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EFFECTS OF PERFORMANCE ASPIRATION AND KNOWLEDGE NETWORK ON TECHNOLOGICAL SEARCH

You-Ta Chuang
York University
School of Administrative Studies
ychuang@yorku.ca

Chun-Chi Yang
Fu-Jen Catholic University
Department of Business Administration
ccyang@fju.edu.tw

Abstract

In this study, we draw upon research on performance aspiration and social networks to examine organizational search activity across technological space. Our analysis of the patenting activities of 197 semiconductor firms shows that the probability of a firm engaging in intensive search decreased as the distance of its performance above aspiration increased. This probability increased as the distance of its performance below aspiration increased. For the firms that did engage in intensive search activity, the distance of the performance above aspiration was negatively associated with the quantity of searching for other firms? technological knowledge in the industry. However, the distance of the performance below aspiration was positively associated with the quantity. Finally, a firm?s embeddedness in the technological knowledge network of the industry moderated the relationship between the performance relative to aspiration and the quantity of the search.

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In this study, we draw upon research on performance aspiration and social networks to examine organizational search activity across technological space. Our analysis of the patenting activities of 197 semiconductor firms shows that the probability of a firm engaging in intensive search decreased as the distance of its performance above aspiration increased. This probability increased as the distance of its performance below aspiration increased. For the firms that did engage in intensive search activity, the distance of the performance above aspiration was negatively associated with the quantity of searching for other firms' technological knowledge in the industry. However, the distance of the performance below aspiration was positively associated with the quantity. Finally, a firm's embeddedness in the technological knowledge network of the industry moderated the relationship between the performance relative to aspiration and the quantity of the search.

Keywords: Performance aspiration, technological search, network embeddedness

One of the central ideas in organizational learning theories is that performance relative to aspiration motivates organizational search (Cyert & March, 1963; Greve, 2003a). Organizational search induced by performance relative to aspiration may lead decision makers in organizations to identify sources of problems that cause performance decline and opportunities to improve or enhance future performance. As a result of this organizational search, the decision makers may initiate organizational change in attempt to improve organizational performance. This idea has led to considerable interest in understanding how performance relative to aspiration – a reference point that distinguishes organizational success and failure – influences the likelihood of different types of organizational changes such as market positions (Greve, 1998), resource allocation (Park, 2007), partner selection (Baum, Rowley, Shilipov, & Chuang, 2005), innovation activity (Chen, 2008; Chen & Miller 2007; Greve, 2003b), timing of acquisitions (Iyer & Miller, 2008), and firm performance such as firm growth and cost reduction (Audia & Greve, 2001; Baum & Dahlin, 2007; Greve 2008).

Despite recent efforts devoted to unfolding the relationship between performance relative to aspiration and a variety of organizational behaviors and outcomes, our understanding of the relationship remains limited in two important ways. First, prior studies have produced inconsistent results as to the effects of performance relative to aspiration on organizational behaviors and outcomes. Some studies reported that the distance of performance above aspiration exerted negative effects on organizational behaviors and outcomes (e.g., Greve 1998; Greve 2003b; Park 2007). Other studies reported either positive effects or no effects (e.g., Baum & Dahlin, 2007; Baum et al., 2005; Chen, 2008; Iyer & Miller, 2008). Though the inconsistent results could be due to the idiosyncratic nature of research settings in these studies (Baum et al., 2005), they do limit our understanding as to the role of performance relative to aspiration in shaping organizational behaviors and outcomes. Second, with few exceptions (Chen 2008; Park, 2007), prior research has not empirically linked performance relative aspiration to organizational search activity and the patterns of search activity in particular. Chen (2008) documented that performance relative to aspiration affected a firm's R&D intensity. Park's (2007) study revealed that firms were more likely to allocate their resources similar to other firms when their performance was below aspiration. However, the patterns of search activity induced by performance aspiration have not been well understood. This is surprising because the organizational search activity is one of central ideas in organizational learning theories and the performance feedback model in particular (Cyert & March, 1963; Greve, 2003a). Recent theorization efforts on the relationships between performance relative to aspiration and organizational search have suggested that performance relative to aspiration can influence the direction of organizational search activity (Baum & Dahlin, 2007; Greve 2003a). Yet, there is limited direct empirical evidence to support such relationships. Addressing these two limitations, the focus of our study, has potential to advance our understanding of how performance relative to aspiration influences organizational behaviors.

