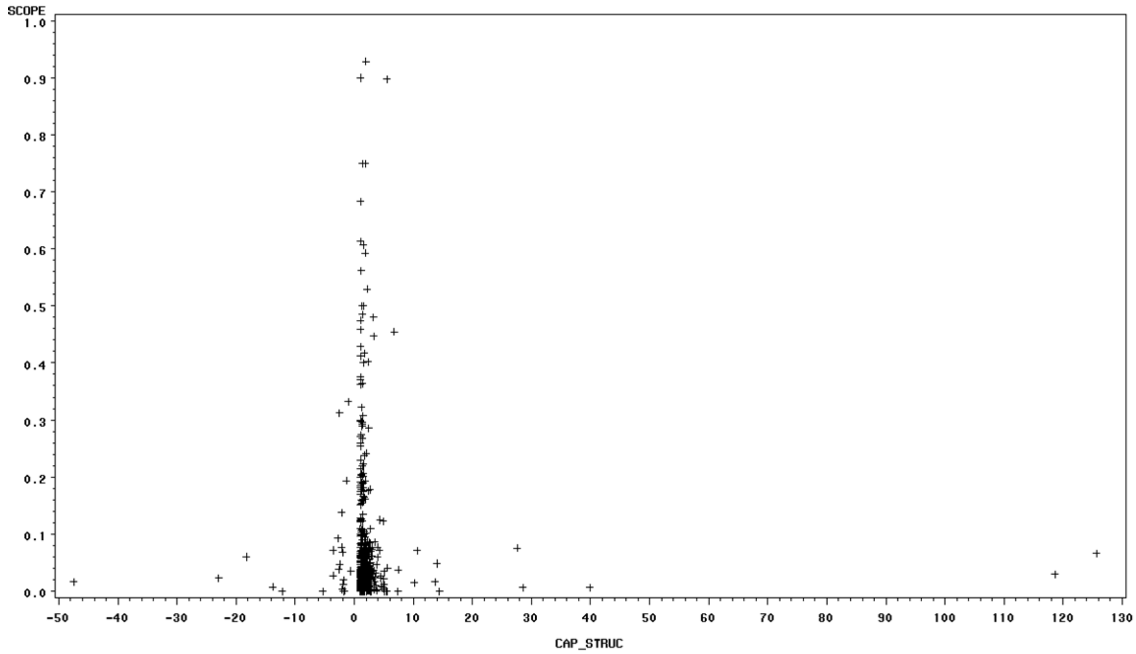
Exploratory Search * R&D intensity



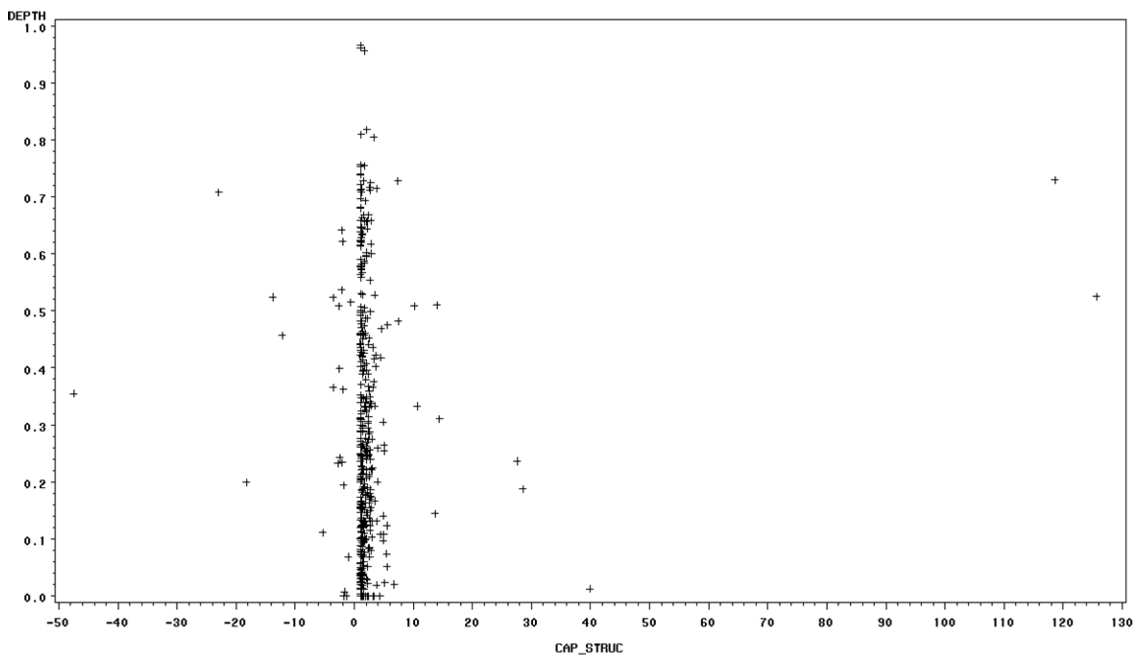
Exploitative Search * R&D intensity



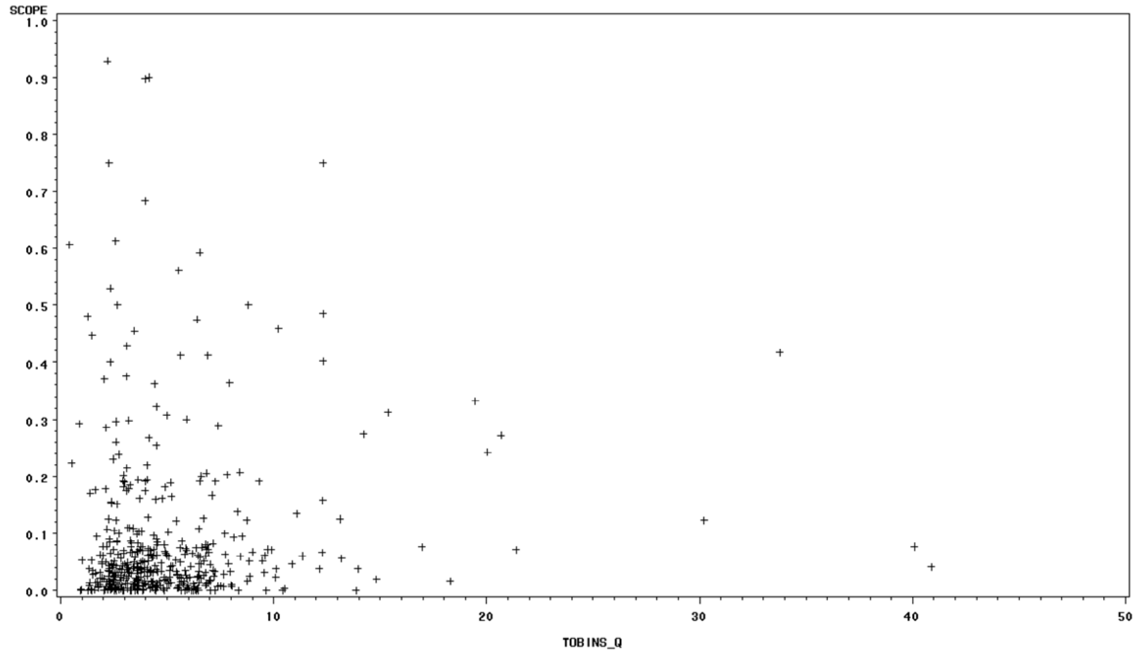
Exploratory Search * Capital Structure



Exploitative Search * Capital Structure



Exploratory Search * Tobins Q



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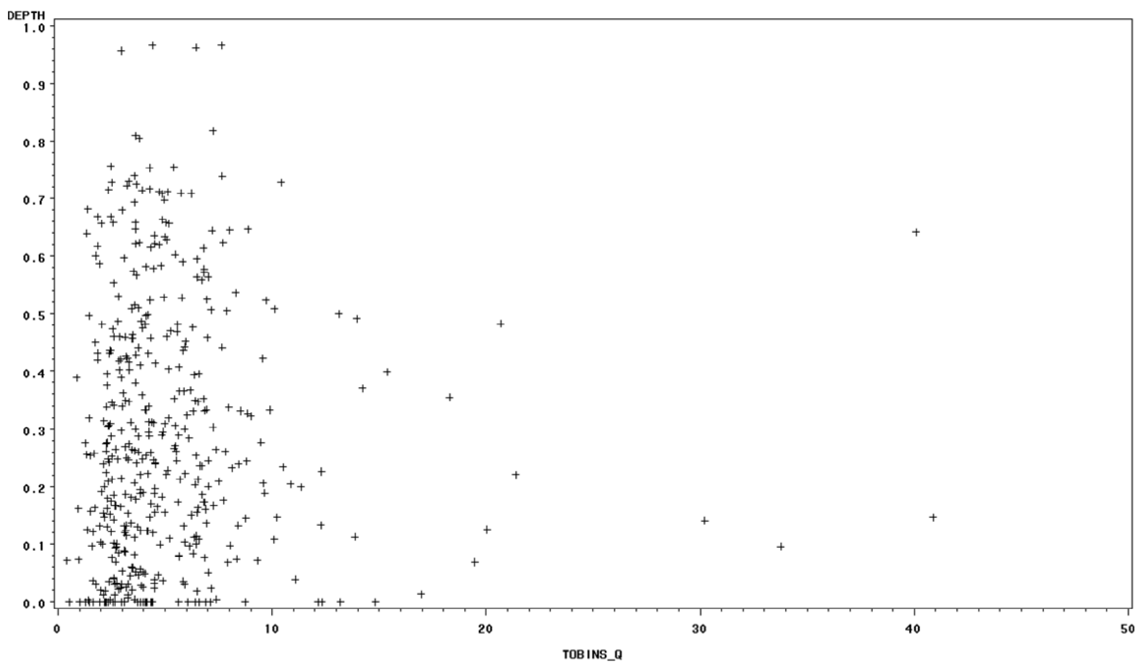
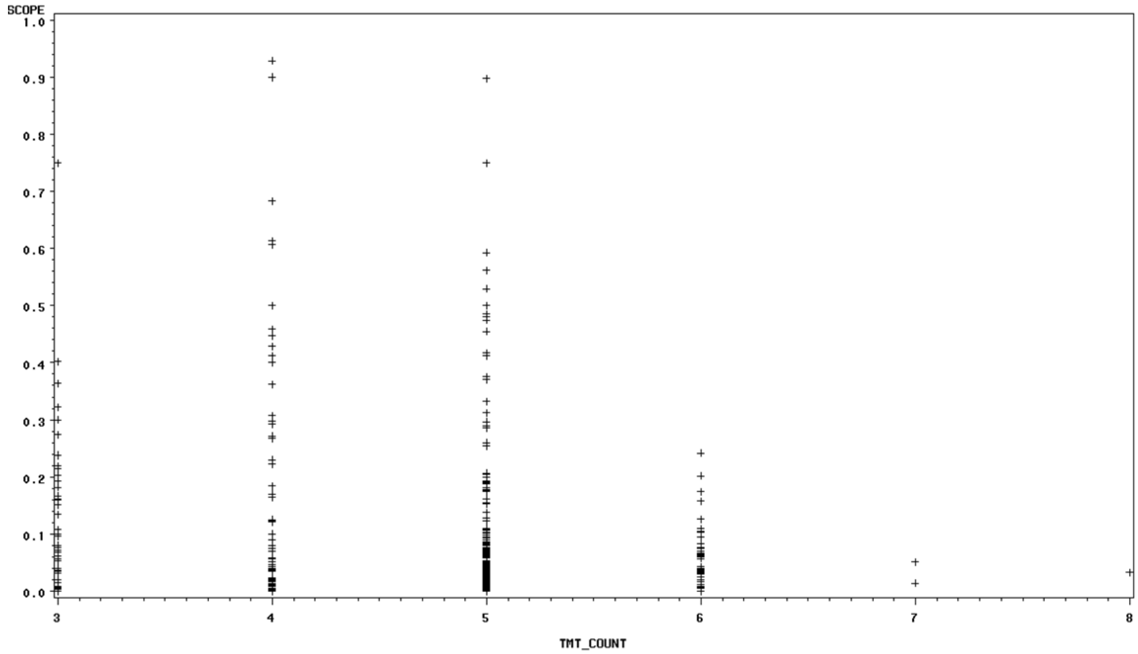


Exploratory Search * TMT Size



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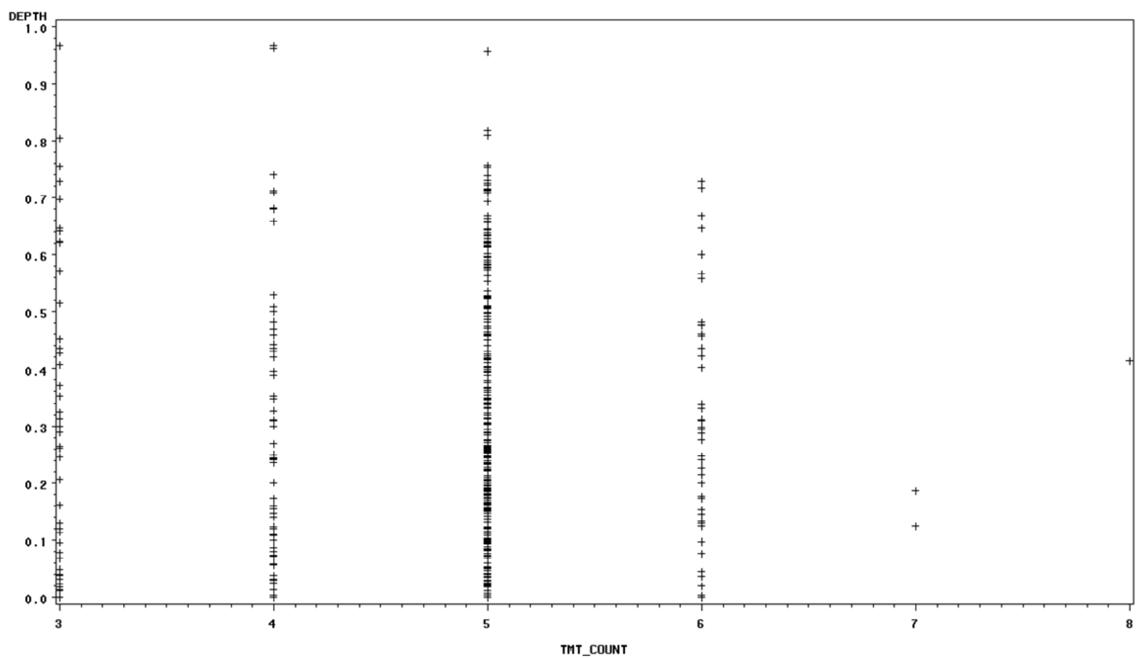
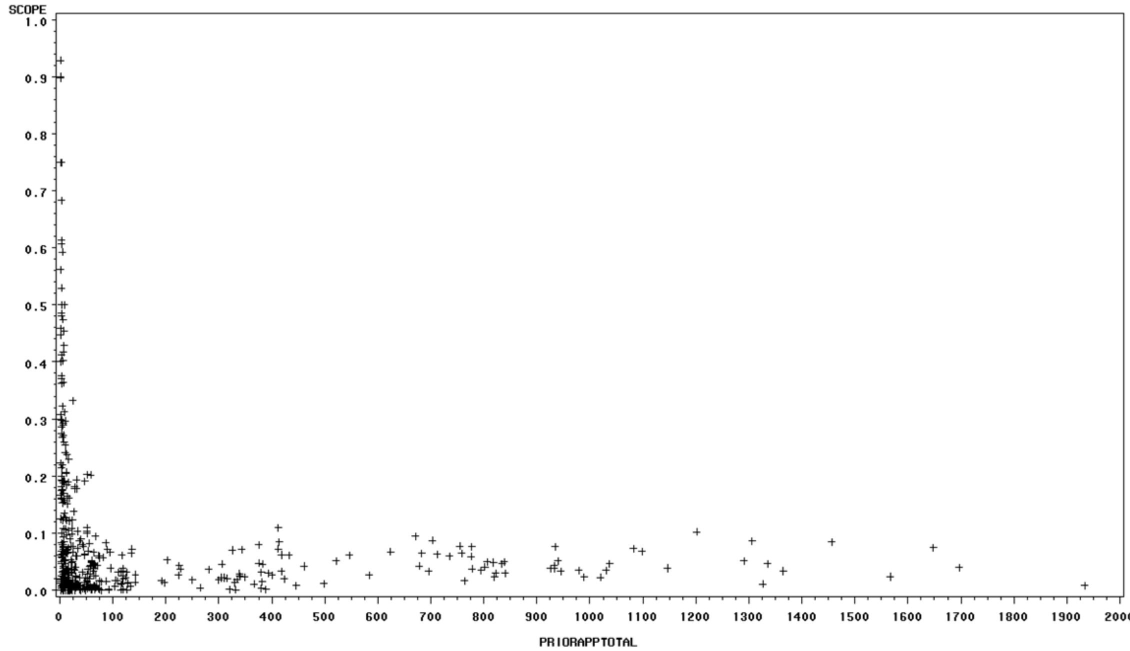
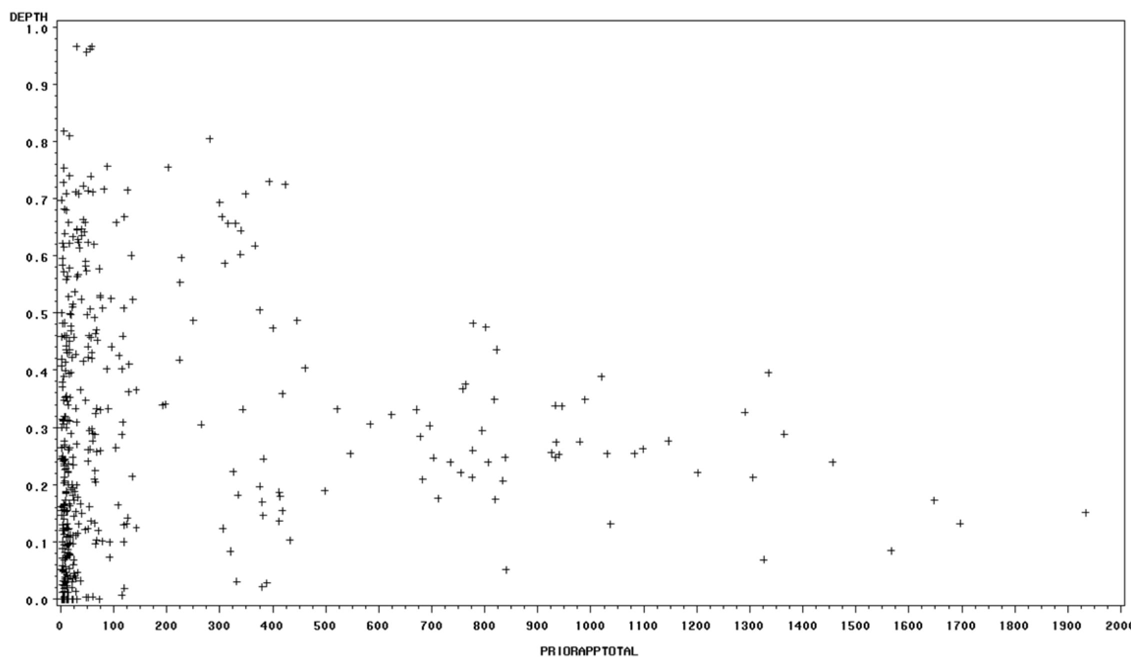


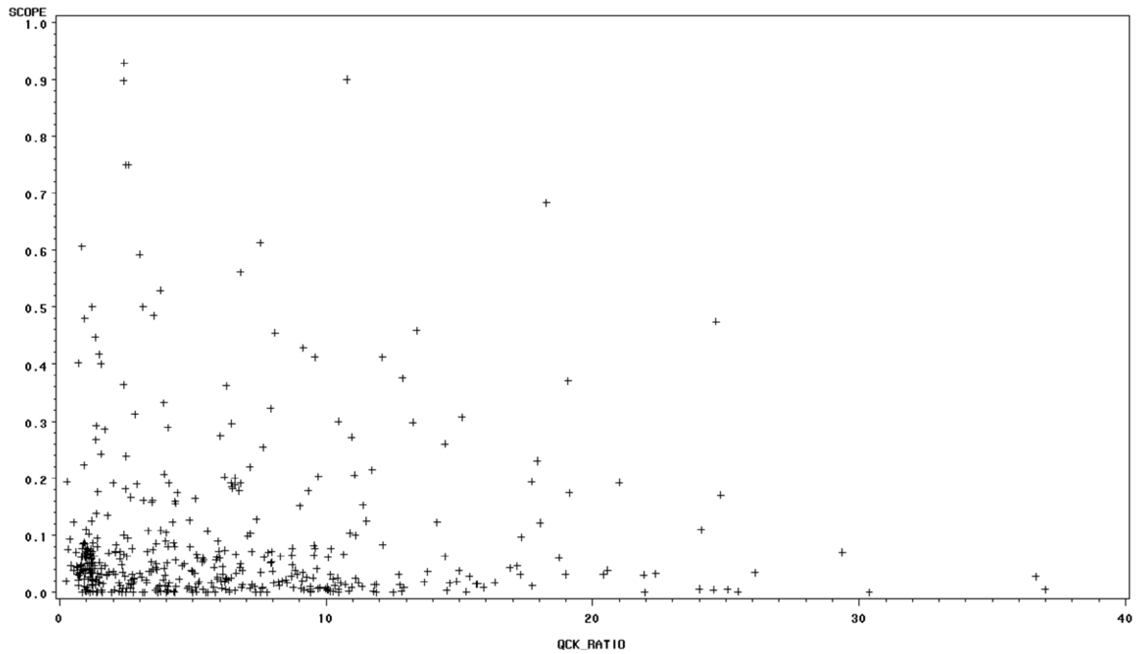
Exploratory Search * Prior Patents



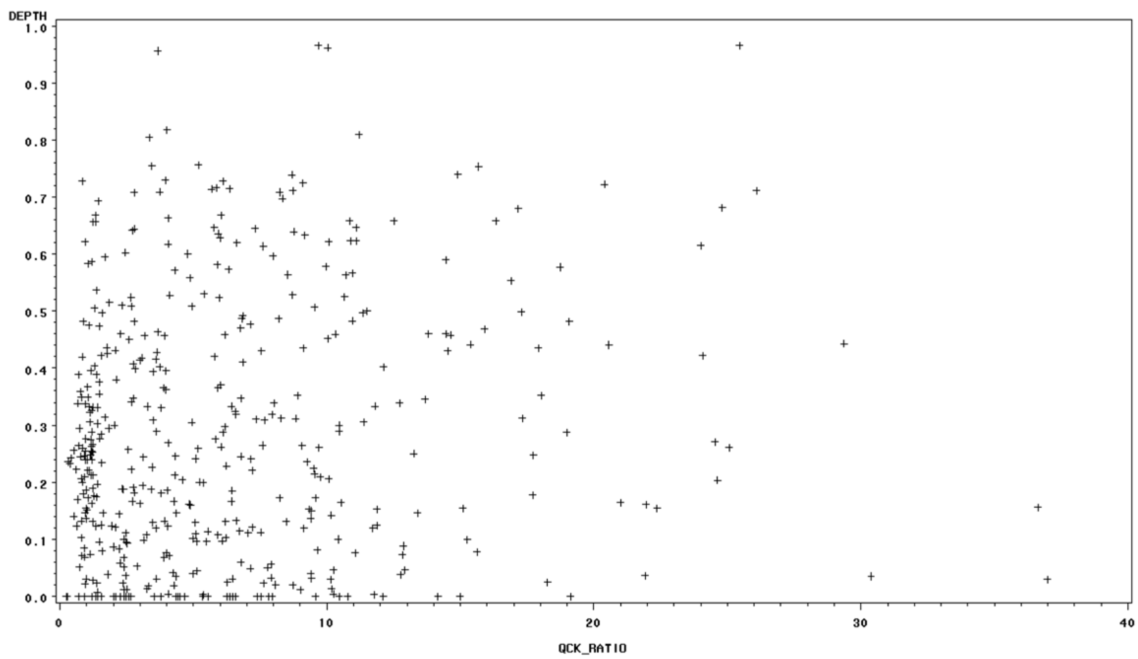
Exploitative Search * Prior Patents



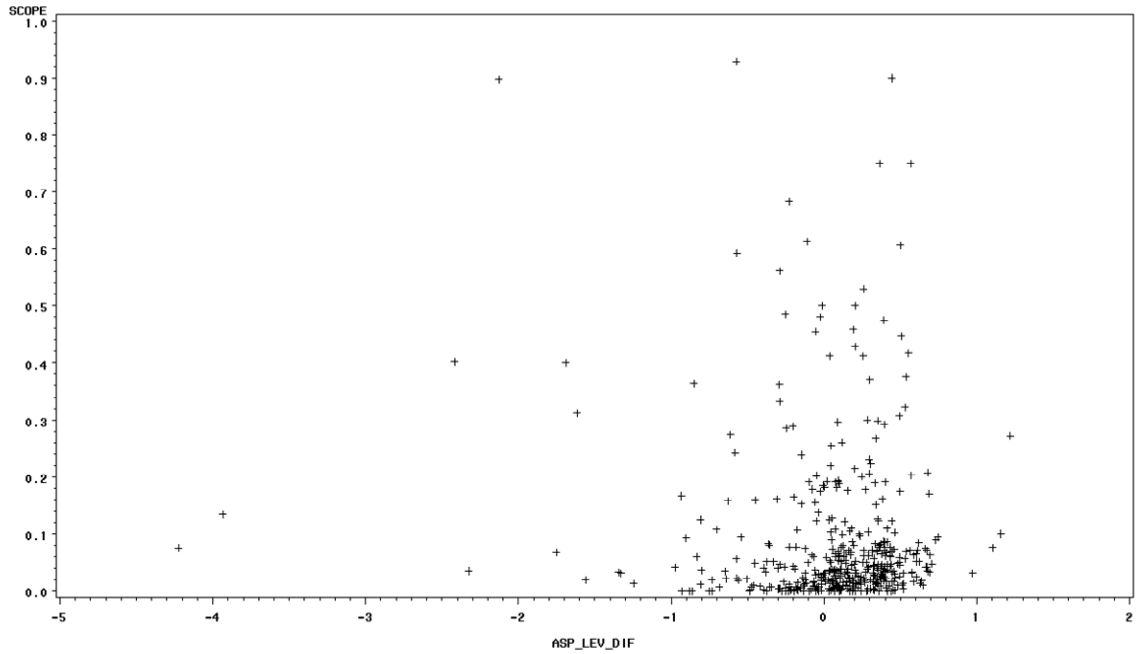
Exploratory Search * Available Slack



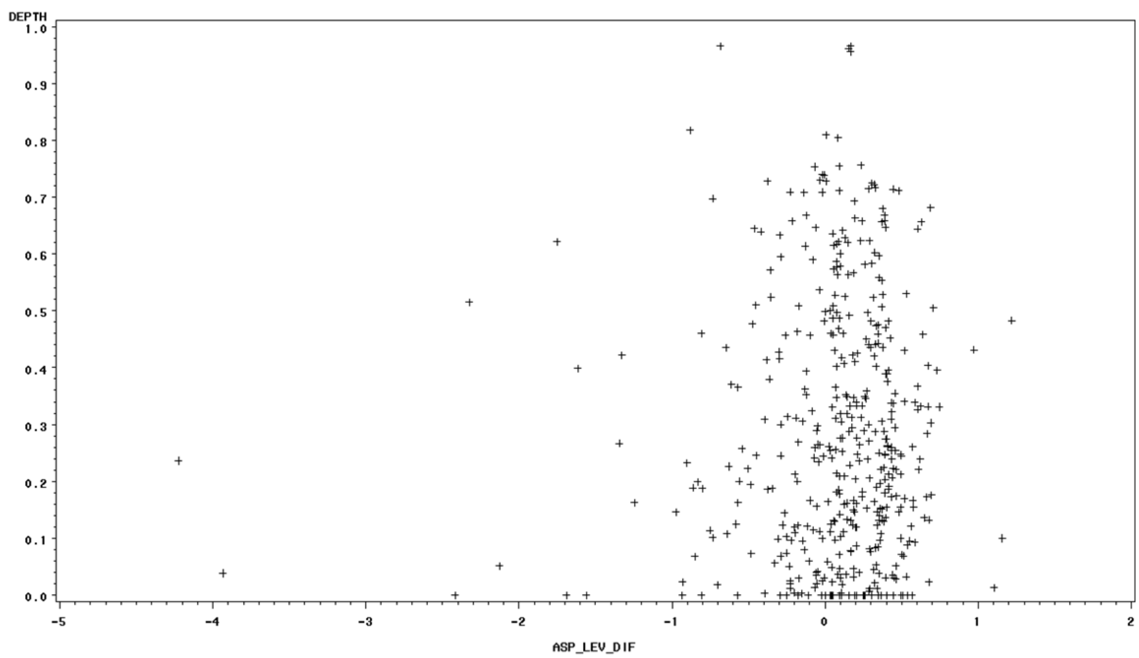
Exploitative Search * Available Slack



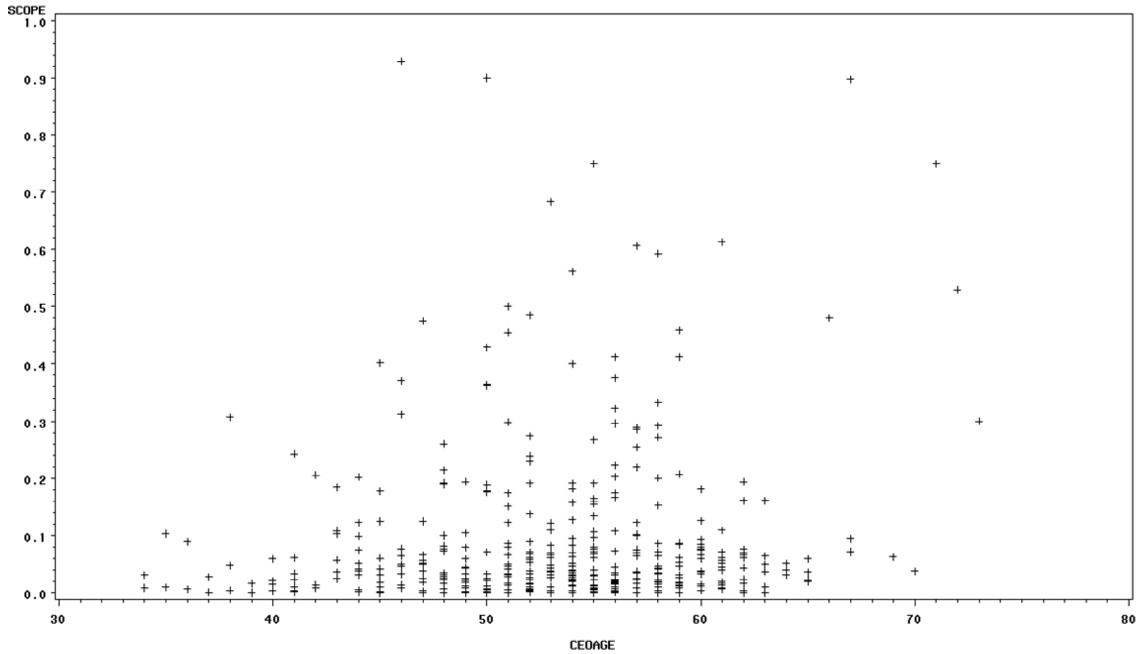
Exploratory Search * Actual–to–Aspired Performance