In this study, we draw upon organizational learning theories and explicitly link performance relative to aspiration to organizational search to examine the patenting activity of 197 semiconductor firms (Cyert & March, 1963; Greve, 2003; Levintal & March, 1993; March 1991). Recent studies have used patenting activity as a proxy to examine organizational search behavior (e.g., Fleming, 2001; Katila, 2002; Katila & Ahuja, 2002; Stuart & Podolny, 1996; Sorensen & Stuart, 2000) and knowledge transfer (e.g., Phelps, 2010), since a firm's patents document its technological search trail (Jaffe et al., 1993). Thus, a firm's patenting activity provides an excellent opportunity to examine how organizational search for technological knowledge is driven by performance relative to aspiration. We argue that performance relative to aspiration motivates decision makers in organizations to engage in either local or non-local search. The motivation to engage in searching for technological knowledge and the types of search are conditional upon their performance relative to aspiration. As the motivation and the types of search reflect two related, but different processes of organizational decision making, we conceptualize the relationship between performance relative to aspiration and technological search as two sequential processes of organizational decision making. As prior studies suggested, organizational search can be driven by a broad institutional context in which an organization is embedded (e.g., Chen & Miller, 2007; Gavetti, Levinthal, & Ocasio, 2007; Greve 2003a; Ocasio, 1997). Therefore, the effect of performance relative to aspiration on the direction of search activity can be influenced by the technological knowledge network of an industry.

Our analysis of these two processes – motivation and the pattern of search – shows that performance relative to aspiration is negatively associated with the motivation to engage in search activities, albeit it exhibits a spline function of influence. Though performance relative to aspiration induces organizations to engage in non-local search activity by searching for new technological knowledge, the organizations are more likely to search for new technological knowledge explored by other organizations in their industry when their performance is below aspiration, compared to performance above aspiration. Yet, the technological knowledge network of an industry exerts great influence on how organizations exploit the new knowledge of other organizations in the industry. Accordingly, our study aims to make two important contributions to the literature on performance aspiration and organizational search. First, we reconcile the inconsistent results in prior studies on the effects of performance aspiration by separating two decision-making processes affected by performance aspiration. Second, we provide more direct evidence on the relationships between performance aspiration and the pattern of organizational search and examine how such relationships can be influenced by a broad institutional context in which firms are situated.

Performance Feedback and Organizational Behaviors

A basic assumption of organizational learning theories is that individuals and organizations learn and adjust their behavior in response to past experience (March & Simon, 1958). According to the performance feedback model, the behavior of decision makers in organizations, as bounded, rational actors, is routine-based, history-dependent, and target-oriented which, in turn, contributes to organizational routines (Cyert & March, 1963; Levitt & March, 1988; March, 1981). Organizational routines are repeatedly invoked, socially constructed programs of action that are embedded with the knowledge, capabilities, beliefs, and values of the organization (Nelson & Winter, 1982). The likelihood that the routines of an organization will be drawn upon increases when they are associated with success in reaching satisfactory performance, and decreases when they are associated with failure (Cyert & March, 1963). Organizations may have different definitions of satisfactory performance, depending on their histories and the attention patterns of their members (Ocasio, 1997); consequently, a very similar performance level may be evaluated differently in different organizations. Whether a given performance level is perceived as a success or failure depends on decision makers' interpretation of a given outcome (Dutton & Jackson, 1987; Kahneman & Tversky, 1979).

Based on the assumption of bounded rationality, the performance feedback model proposes that organizations act on their performance relative to aspiration to adjust their behavior (Cyert & March, 1963). Performance feedback governs the direction of aspiration adaptation in that aspiration is adjusted upward in response to favorable feedback and downward in response to unfavorable feedback. Past research has further suggested that performance relative aspiration induces organizations' decision makers to undertake various risky behaviors. Since decision makers react more strongly to threats than opportunities, performance below aspirations is more likely to trigger risk taking (Bromiley, 1991; March & Shapira, 1992; Tversky & Kahneman, 1986). Specifically, compared to organizations that are more distant from their aspirations, decision makers in organizations performing slightly below or above aspirations are less likely to pursue risky behaviors. The decision makers need only small improvements and minor adjustments to reach their targets or maintain their current performance. Decision makers in organizations that experience performance far below their aspirations may not be able to achieve acceptable performance through small improvements or minor adjustments. Instead, their poor performance may induce the decision makers to undertake risky activity by challenging status quo and stimulating exploration of new practices, strategies, and technologies (Greve 1998). The poor performance provides information on the ineffectiveness of current practices, strategies, and technologies which in turn induces decision makers to abandon them (Chuang & Baum, 2003). In contrast, decision makers in organizations that enjoy performance far above their aspirations may be less likely to engage in risky activity (Bromiley, 1991; Greve, 1998; Tversky & Kahneman, 1986). Though their favorable performance may allow the organizations to accumulate slack resources (Bromiley, 1991; Greenley & Oktemgil, 1998; Singh, 1986) that can serve a cushion to explore new opportunities, the performance can induce managerial complacency that leads the decision makers to maintain status quo (Greve, 1998; Levinthal & March, 1993).