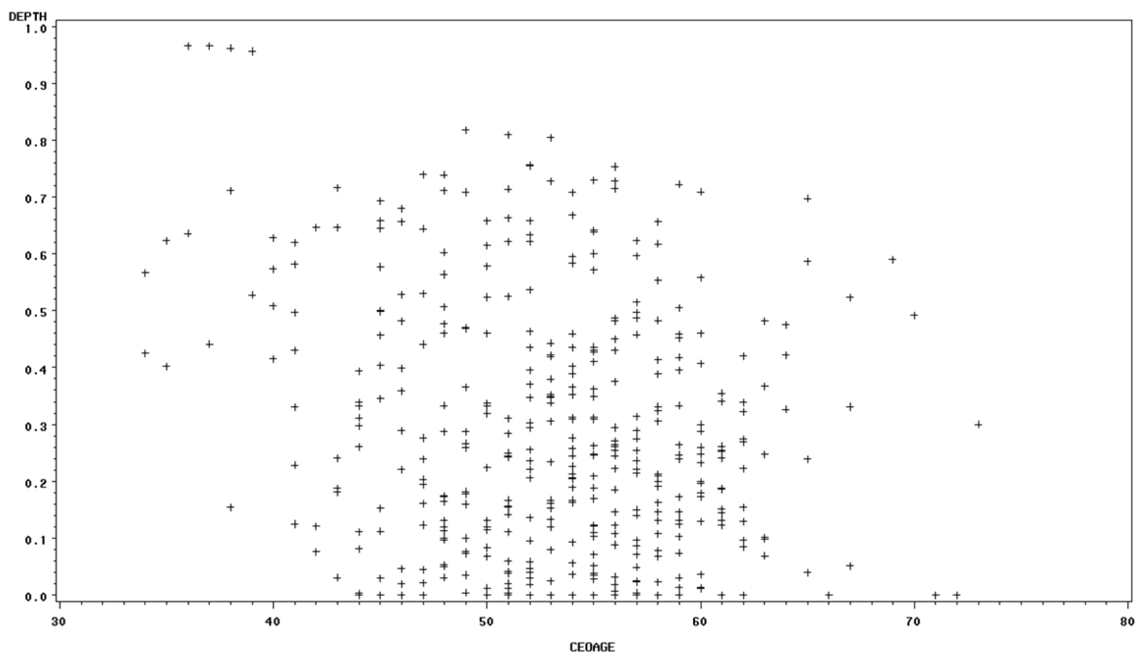
Exploitative Search * Actual–to–Aspired Performance



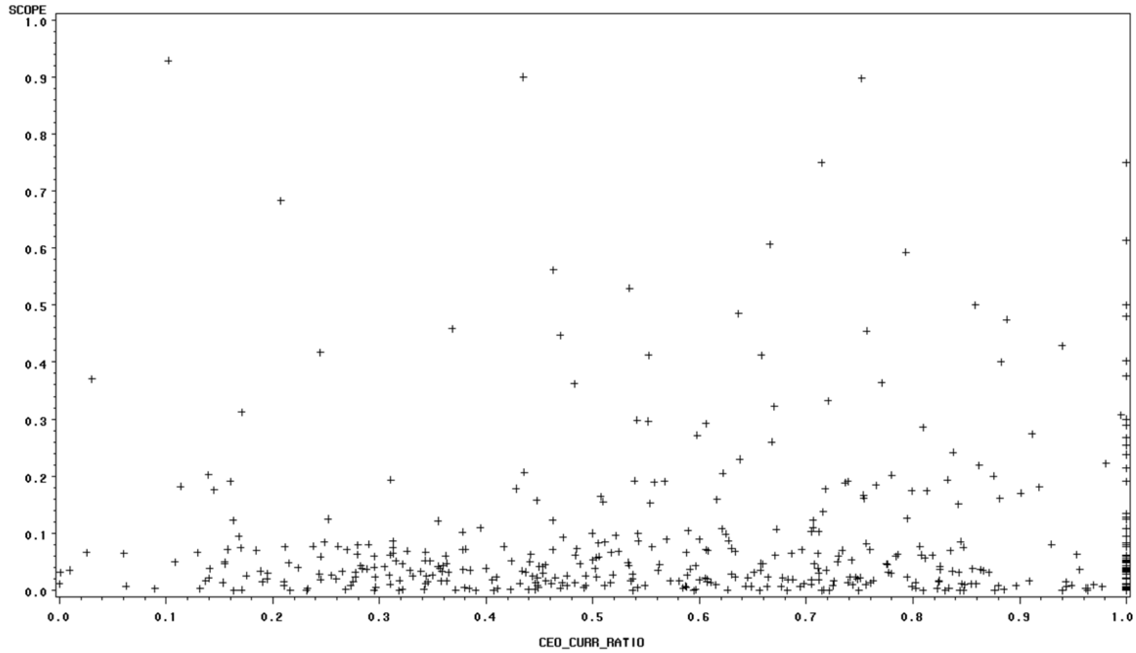
Exploratory Search * CEO Age



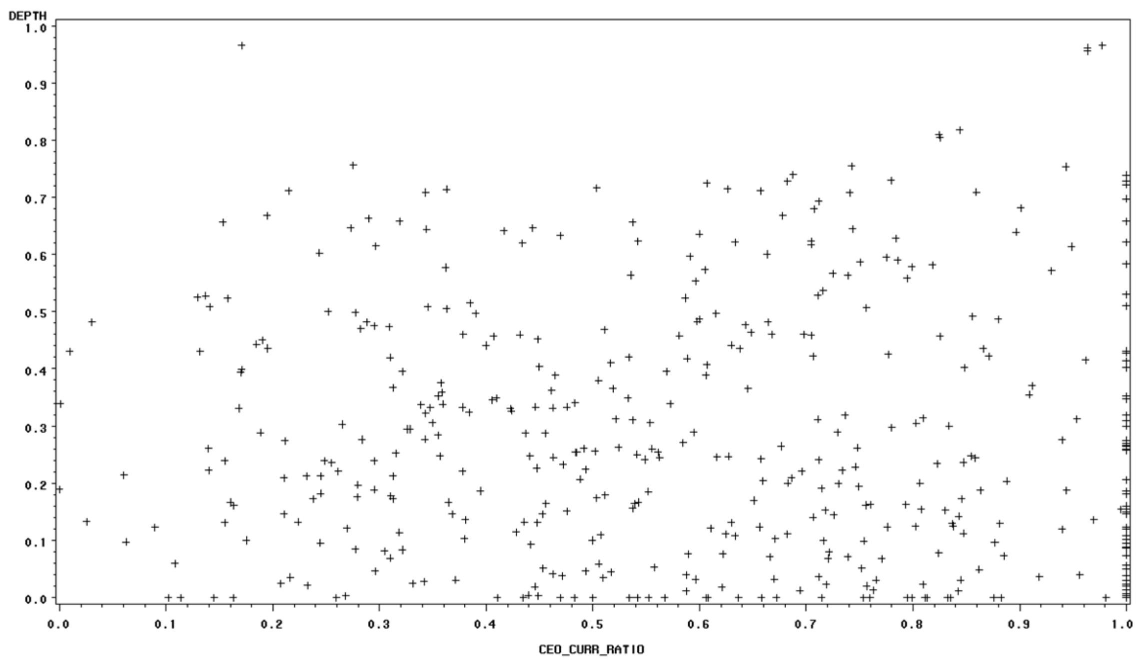
Exploitative Search * CEO Age



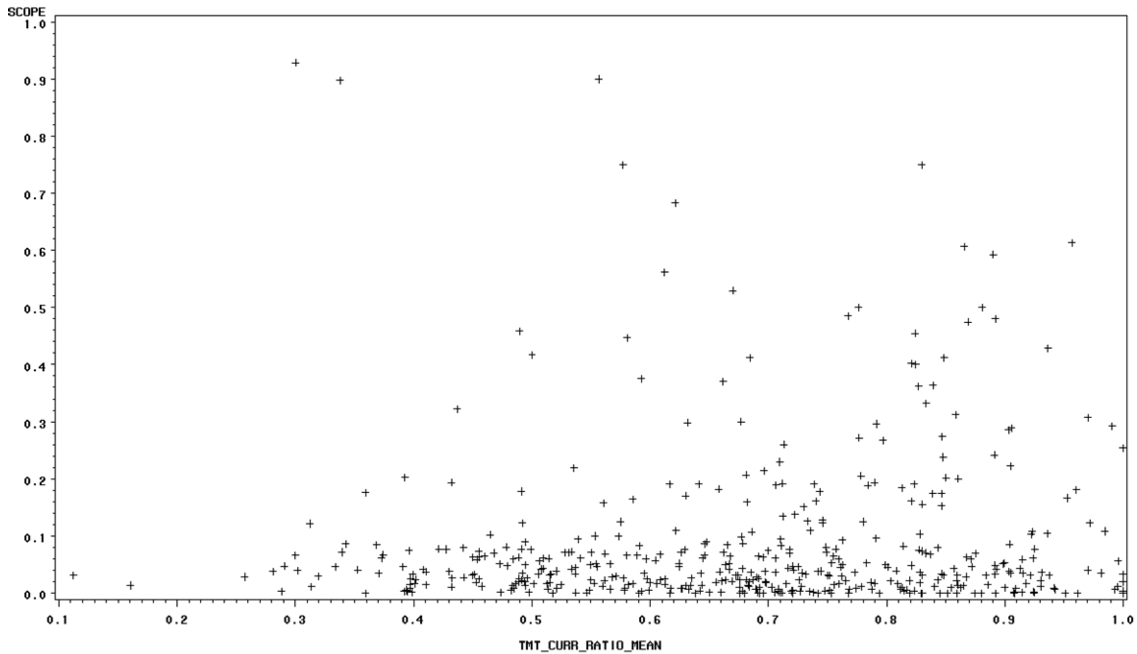
Exploratory Search * CEO Short–Term Ratio



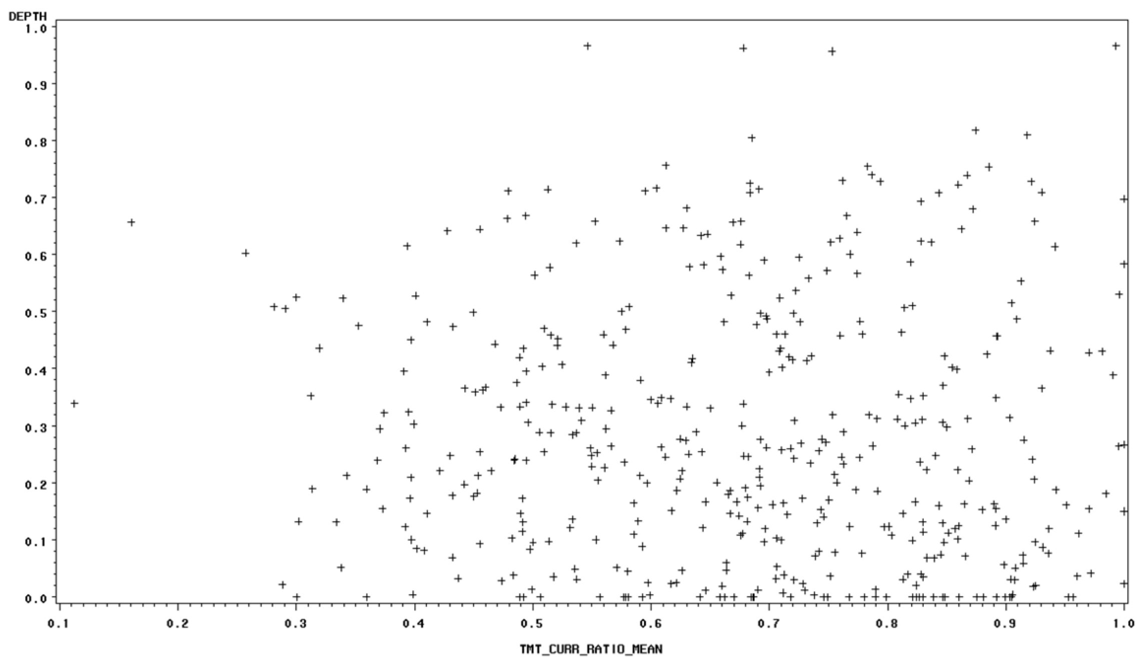
Exploitative Search * CEO Short–Term Ratio



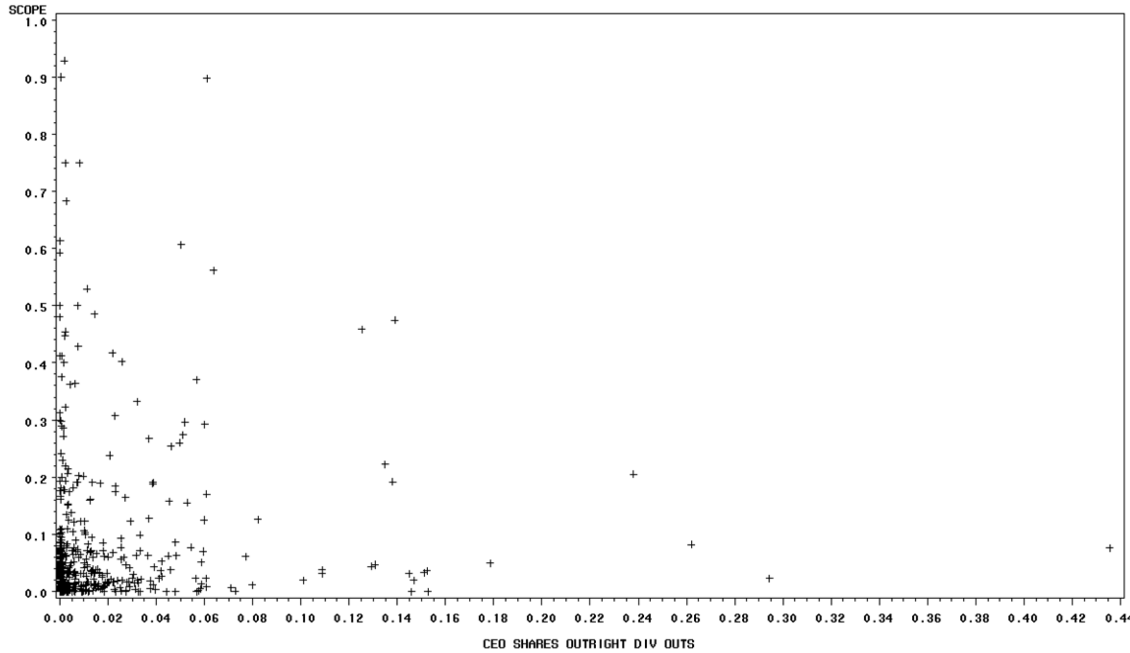
Exploratory Search * CEO Long–Term Ratio



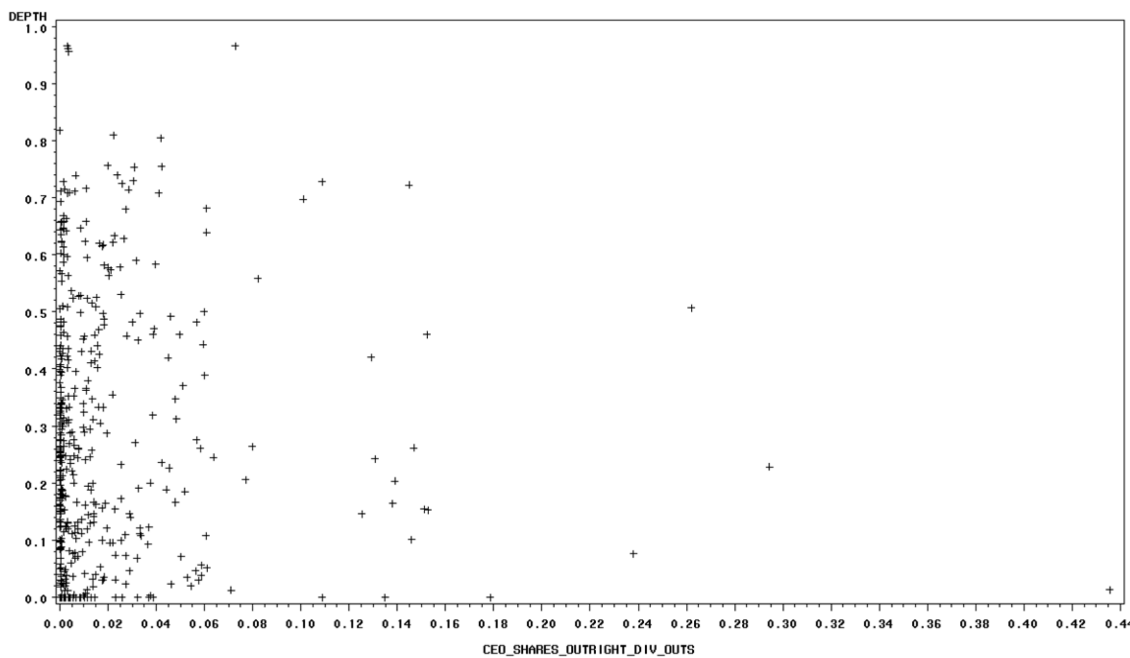
Exploitative Search * CEO Long–Term Ratio