Recent studies have drawn upon the performance feedback model to examine various organizational behaviors and outcomes; however, the studies have produced inconsistent results as to the effects of performance relative to aspiration. For example, Greve (1998) showed that the distance of performance relative to aspiration was negatively associated with the probability of a radio broadcasting station changing its market position. Iyer and Miller (2008) found the distances of performance above and below aspiration were negatively and positively associated with the timing of acquisitions, respectively. Baum and his colleagues (2005) documented that the distance of performance relative to aspiration was positively associated with the proportion of new partners in a Canadian investment bank's partner portfolio. Greve (2003) reported that the distances of performance below and above aspirations had negative and no effects on innovation activity of Japanese shipbuilders, respectively. Yet, Chen (2008) showed that the distances below and above aspirations were positively and negatively associated with R&D intensity of manufacturing firms. These inconsistent findings may be due to the idiosyncratic nature of research settings in these studies. However, these studies shed light on the need for a close examination of the relationship between performance aspirations and organizational behaviors and outcomes. Indeed, Bromiley (2010) and Hu, Blettner, and Bettis (2011) both argue that prior empirical studies using large scale archival data to examine the effect of performance aspirations might have over-simplified the processes by which decision makers respond to performance relative to aspirations. Thus, it is important to unfold the processes of how decision makers respond to performance relative to aspiration to reconcile the inconsistent findings.

Recent developments in cognitive psychology have offered substantial evidence that people have quite strong pattern recognition capabilities but process almost all information serially, especially when making complex decisions under uncertain environment (Koehler & Harvey, 2004). Moreover, decision makers tend to use a relatively small number of cues and variables to edit and simplify problems and make decisions sequentially (March, 1994). Faced with environmental complexity and bounds on their adaptability and information-processing capability, decision makers in organizations often develop certain procedures to deal with bounded rationality. The two most common procedures are routinization and decomposition (March & Simon, 1958). To economize cognitive resources, reduce complexity, and increase reliability, decision makers in organizations often develop various kinds of organizational routines for employees to act upon (Feldman & Pentland, 2003). Decision makers in organizations may also subdivide complex problems into smaller, manageable problems. Decomposition of a complex problem into sub-problems prevails when the complexity of the problem outweighs the bounded information-processing capability of managers. Such decomposition is a necessary heuristic because it allows managers to reduce a complex problem to a collection of more manageable sub-problems, even though it may lead to a local optimum rather than a global optimum outcome (Simon, 1982). To that end, we propose that performance relative to aspiration may induce two sequential decision making processes – motivation to undertake change in organizational routines of search activity and the direction of organizational search.

Performance Aspiration Induces Motivation of Organizational Search

Organizational search is a central concept in organizational learning theories and the performance feedback model in particular. Organizational search has been conceptualized as a learning process through which decision makers in organizations attempt to solve problems they encounter (Cyert & March, 1963; Huber, 1991; Nelson & Winter, 1982). Due to bounded rationality and existing organizational routines, decision makers tend to engage in local search for solutions to the problems they encounter. Local search (also referred to as exploitation) has been defined as learning gained via experiential refinement and selection of existing routines. (Nelson & Winter, 1982). Not until search leading to satisfying outcomes do decision makers expand local search to non-local search (also referred to as exploration – exploring or experimenting ideas that are new to organizations or their industry). Decision makers in organizations may pursue local and non-local search simultaneously; however, there is bias toward local search because of the certainty of the immediate outcome of search (Denrell & March, 2001; Levinthal and March, 1993; March, 1991).

Recent studies on innovation have examined patterns of organizational search across technological space. For example, Fleming and his colleague (Fleming, 2001; Fleming & Sorensen, 2004) showed that technological invention is a driven by a firm's recombinative capability - the ability to incorporate different knowledge elements to create new knowledge. Sorensen and Stuart (2000) examined the patenting activity of semiconductor and biotechnology firms and found that firms tended to rely more on local search by searching their own aging patents. Although such local search activity reduced the cost of technological development, it reduced the impact of their innovations. Katila (2002) conceptualized local search as time to examine its impact on new product introduction in the robotics industry. She documented that although searching for old knowledge of the focal organizations and competitors was helpful for innovation because of reliability and legitimacy, it hurt by making innovation obsolete. Katila and Ahuja (2002) reported that the combination of local and non-local search had a greater positive effect on the rate of new product introductions in the robotics industry compared to local search or non-local search alone. In addition, the more non-local search conducted, measured by the ratio of new citations over total citations, the greater the number of new products introduced. The abovementioned studies document the effects of organizational search on technological innovation; however, they have not specified if the direction of organizational search is conditional on performance relative to aspiration.