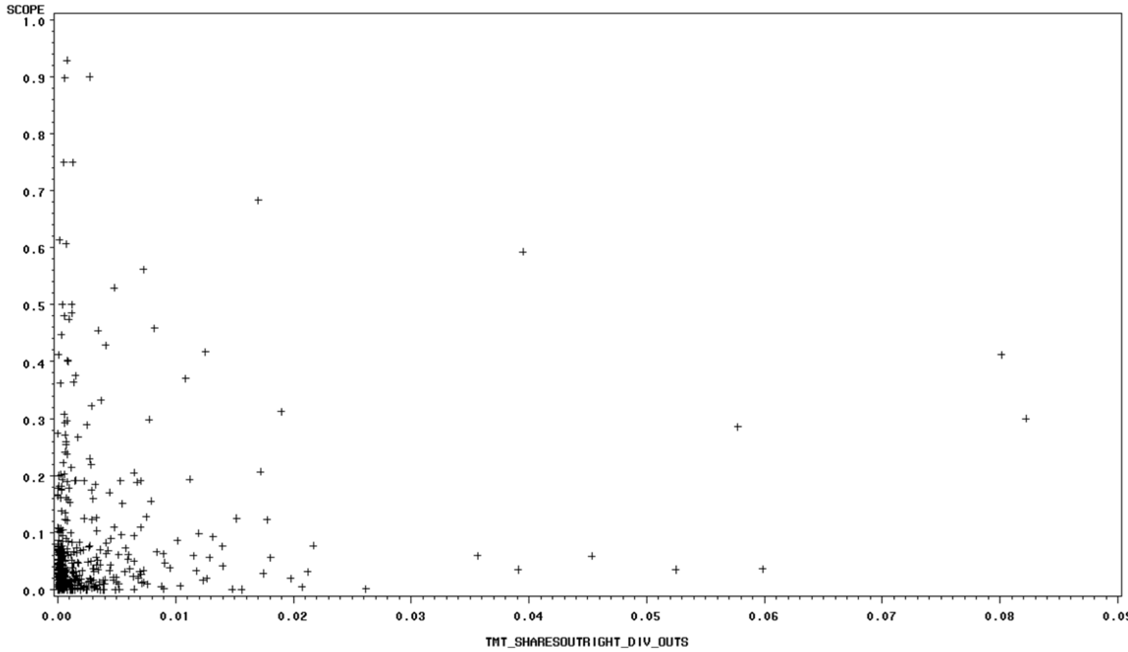
Exploratory Search * CEO Equity



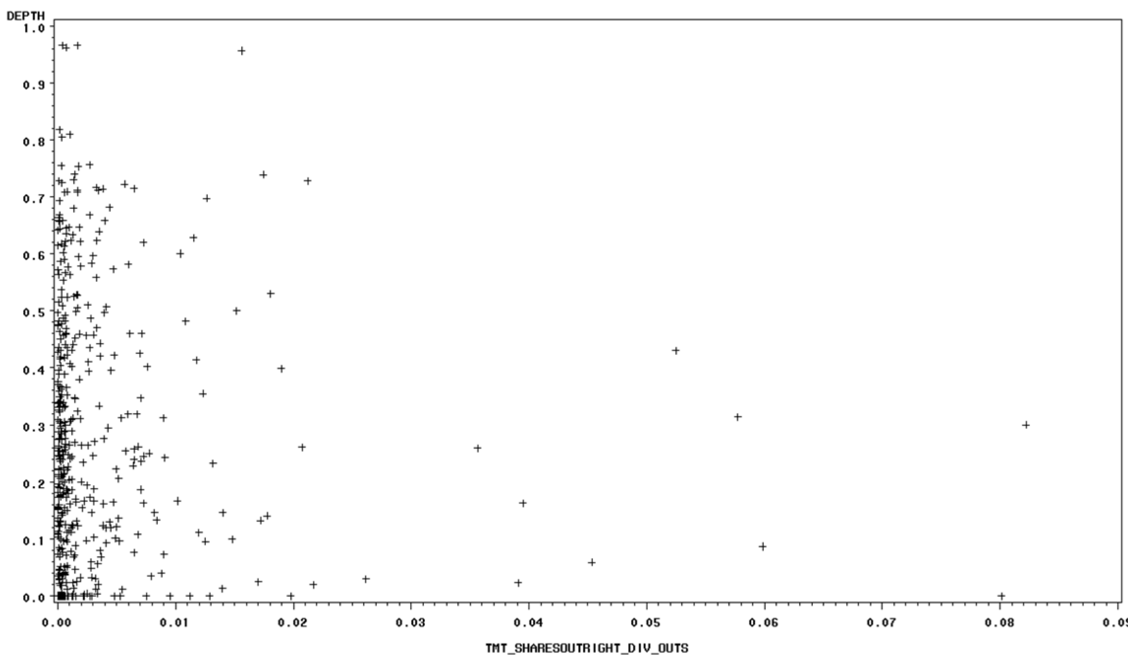
Exploitative Search * CEO Equity



Exploratory Search * TMT Equity



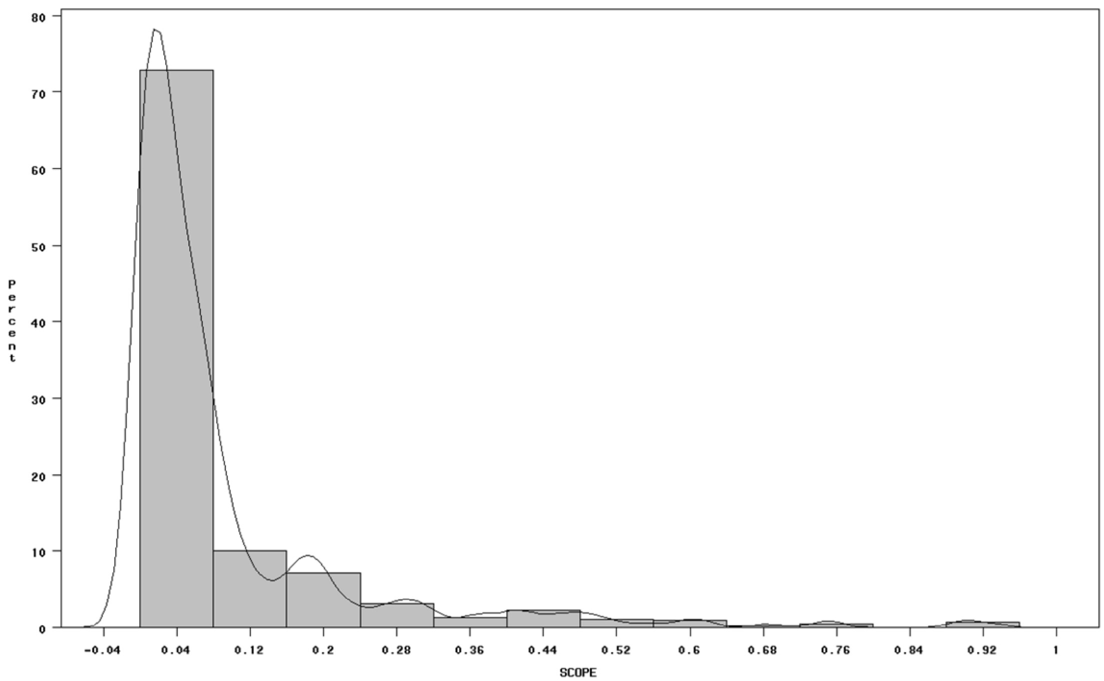
Exploitative Search * TMT Equity



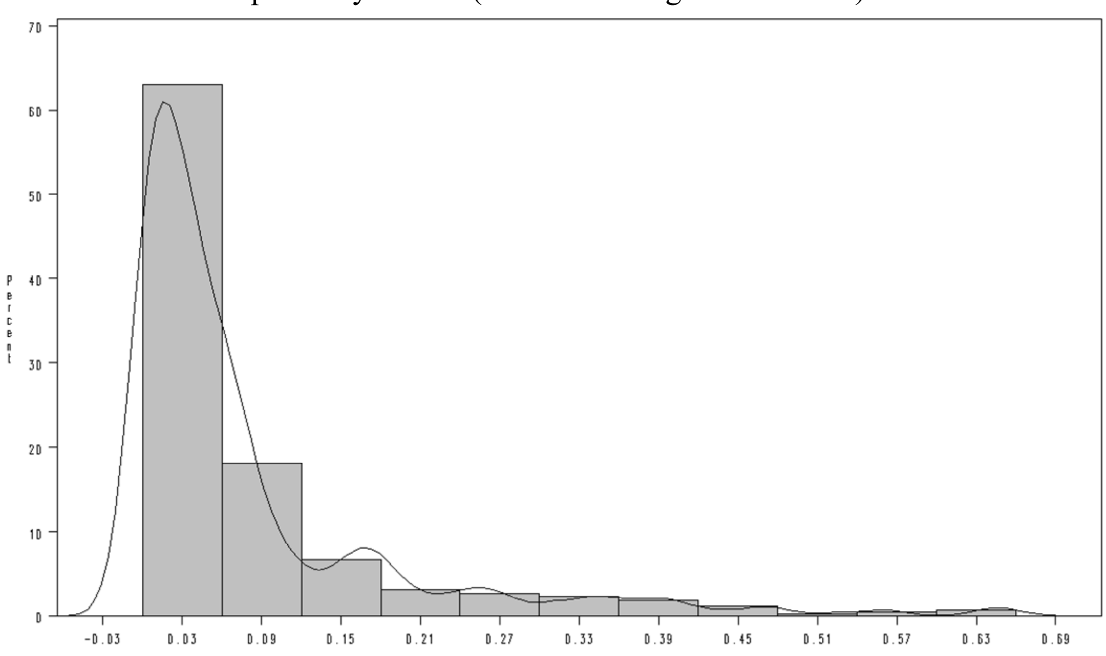
APPENDIX B:

HISTOGRAMS OF UNTRANSFORMED AND TRANSFORMED VARIABLES

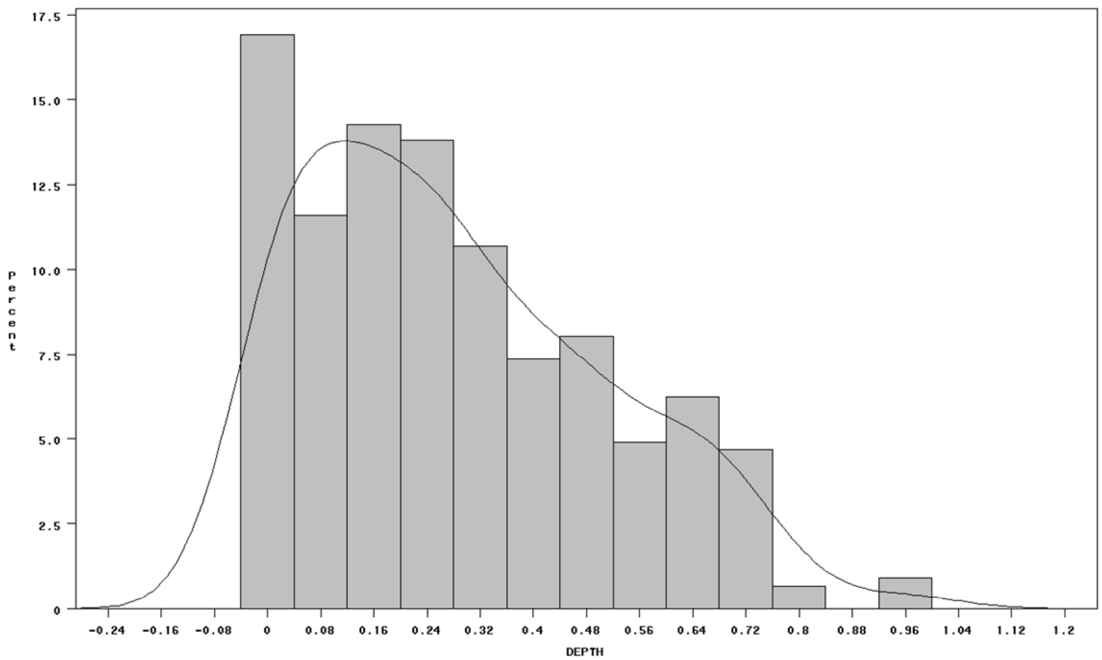
Exploratory Search (Untransformed)



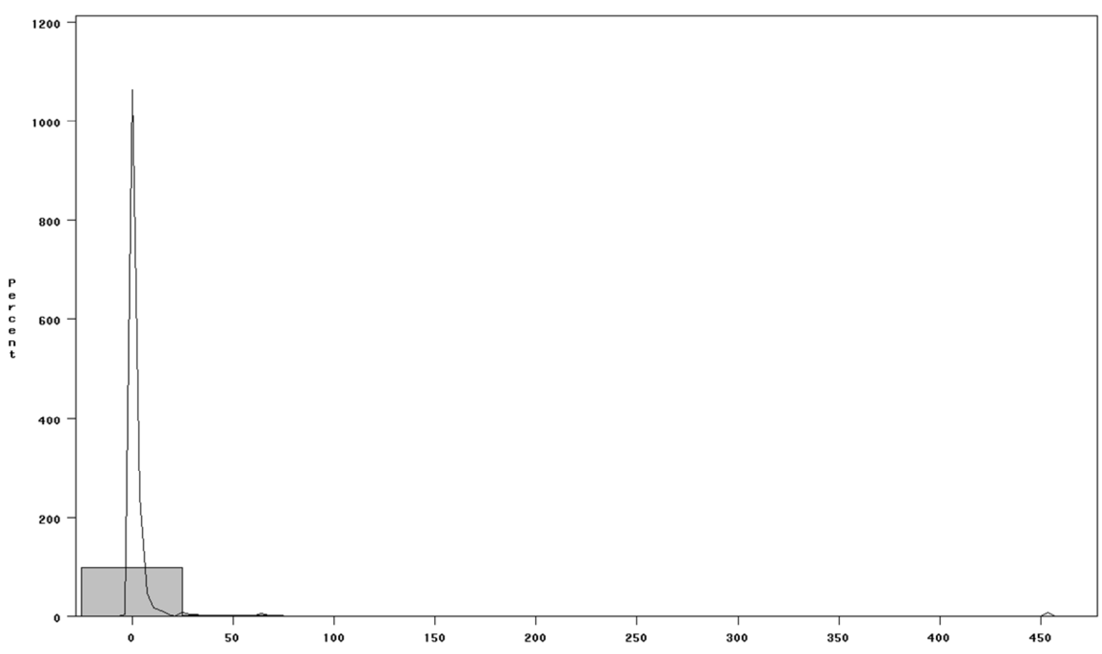
Exploratory Search (Constant + Log Transformed)



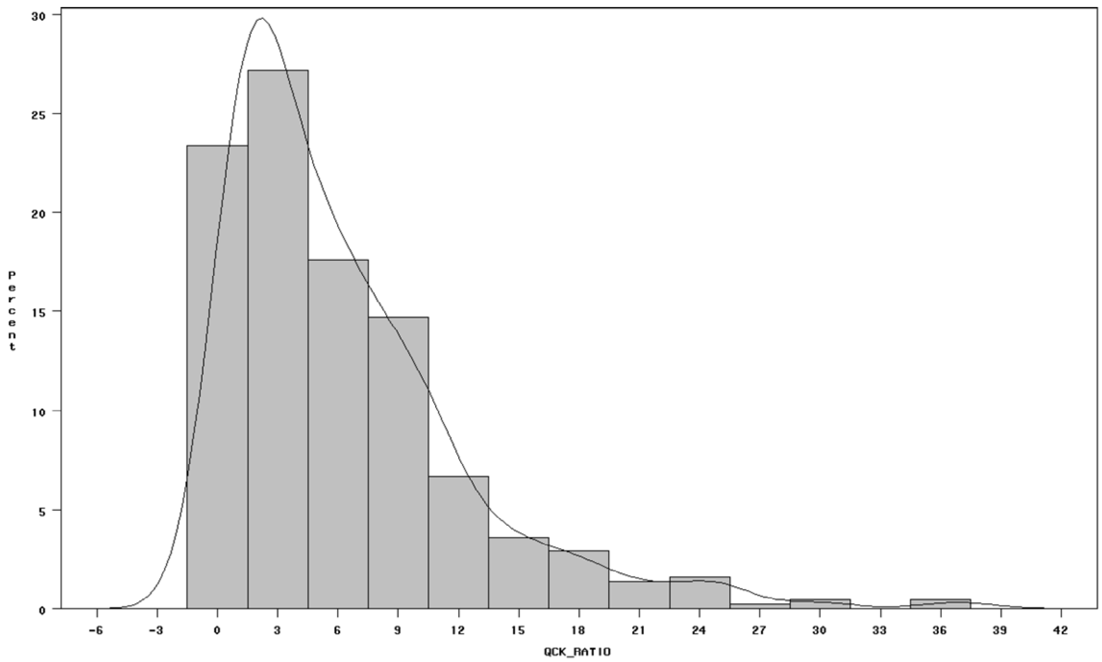
Exploitative Search (Untransformed)



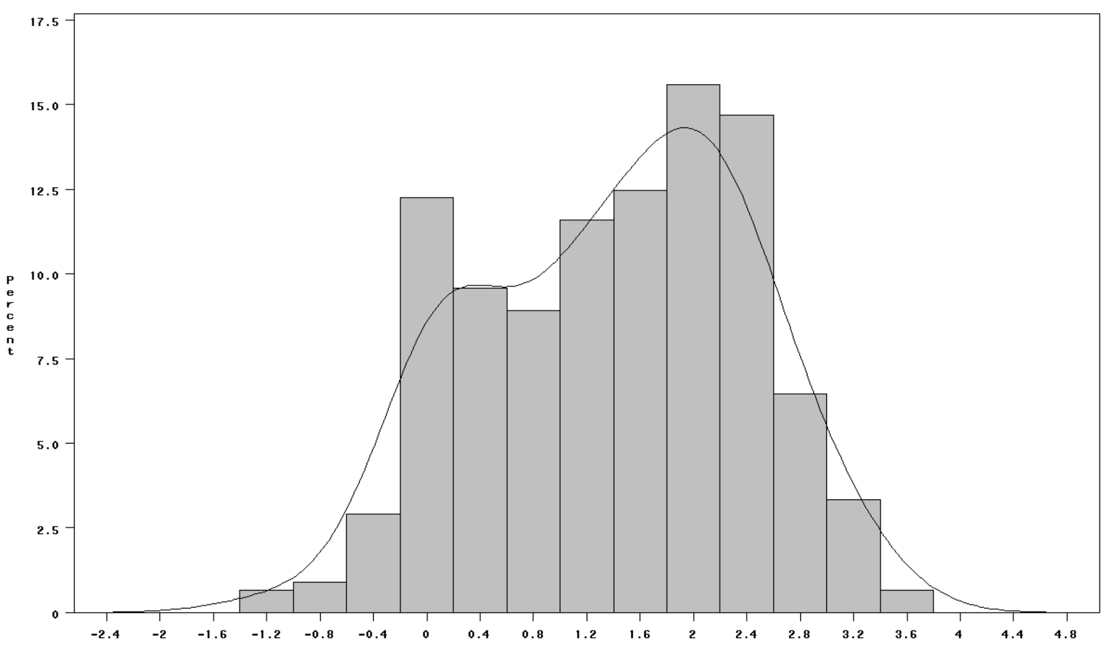
Recoverable Slack (Variable dropped because of too many missing observations)



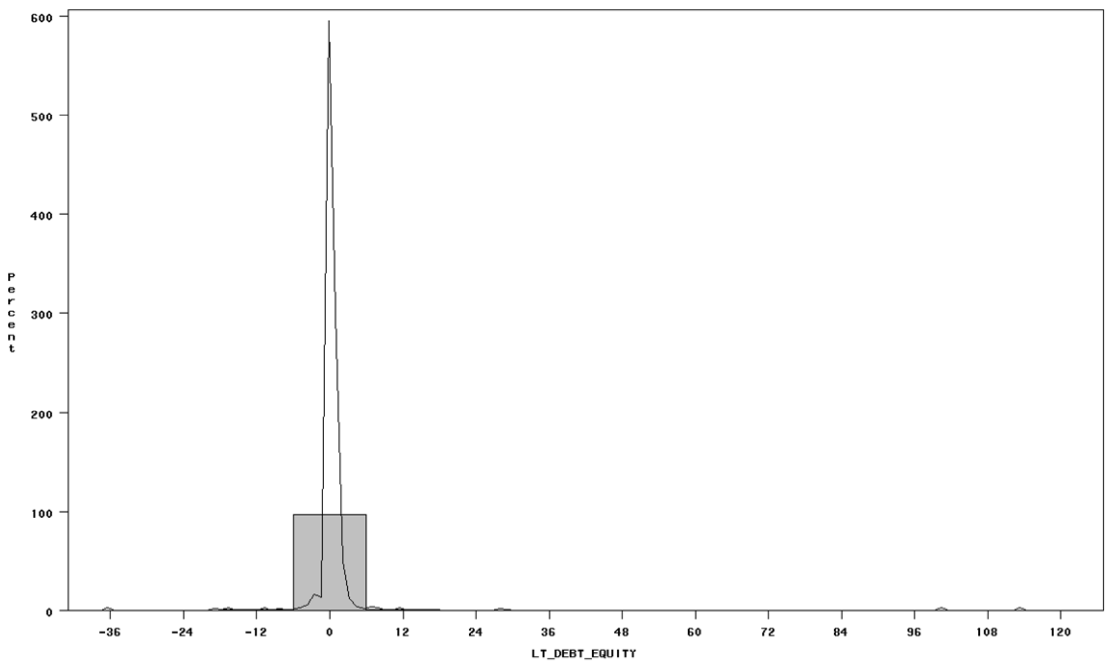
Available Slack (Untransformed)



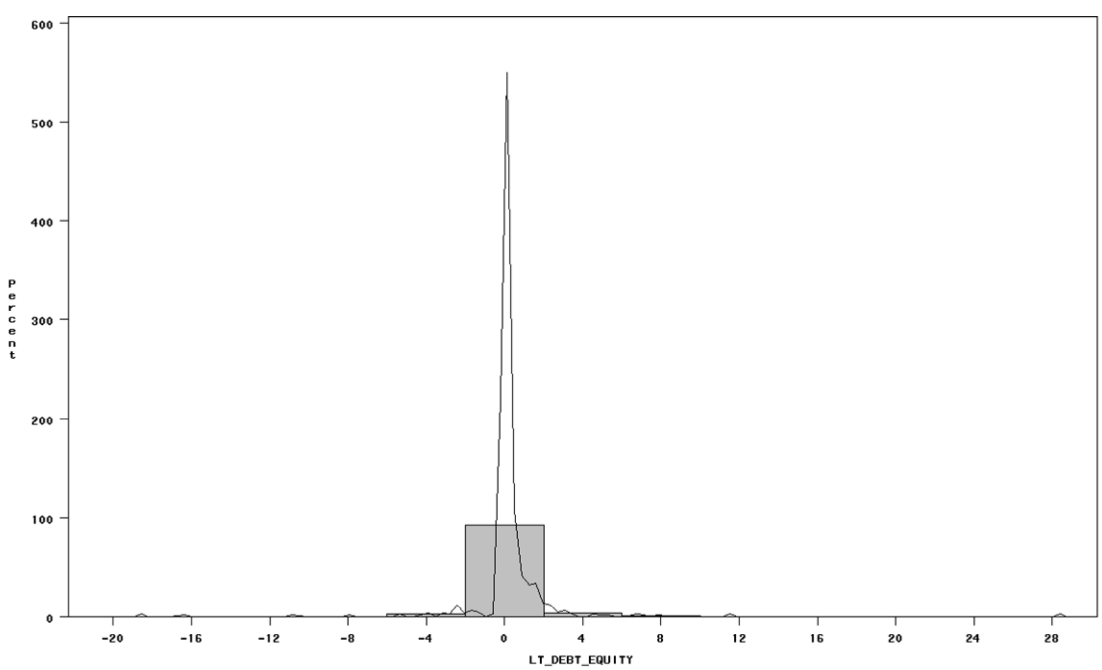
Available Slack (Log transformed)



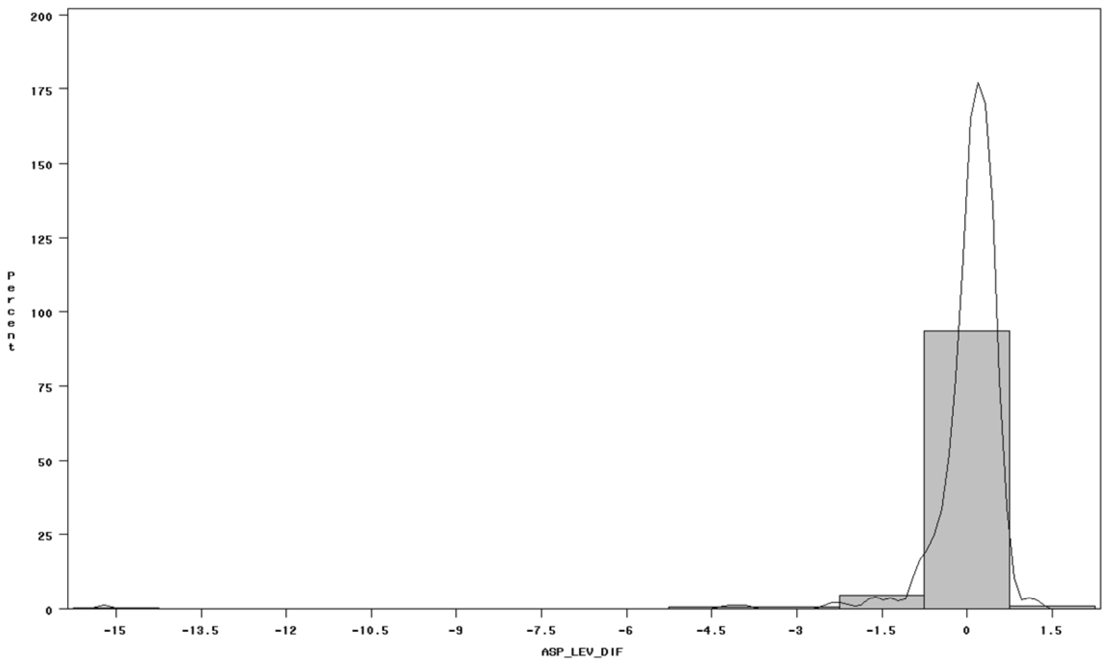
Potential Slack (Untransformed)



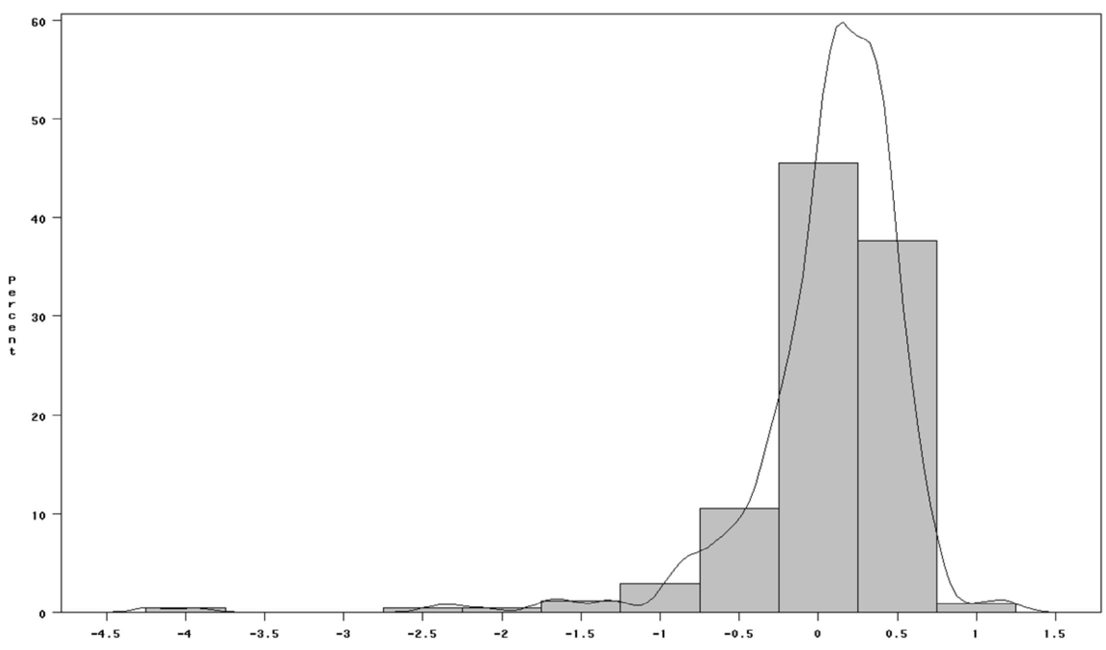
Potential Slack (After outlier removal – no other transformations needed)



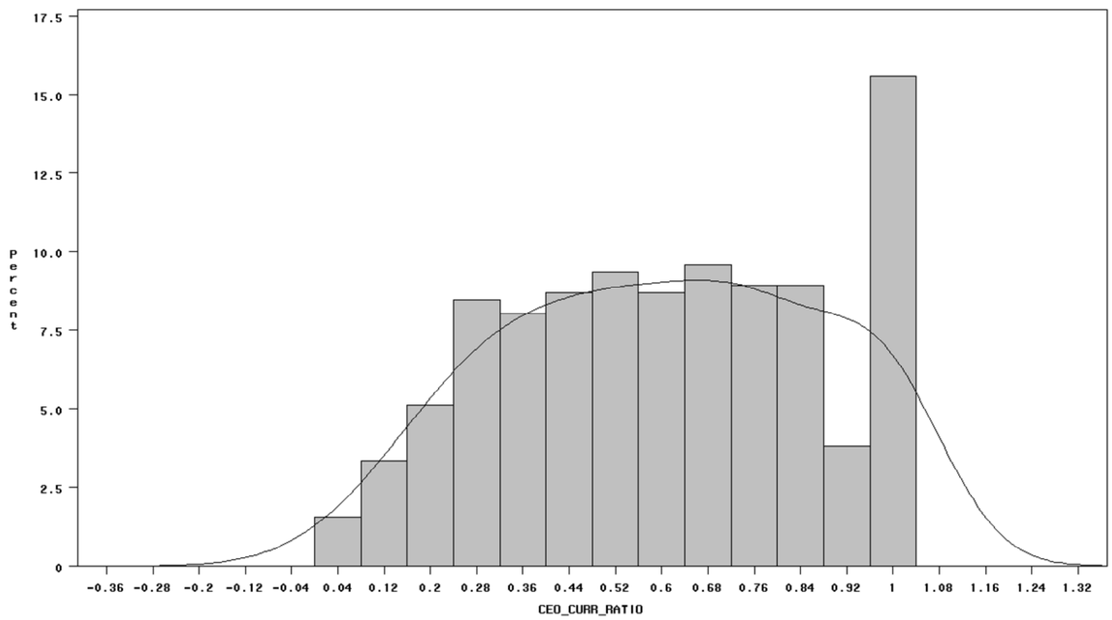
Actual-to-Desired Performance (Untransformed)