We argue that the direction of organizational search for technological knowledge depends upon performance relative to aspiration. Specifically, decision makers in organizations that experience performance falling below their aspiration may be motivated to change their technological search activity (Chen, 2008; Chen & Miller 2007). The greater the distance of performance below aspiration, the higher the motivation to change the activity. Though such change is risky and uncertain, the declining performance calls current organizational routines in technological search in question and signals the need for change. Since organizations race for new technological knowledge search (Katila & Chen, 2008) and observe other firms' search behaviors and intensity (Baum et al., 2000; Chen & Miller, 2007; Chuang & Baum, 2003; Ocasio, 1997; Park 2007), they are likely to increase the rate of searching for new technological knowledge higher than that of other firms when their performance is below aspiration. By increasing the rate above other firms, organizations might be able to launch new products early and improve their performance. In contrast, decision makers in organizations that experience performance above aspiration may be less likely to change their current technological search activity (Greve, 1998). Their performance above aspiration indicates current search activity is satisfactory. Such performance can also increase managerial complacency (Cyert & March 1963) and reduce their motivation to attend to technological search activity of other firms (Ocasio, 1997). The above reasoning leads to the following hypotheses:

Hypothesis 1a: The distance of a firm's performance below its aspiration will be positively associated with the probability of the firm's increases in searching new technological knowledge to be above the industry average.

Hypothesis 1b: The distance of a firm's performance above its aspiration will be negatively associated with the probability of the firm's increases in searching new technological knowledge to be above the industry average.

Differential Non-local Search Induced by Performance Aspiration

Hypotheses 1 proposed that performance relative to aspiration influences the motivation of decision makers in organizations to modify their rates of search for new technological knowledge. However, it is not clear in the past literature how performance relative to aspiration guides the direction of organizational search if decision makers are motivated by performance aspiration to engage search activity. Search is usually costly due to its association with uncertainty (March, 1991). Organizations are often faced with insufficient information and knowledge about the success and failure of their own actions and the actions of others when developing technologies. Under such conditions of ambiguity and uncertainty, organizations may examine the technological knowledge developed other organizations in order to adjust their own technological development to reduce the degree of ambiguity and uncertainty they encounter (Levitt & March, 1988).

We propose performance below and above aspiration can lead to different non-local search activities. When performance is far below aspirations and decision makers are motivated to increase their search for new knowledge in the technological space, their search attention will be likely to be directed towards to the knowledge developed by other organizations that they have not exploited. In the process of non-local search, decision makers may explore various technological knowledge that is new to their organizations in attempt to improve their performance. However, technological knowledge in the technological space competes for resources and attention and there are practical limitations on how many can be adopted. Faced with uncertainty associated with unfamiliar technological knowledge and resource limitation derived from poor performance, decision makers may be more likely to search for the ones developed by other organizations in their industry (Baum et al., 2000; Haunschild & Miner, 1997; Levinthal & March, 1993; Park 2007). In addition, search for technological knowledge outside the industry might require more integration efforts (Grant, 1996). Hence, decision makers are more likely to search technological knowledge developed by other firms in the industry when their search is motivated by performance below aspiration.

In contrast, when performance is above aspiration, decision makers in organizations may engage in a different kind of non-local search activity if they are motivated by their high performance. It is plausible that decision makers are less likely to explore technological knowledge developed by other organizations in their industry. Instead, the decision makers may direct their efforts to explore technological knowledge outside the industry. By exploring such knowledge organizations can further enhance their innovativeness (Katila, 2002). Such exploration can also help organizations to strengthen recombinative search capability by providing more knowledge elements for technological development (Fleming 2001). While the exploration of technological knowledge that is new to the industry usually costly and uncertain, their slack resources derived from prior high performance may serve to buffer the potential cost associated with exploration. In addition, by searching technological knowledge of other organizations in the industry could have detrimental effects on firm's innovativeness as there is practically a limit on the applications of such knowledge (Fleming, 2001; Katila, 2002; Katila & Chen, 2008). Therefore, decision makers are less likely to search technological knowledge developed by other organizations in the industry when their search is motivated by performance above aspiration. Thus,

Hypothesis 2a: The distance of a firm's performance below its aspiration will be positively associated with the quantity of other firms' technological knowledge in its industry cited by the firm.

Hypothesis 2b: The distance of a firm's performance above its aspiration will be negatively associated with the quantity of other firms' technological knowledge in its industry cited by the firm.

Influence of Technological Knowledge Network of the Industry

To this point, we have described the differential effects of performance relative to aspiration on organizational search activity. However, recent studies have suggested that such effects can be influenced by organizational contextual factors such as experience (Baum & Dahlin, 2007) and decision maker's attention patterns (Chen & Miller, 2007; Greve, 2008; Park 2007). More broadly, prior studies have suggested that decision maker's attention patterns guide organizational search activity (Ocasio, 1997) and such patterns can be influenced by environmental factors (Gavetti et al., 2007; Greve, 2003a). Thus, it is possible that an organization's relationship with other organizations can play an important role shaping the organization's search activity in response to performance relative to aspiration.

A large body of research on interorganizational relationships has documented that an organization's relationships with other organizations exert great influence on organizational innovation (e.g., Ahuja, 2000; Phelps, 2010; Stuart & Podolny, 1996). Research on technological innovation has also suggested that organizations draw upon prior technological inventions of other organizations to develop new knowledge (e.g., Fleming, 2001; Katila, 2002; Katila & Chen, 2008; Podolny, Stuart, & Hannan, 1996). Such technological relationships among organizations in the technological space form a technological knowledge network that influences organizational performance (Podolny et al., 1996). Figure 1 depicts a subset of the technological knowledge network of patenting activity derived from semiconductor firms between 1996 and 2000. As shown in Figure 1, firm 65 drew upon patents developed by firms 20 and 699. Many firms in the industry used firm 655's patents to develop their technological knowledge; at the same time, firm 655 used firm 65's patents to develop its own knowledge.

<<Insert Figure 1 about here>>

As organizations search for new knowledge in the technological knowledge network, their relationships in such a network might influence how the organizations react to their performance relative to aspiration. Specifically, an organization's position in the technological knowledge network of its industry can influence the organization's ability to exploit the technological knowledge developed by other organizations. When an organization is in a more central position of the technological knowledge network, the organization is more likely to not only have understood the technological knowledge of other organizations upon which the organization has drawn but also enable to appreciate other knowledge that has been explored by the organizations. The firm may also have better recombinative capacity as it has access to various knowledge elements due to its network position. As such, the firm may have a better ability to exploit technological knowledge of other organizations in the network.

For an organization with performance far below aspiration, we argue that the organization is more likely to have better understanding of different technological knowledge developed by other organizations when the organization occupies in a more central position of the technological knowledge network of its industry. The position may help the organization to reduce ambiguity and uncertainty associated with searching for technological knowledge. As such, the organization is likely to draw upon other organizations' technological knowledge in response to performance below aspiration in an attempt to enhance its future performance. Therefore, an organization's position in the technological knowledge network of its industry can increase the positive effect of performance below aspiration on the organization's search intensity of technological knowledge owned by other organizations in the industry.

As to an organization with performance above aspiration, we propose that the organization occupying in a more central position of the technological knowledge network of its industry is more likely to draw upon the technological knowledge of other organizations in the industry to exploit their technological capabilities. Particularly, the organization that is in a central position of the network may have developed organizational routines for searching technological knowledge of other organizations in the industry. Searching for new knowledge outside the industry might require different internal coordination routines to realize the usefulness of the knowledge (Henderson & Clark, 1990). To economize information processing and reduce search uncertainty, the organization is more likely to continue deploying the routines to search technological knowledge of other organizations the organization already has access. Therefore, for an organization with performance above aspiration, the more central its position in the technological knowledge network of its industry, the less likely the organization will explore technological knowledge outside the industry. Formally, we hypothesize,

> *Hypothesis 3a: The positive effect of performance below aspiration on the quantity of other firms' technological knowledge in its industry will be stronger as a firm's degree of centrality in the technological knowledge network of the industry increases.*
>
> *Hypothesis 3b: The negative effect of performance above aspiration on the quantity of other firms' technological knowledge in its industry will be weaker as a firm's degree of centrality in the technological knowledge network of the industry increases.*

In addition to the influence of an organization's position in the technological knowledge network on its response to performance relative to aspiration, it is possible that the density of the technological knowledge network of an industry may moderate the relationship between performance relative to aspiration and the direction of technological search. Prior research on social networks suggests that the degree of interconnectedness among organizations facilitates the development of common mindsets and appropriate action (Burt, 2005; Coleman, 1988). When the technological knowledge network of an industry is dense, organizations in the industry are likely to attend to and have better understanding of each other's technological knowledge. The information on the new knowledge developed by other organizations is also quickly diffused in the industry. Further, organizations may have developed similar recombinative routines to combine technological knowledge shared among organizations since organizations in such a network are likely to draw from similar pool of technological knowledge.