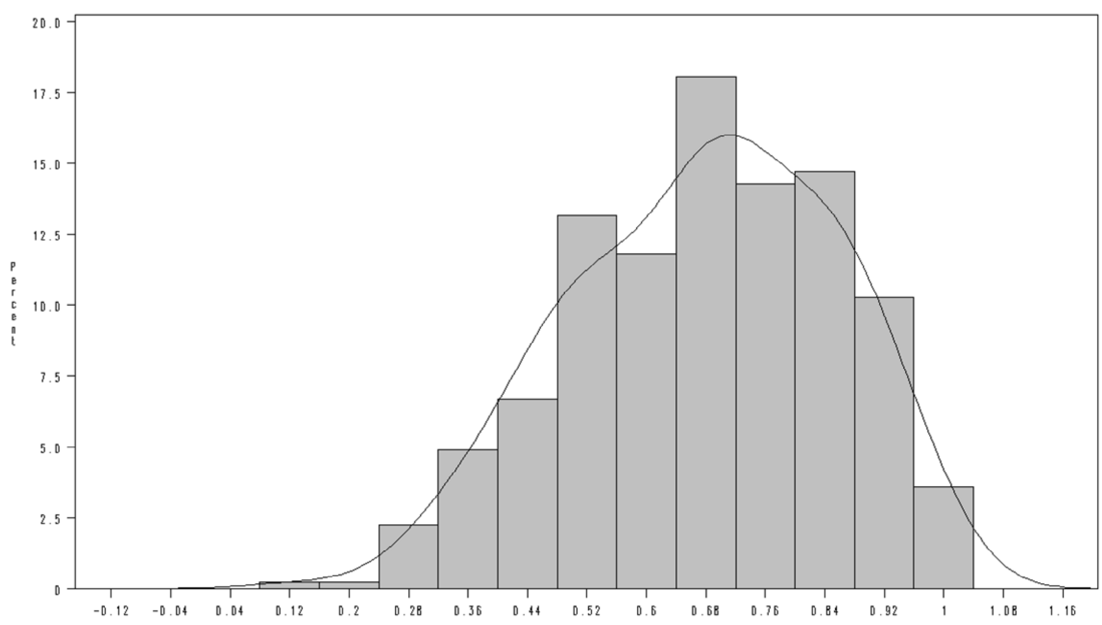
Actual-to-Desired Performance (After outlier removal – no other transformations needed)



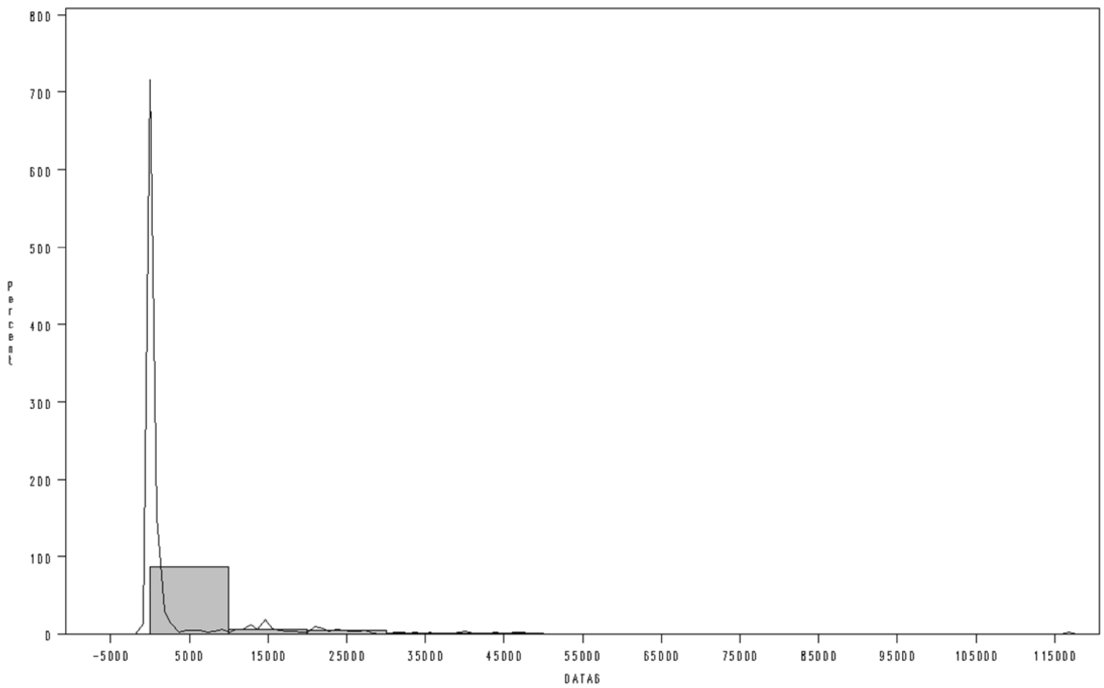
CEO Current Ratio (No transformation needed)



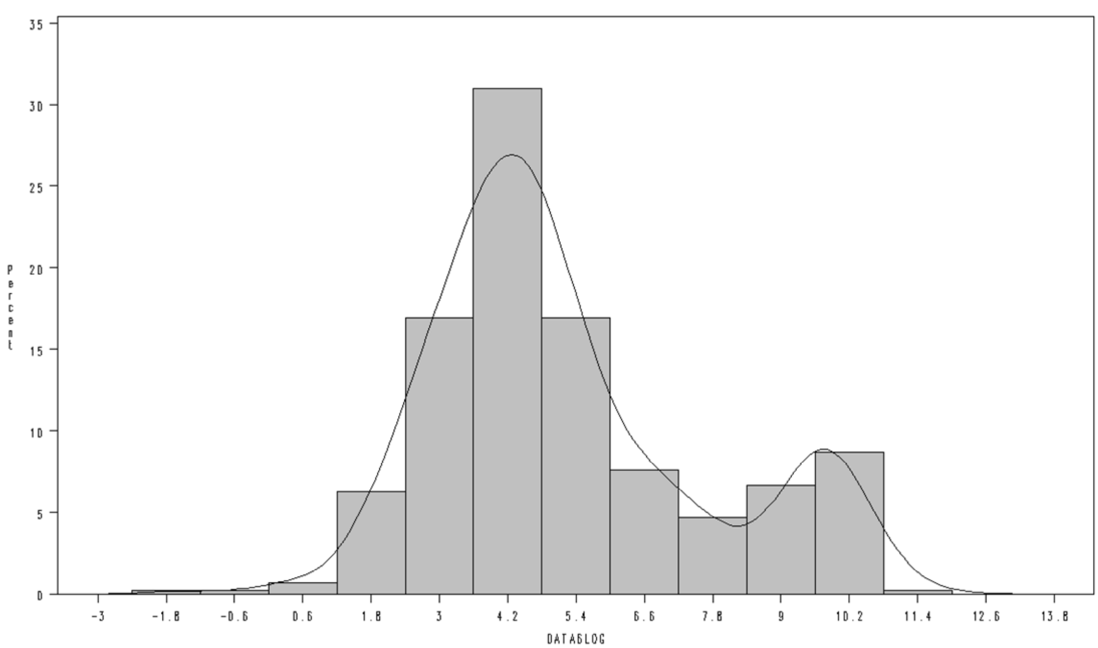
TMT Current Ratio (No transformation needed)



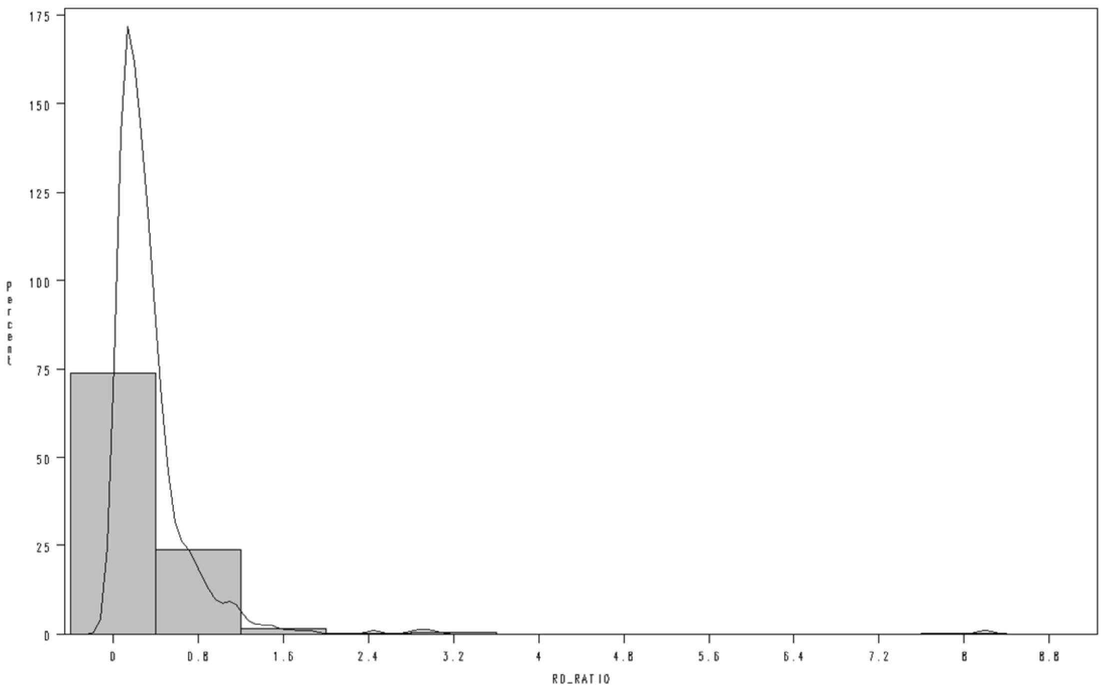
Firm size (Untransformed)



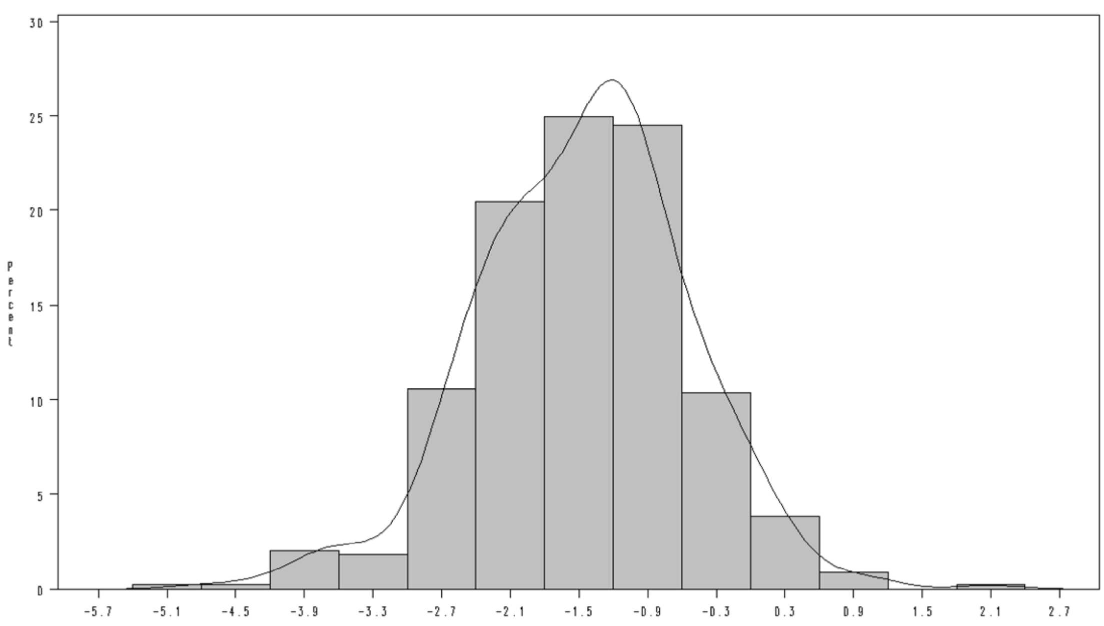
Firm size (Log transformed)



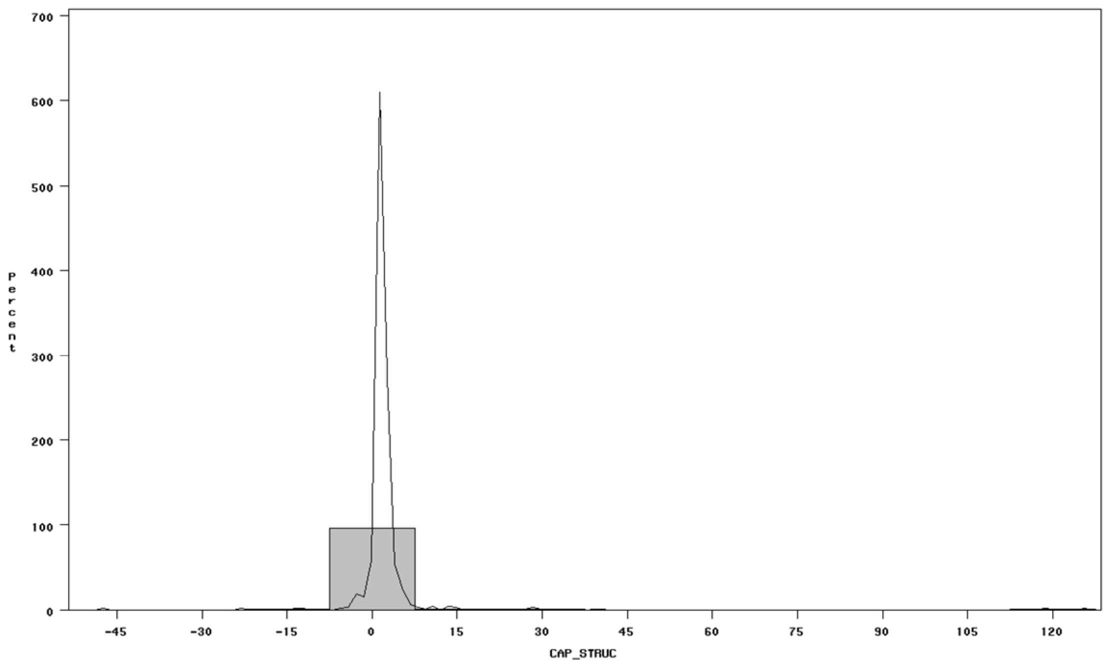
R&D Ratio (Untransformed)



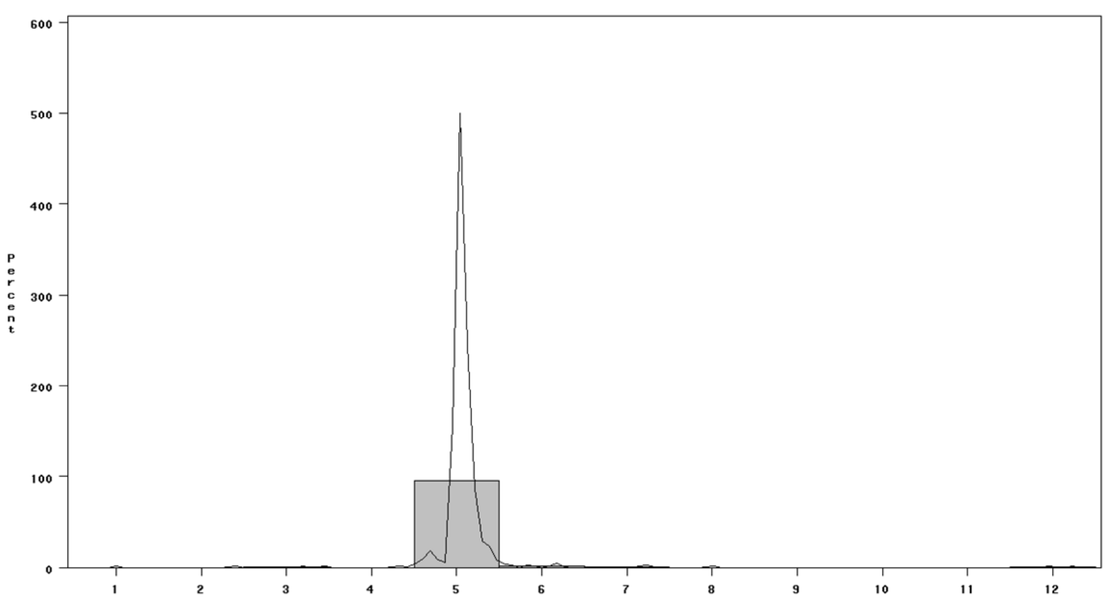
R&D Ratio (Log transformed)