We propose that the density of the technological knowledge network of an industry can shape the direction of organizational search induced by performance relative to aspiration. Specifically, when the network is highly dense, the high interconnectedness of organizations' technological knowledge not only facilitates organizations to develop similar understanding of technological process and market demands but also direct organizations' attention to other organizations' knowledge. Such interconnectedness might prompt organizations to engage in exploitation of other organizations' technological knowledge. When decision makers engage in non-local search induced by performance below aspiration, the high interconnectedness of the technological knowledge network may provide an opportunity for the organization to reduce search cost (cf. Phelps, 2010). Therefore, decision makers are more likely to search for technological knowledge of other organizations in the industry to respond to performance below aspiration in a denser technological knowledge of the industry. In contrast, when decision makers in organizations engage in non-local search induced by performance above aspiration, the high interconnectedness of the technological knowledge network may impose constraints on the decision makers' attention to technological knowledge outside the industry. Though their organizations might have accumulated slack derived from their past high performance which allows them to explore technological knowledge that is new to the industry, the common mindsets stemming from the high network density may reduce their propensity to search for knowledge outside the industry (cf. Coleman 1988). Thus, the decision makers may be more likely to search for technological knowledge in the network to explore new combinations of technological knowledge. Accordingly, we propose,

Hypothesis 4a: The positive effect of performance below aspiration on the quantity of other firms' technological knowledge in its industry will be stronger as the density of the technological knowledge network of the industry increases.

Hypothesis 4b: The negative effect of performance above aspiration on the quantity of other firms' technological knowledge in its industry will be weaker as the density of the technological knowledge network of the industry increases.

METHODS

Our data consist of firms in the global semiconductor industry, 2000 – 2008. The semiconductor industry provides a good opportunity to examine the relationship between performance relative to aspiration and organizational search activity across technological space. Technological innovation has been found to be an important factor shaping the performance and survival of semiconductor firms (e.g., Podolny et. al, 1996; Stuart, 2000). Our data came from *Dataquest* database maintained by Gartner, a market research agency specializing in the global semiconductor industry. The database has been used in prior studies on technological innovation in the semiconductor industry (e.g., Podolny, et al, 1996; Stuart, 2000). Gartner collects information on a semiconductor's sales in each market segment. Though Gartner does not collect information on the sales of all the firms in industry, the total sales of the firms included in *Dataquest* accounts approximately 90 percent of market share in the industry. As Gartner re-classified market segments in *Dataquest* in 2000, we chose Year 2000 as the first year of our observation and included all firms in the database between 2000 and 2008. As our theoretical interest is to examine how a firm's patenting activity is driven by its performance aspirations, we obtained patent data from the USPTO patent database. In total, there were 197 semiconductor firms that had filed patents in observed time period.

Dependent variables and analysis

In our theorization, we proposed a sequential model of a firm's reaction to its performance relative to aspiration. Thus, there are two dependent variables in our study. The first dependent variable, $P(Y_{it+1})$, is the probability of a firm *i* to increase its proportion of searching new technological knowledge above that of the industry average. To construct this dependent variable, we first pooled all patent citations in a firm's patents filed in year *t* and calculated the ratio of a firm's new patent citations, excluding self-citations, over the total number of patent citations listed in the firm's patents in the year. We defined a new patent citation as the patent that a firm has not cited in the five years prior to year t+1. A five-year window is used because organizational memory is not perfect and decays over time (Argote, 1999). The impact of semiconductor patents also lasts approximately 5 years (Podolny, et al., 1996). Our approach is similar to the one adopted by prior studies (Katila & Chen, 2008; Podolny et al., 1996). We further computed the difference between the ratios at year $t+1$ and year t. We then constructed the industry average of the difference and coded Y_{it+1} as 1 if a firm's difference was greater the industry average, 0 otherwise. We pooled observations on all sampled firms between 2000 and 2008 and used cross-sectional, time-series, GEE Logit regression to model a firm *i*'s propensity to increase its search for new technological knowledge above the industry average (Zeger, Liang & Albert, 1988). This technique addresses problems of multiple observations across time for the same firm (Yamaguchi, 1991). In addition, we treated the correlations within a firm over time as unstructured. In doing so, we accounted for not only the dynamics between different time *t,* but also the correlation between the behaviors of the same firm. The advantage of this treatment was that the independence assumption could be relaxed and there was no need to specify the exact within-group dynamic mechanisms and how the lag effect was distributed (Wooldridge, 2002).

Our second dependent variable is the quantity of other firms' technological knowledge that has not been used by a focal firm before. To construct this variable, we first pooled out all new patent citations in a firm's patents and counted the number of the patents that are owned by other firms in the industry. Because this measure is a nonnegative, integer count variable, using linear regression to estimate on such a variable can produce inefficient, inconsistent and biased coefficient estimates (Long, 1997). Accordingly, we employed cross-sectional, time-series, negative binomial regressions suggested by Hausman, Hall, and Griliches (1984). Unlike poisson models assuming the mean and variance of the observed distribution are equal, negative binomial models allow the variance to be greater than the mean, which is likely the case for patent citation data. In addition, past research suggested that it is important to correct for endogeneity when examining the outcomes of organizational choice (e.g., Hamilton & Nickerson, 2003). Because our second dependent variable is the outcome of a firm's reaction to performance relative to aspiration, we performed Heckman's two-stage estimation (Heckman, 1979) to correct for endogeneity biases derived from self-selection.

Independent Variables

Our theoretical interests rests on how performance relative to aspiration influences a firm's search behavior across technological space. Past studies have used various performance indices to examine the effects of performance relative to aspiration on firm behavior and outcome such as market share (Baum et al., 2005; Greve, 1998), firm size (Greve, 2008), and ROA (Chen, 2008; Chen & Miller, 2007; Iyer & Miller, 2008). In this study, we used market share as a performance proxy as it provides decision makers in a firm with information on its technological performance in the market place. Following past studies (e.g., Greve, 2003), we computed aspiration level (A) as a mixture of historical and social aspiration levels. The social aspiration level (SA) is measured by using the following formula,

$$SA=$$

$$(\sum_{i\neq j}^{n} Marketshare_j \times s_{ij}) / (n-1), \quad (1)$$

where s is the degree of similarity between firm i and j. The degree of similarity was measured as:

$$s_{ij} = \frac{\sum_{m=1}^{52} x_{im} \min(x_{im}, x_{jm})}{\sum_{m=1}^{52} x_{im}^2} \quad (2)$$

(Sohn, 2001), where x_{im} is firm i's sales in market m, x_{jm} is a rival j's sales in market m.

The historical aspiration (HA) level is a mixture of past-period historical aspiration level and the previous market share of the focal firm. Letting a1 and a2 be weights, the formulas for a focal firm i's aspiration level in a given year t are:

$$HA_{it}=a_1 HA_{i,t-1} + (1-a_1)Marketshare_{i,t-1} \quad (3)$$

$$A_{it}=a_2 SA_{i,t-1} + (1-a_2)HA_{i,t-1} \quad (4)$$

To determine the values of a1 and a2, we estimated the weights by searching for parameter values by increments of 0.1 and taking the combination given the best goodness of fit. In the models reported below, the values of 0.6 and 0.5 for a1 and a2 revealed the best goodness of fit, respectively. We then measured a firm's performance relative to aspiration as the firm's market share at year t minus its aspiration at year t. To test our hypotheses, we specified performance relative to aspiration as a spline function (Greene, 1993). Specifically, we separated performance relative to aspiration into two variables: *Performance above aspiration* and *Performance below aspiration*. *Performance above aspiration* equals zero for all observations in which performance relative to aspiration is less than zero. Symmetrically, *Performance below aspiration* equals zero for all observations in which performance relative to aspiration is greater than zero. For ease of interpretation, we reverse-coded *Performance below aspiration* so its values were positive. To support Hypotheses 1a and 2a requires positive coefficient estimates for *Performance below aspiration*. In contrast, negative coefficient estimates for *Performance above aspiration* are required to support Hypotheses 1b and 2b.

Hypotheses 3a and 3b suggested a firm's degree of centrality in the technological knowledge network of an industry would moderate the relationship between performance relative to aspiration and a firm's search behavior. We defined the technological knowledge network as the patent citation network of sampled firms in five-year moving windows. In total, our sample firms have 416,313 granted patents in the period between 1996 and 2008. To obtain the degree of centrality, we first constructed the citation matrices (e.g., 1996-2000, 1997-2001) by using citation information in the patents of all sampled firms. We then used *UCINET* 6 to obtain a firm's normalized out-degree centrality, *Out-degree centrality*. Normalized degree of centrality was used is because degree of centrality has been found to be sensitive to network size (Wasserman & Faust, 1994). Out-degree centrality is used because our theoretical interests rested upon a firm's propensity to incorporate other firms' technological knowledge to develop its own technological knowledge. To test the hypotheses, we further constructed two interaction terms, *Performance below aspiration* x *Out-degree centrality* and *Performance above aspiration* x *Out-degree centrality* after we centered each variable to its respective mean. To test Hypotheses 4a and 4b, the influence of network density, we first used the citation matrices and *UCINET* 6 to obtain *Network density*. We then constructed two interaction terms, *Performance below aspiration* x *Network density* and *Performance above aspiration* x *Network density* after we centered each variable to its respective mean.