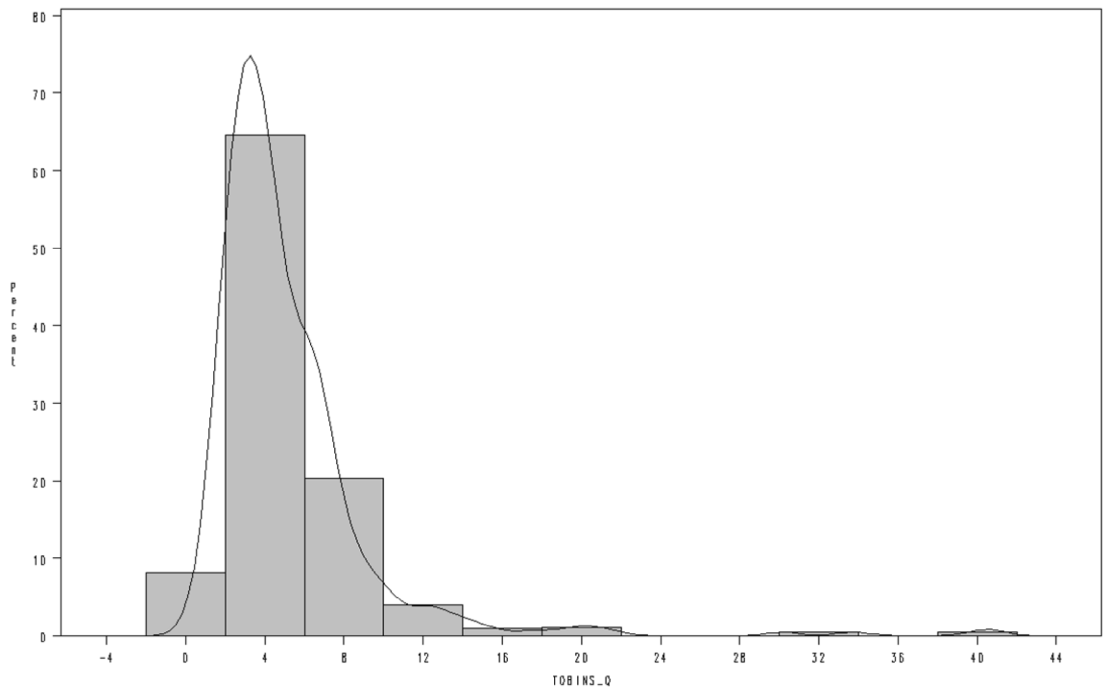
Capital Structure (Untransformed)



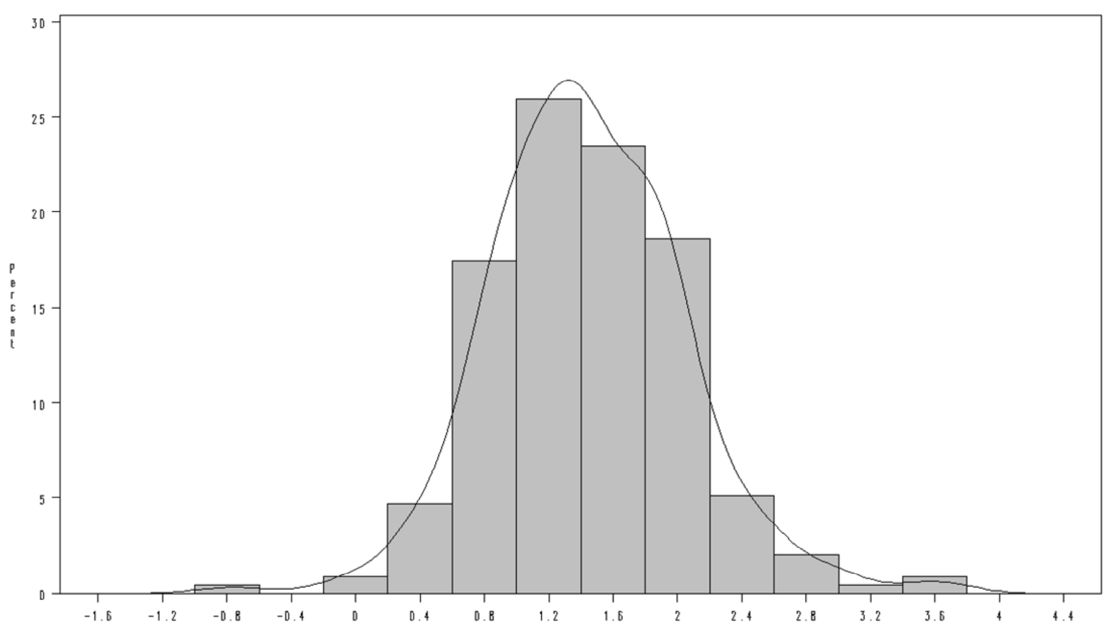
Capital Structure (After outlier removal + Constant + Sq Rt Transform)



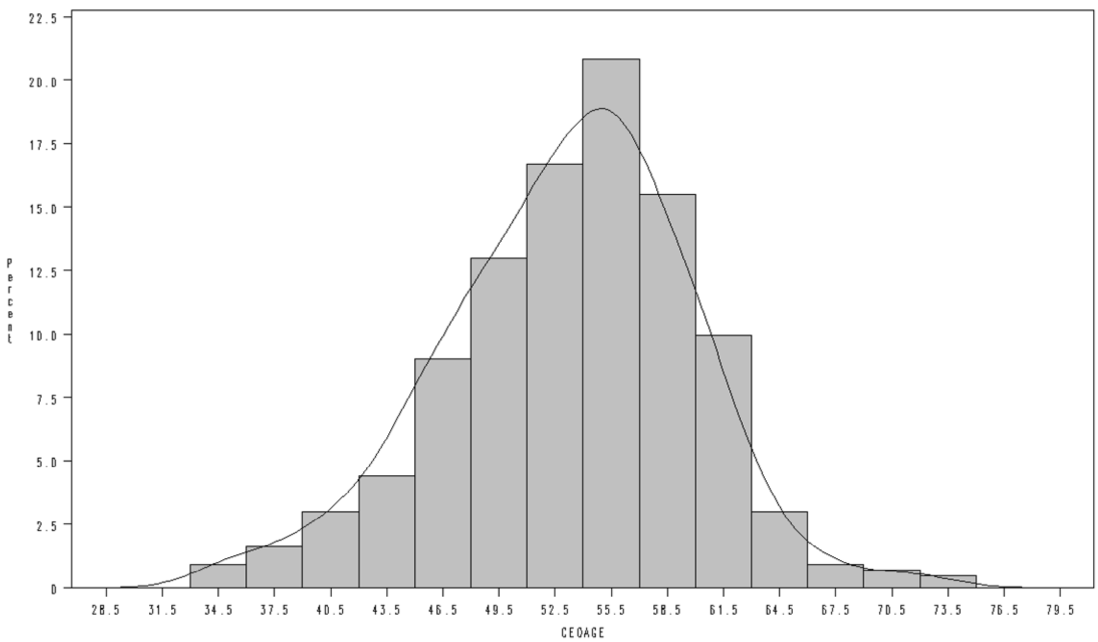
Tobin's Q (Untransformed)



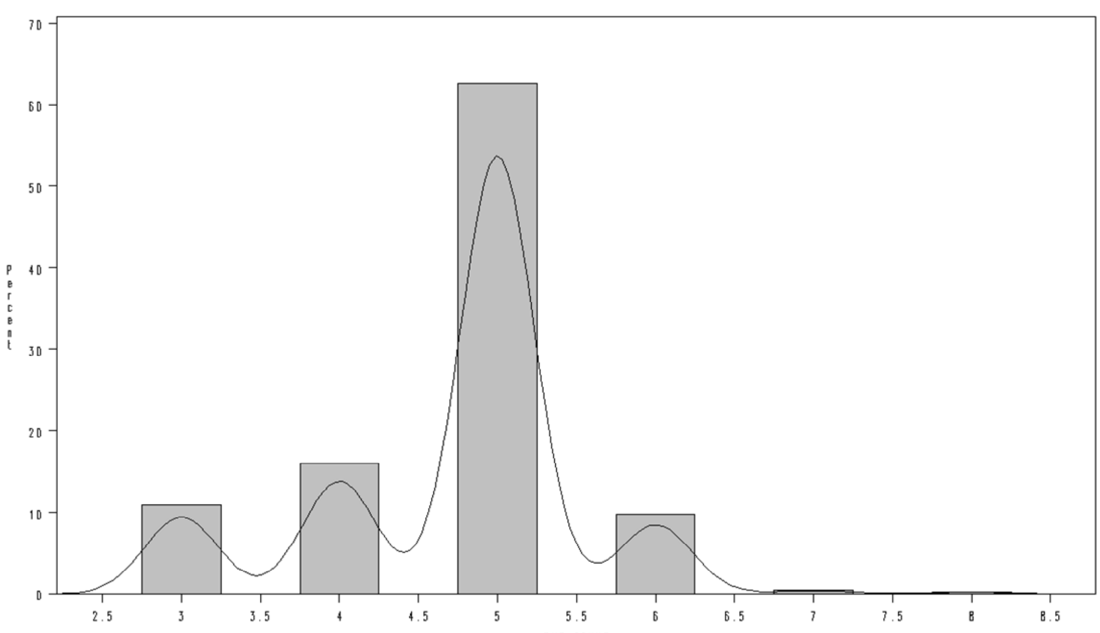
Tobin's Q (Log Transformed)



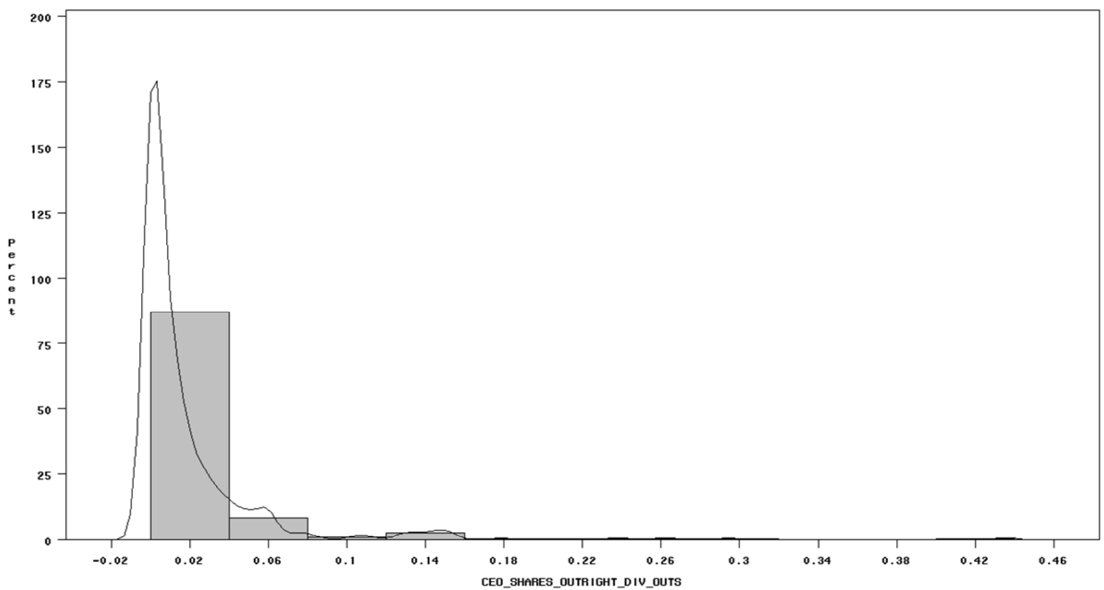
CEO Age (No transformation needed)



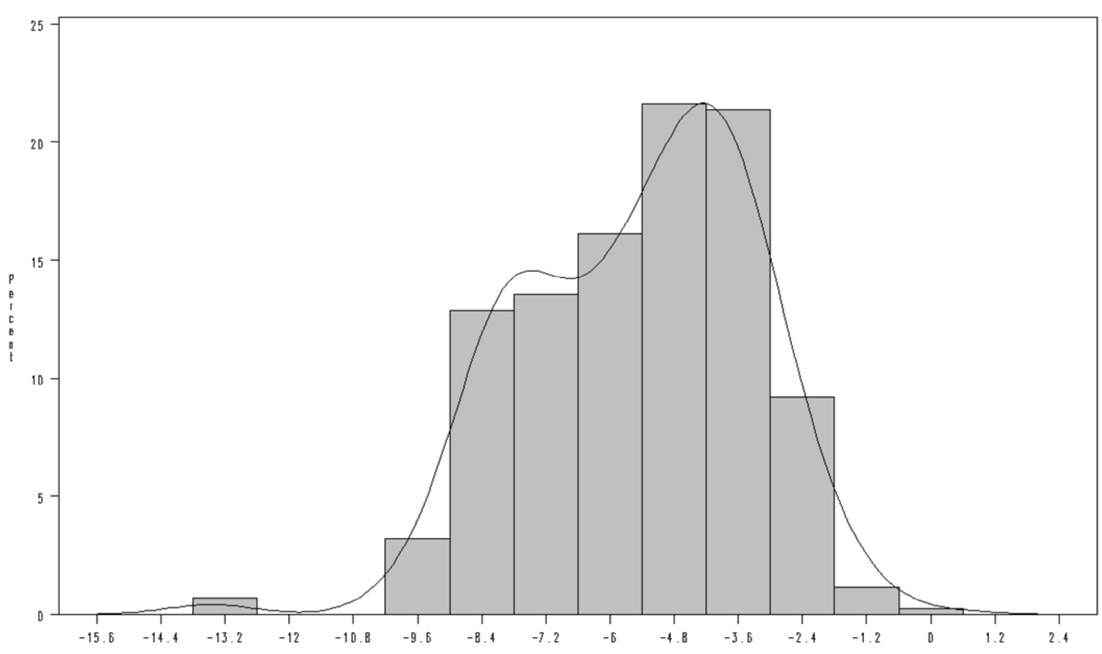
TMT Size (No transformation needed)



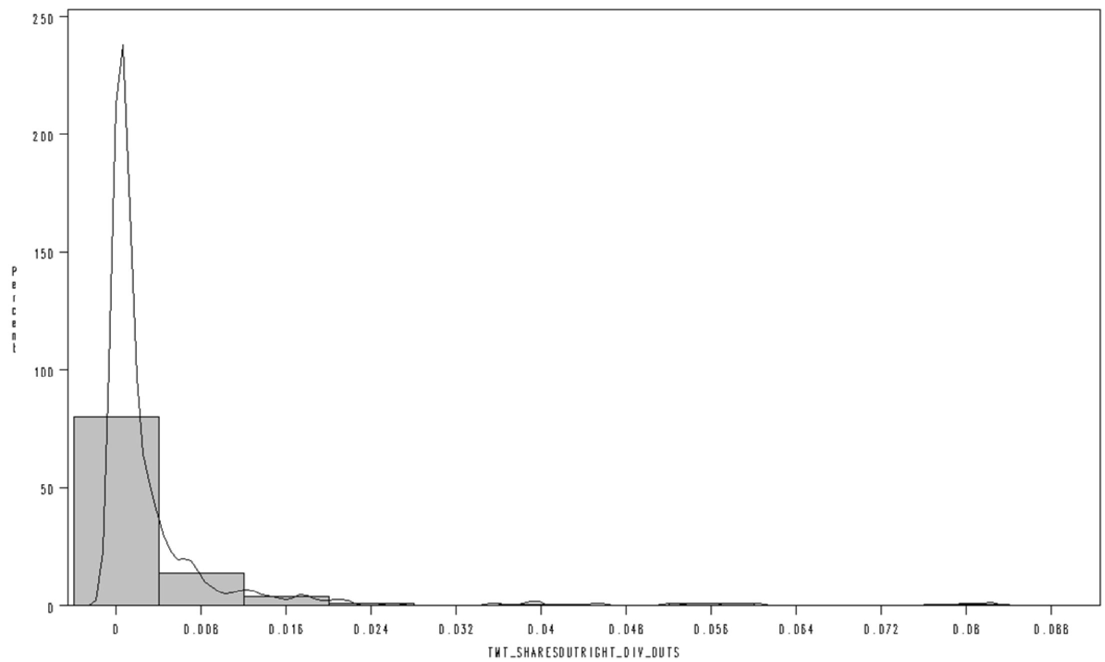
CEO Equity Ownership (Untransformed)



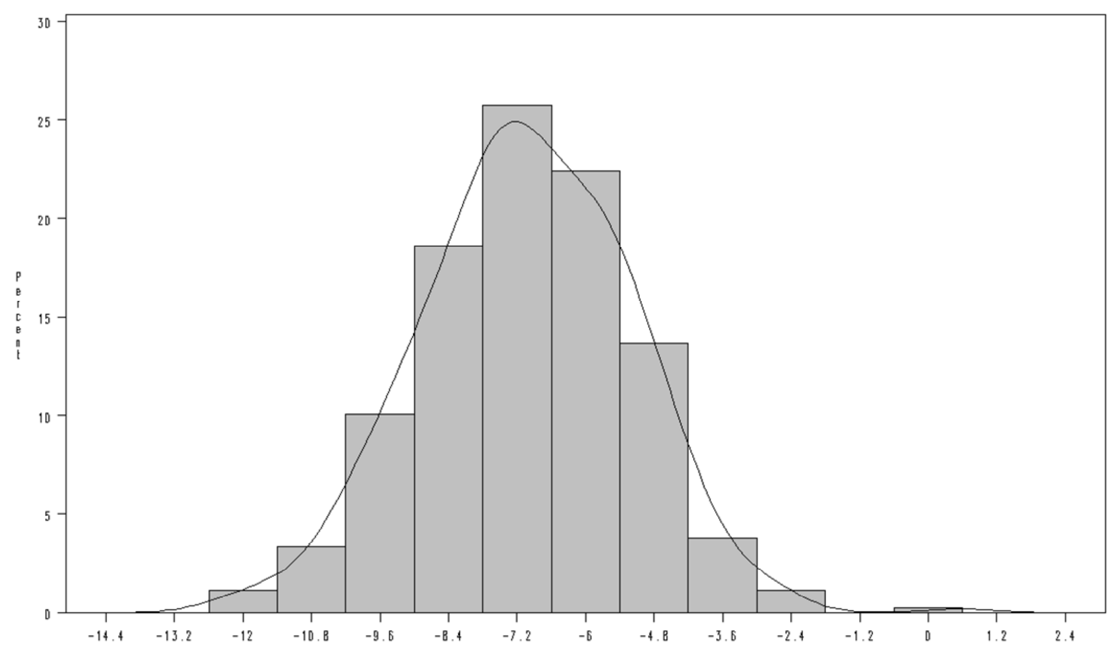
CEO Equity Ownership (Log transformed)



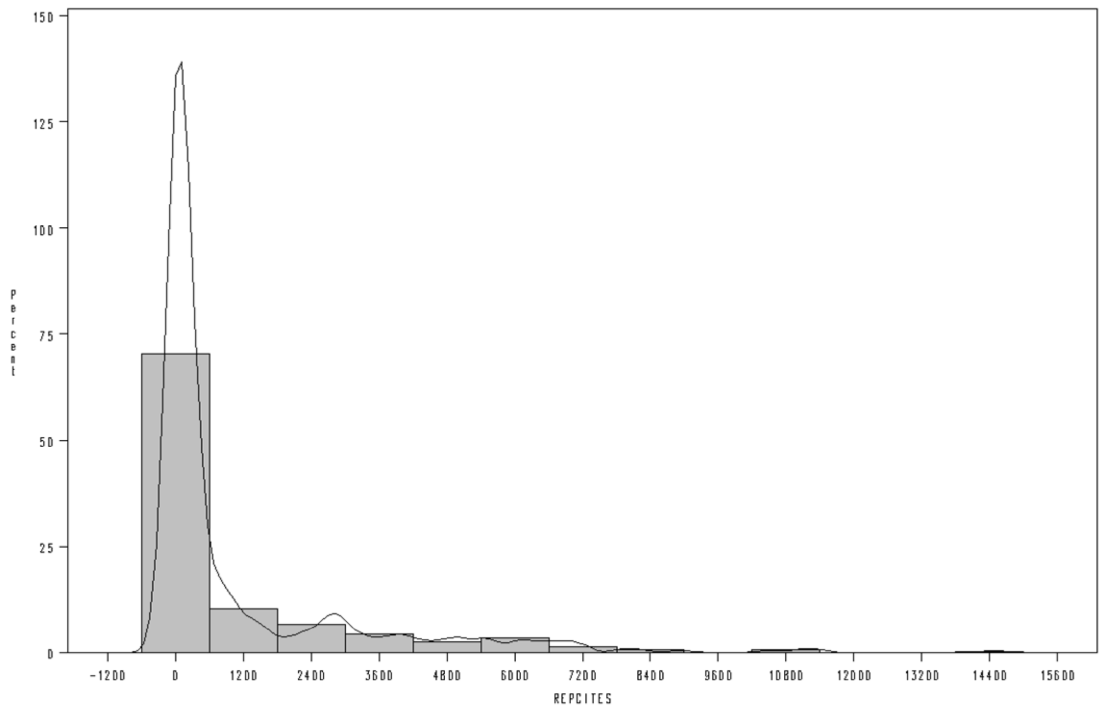
TMT Equity Ownership (Untransformed)



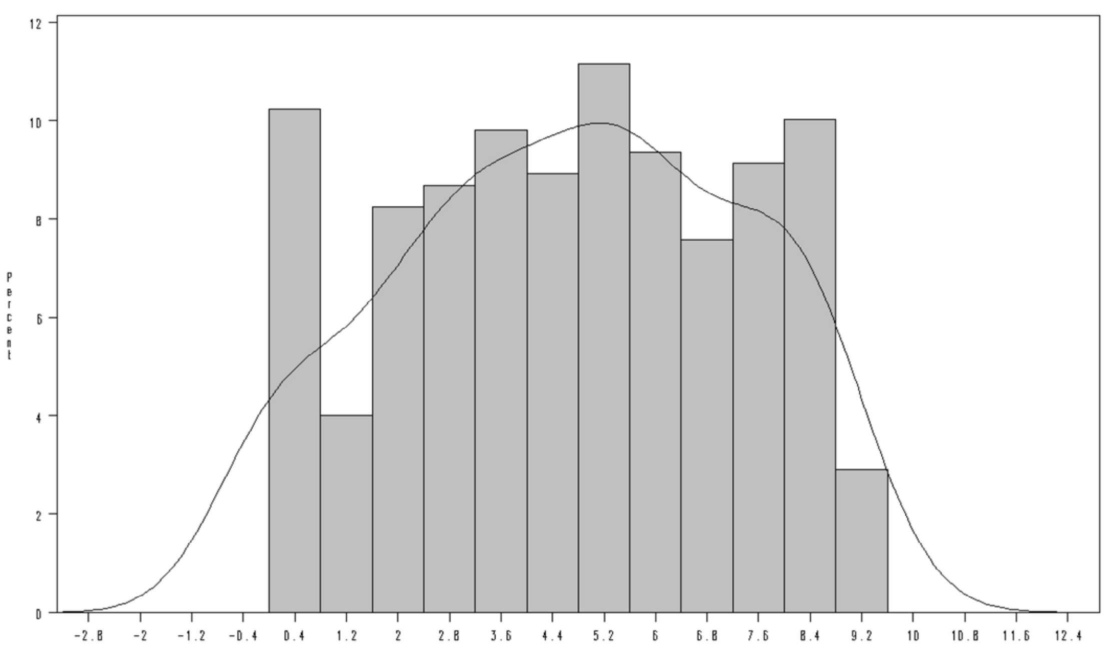
TMT Equity Ownership (Log Transformed)



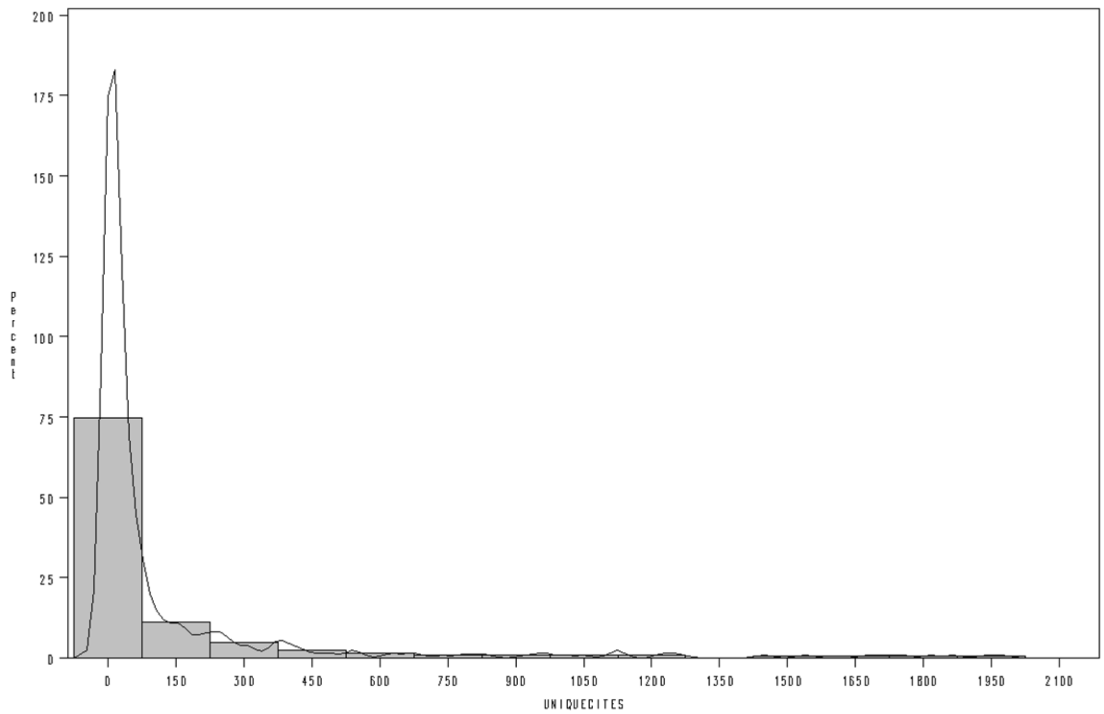
Repeated Cites (Untransformed)



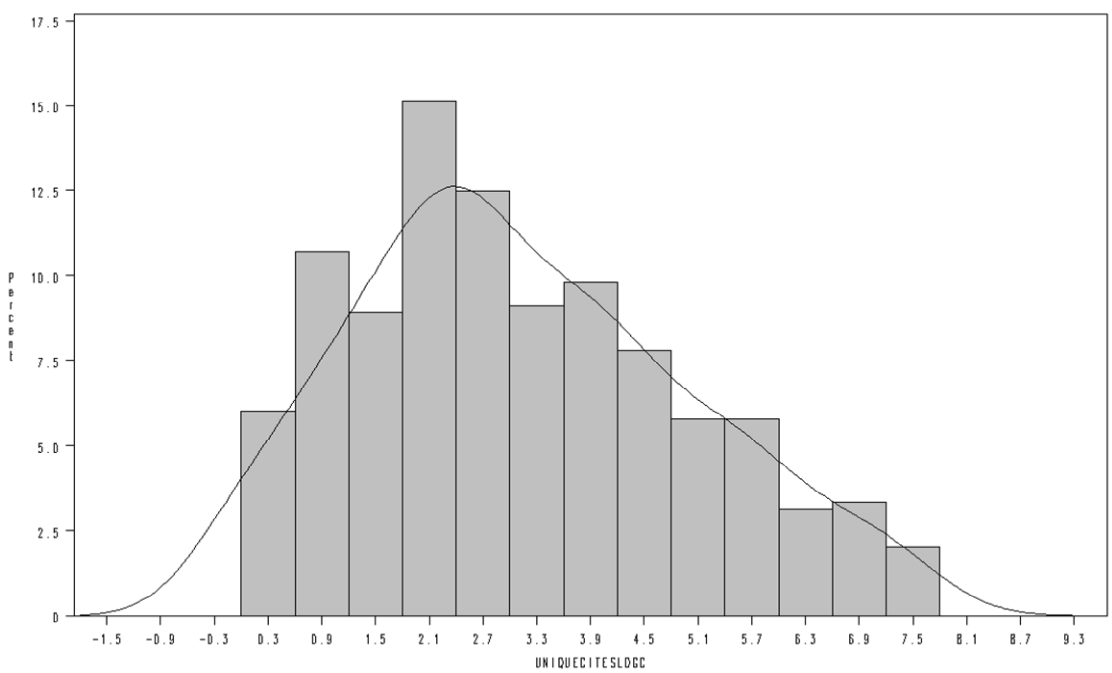
Repeated Cites (Log Transformed)



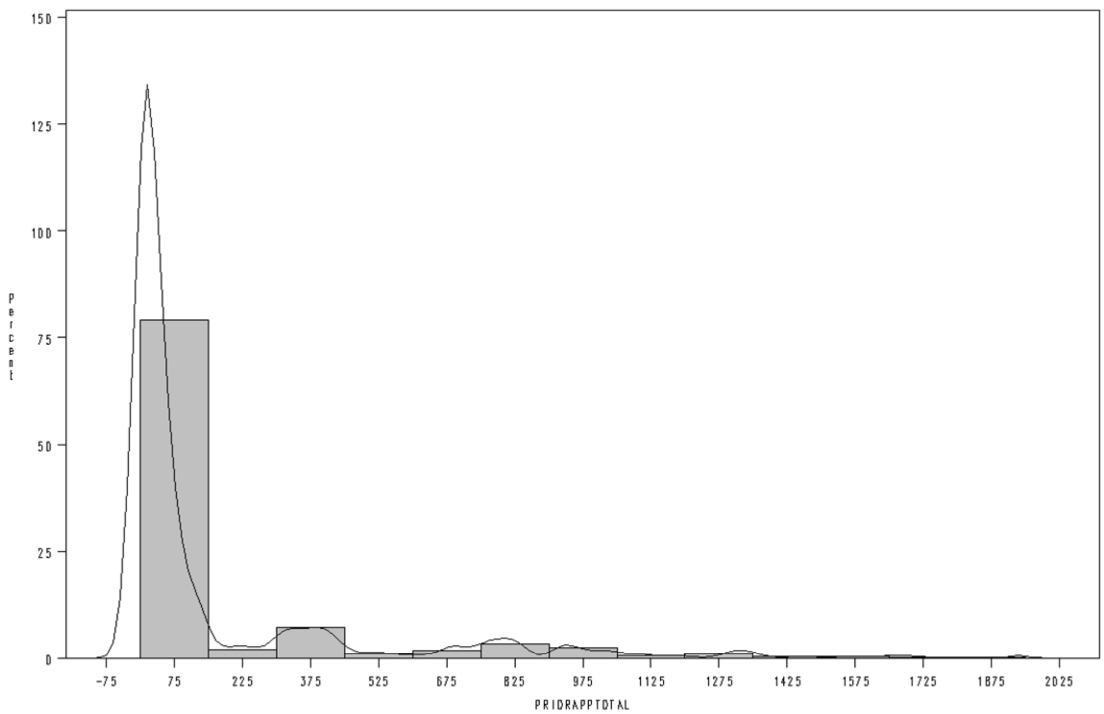
Unique Cites (Untransformed)



Unique Cites (Log Transformed)



Prior Patents (Untransformed)



Prior Patents (Log Transformed)