Control variables

We controlled for several firm-specific and market-specific variables to rule out possible alternative explanations for an increase in a firm's new citation rate above the industry average. First, past research suggests that larger or more diversified firms may respond to changes in environments differently due to their resources and organizational structure (e.g., Hannan & Freeman, 1989). Thus, we included *Firm size* (measured by the natural logarithm of a firm's total sales) and *Degree of market diversification* (measured by the entropy index) to control their effects on the relationship between performance relative to aspiration on the dependent variable. Second, research on multi-market competition suggests that multi-market firms, compared to single-market firms, may behave differently due to their multi-market contact with other multi-market firms (e.g., Anand, Mesquita, & Vassolo, 2009; Baum & Korn, 1999; Scott, 2001). We included a dummy variable, *Multi-market dummy*, to control its effect on our dependent variable. *Multi-market dummy* was coded as 1 if a firm competed in more than one market in a given year, 0 otherwise. A firm's technological capability may affect its technological search ability (e.g., Katila 2002). Accordingly, we included two variables to capture their effects on our dependent variable: *Number of granted patents* (measured by the natural logarithm of a firm's granted patents in a given year) and *Degree of patent class diversification* (measured by the entropy index of a firm's international patent classes in a given year).

Prior studies on alliances have shown that a firm's alliances exert great influences on the firm's technological capability (e.g., Phelps, 2010; Stuart & Podolny, 1996). To capture the effects of alliances on a firm's ability to search across technological space, we collected alliance information from *Thomson SDC* database, one of the most comprehensive alliance databases (Schilling, 2009). Though the *SDC* provides comprehensive coverage of alliance activity, its information on the duration of alliance activity is incomplete. Following the approach used in prior research (e.g., Bae & Gargiulo, 2004; Baum, et al., 2005), we constructed a five-year moving window of alliance networks starting 1996. In total, there were 5,134 alliances among our sampled firms from 1996 to 2008. We thus included *Number of alliances* and *Normalized degree centrality* in the industry alliance network to control their effects. Finally, to capture the effect of competition on a firm's response to performance relative to aspiration, we constructed a measure of *Localized competition* by using Equation 2. For models of the quantity of patents owned by other firms in the industry, we included the main effects of *Out-degree centrality* and *Network density* as we have interaction terms.

As patenting activities may vary across markets, we also included market dummies (not reported here) to control their effects. For the models reported below, we included yearly dummy variables (not reported below) in analyses to control for the year-fixed effects on our dependent variables. Descriptive statistics are given in Table 1. We further examined if there were the potential threats from multi-collinearity by conducting VIF tests and there were not (average VIFs ranged from 2.99 to 6.62 for the models reported below).

<<Insert Table 1 about here>>

RESULTS

Table 2 presents the cross-sectional, time-series, GEE Logit models of a firm's probability of increasing its rate of new patent search above the industry average. Model 1 in the table presents the baseline and Model 2 includes performance relative to aspiration variables to test Hypotheses 1a and 1b. Hypothesis 1a proposed that a firm would be less likely to increase its ratio of new patent search above the industry average when its performance was above its aspiration. The negative coefficient estimate of *Performance above aspiration* provides evidence to support the hypothesis (-.882, $p<.05$). Specifically, a unit increase in *Performance above aspiration* reduces the odds ratio by approximate .41 time (=exp(-.882)). Hypothesis 1b suggested that a firm would be more likely to increase its ratio of new patent search above the industry average when its performance was below aspiration. The coefficient estimate of *Performance below aspiration* in Model 2 is positive and significant (5.96, $p<.10$). This supports the hypothesis. A unit decrease in *Performance above aspiration* increases the odds ratio by approximate 3.87 times higher (=exp(5.96). We also tested if the slopes for *Performance above aspiration* and *Performance below aspiration* were significantly different and they were (chi-square=2.73, $p<.10$).

<<Insert Table 2 about here>>

Turning to Hypotheses 2a and 2b, we proposed that a firm's search quantity of patents owned by other firms in the industry that the firm had not used before was contingent on its performance relative to aspiration. The coefficient estimate for *Performance above aspiration* in Model 1 in Table 3 is positive, significant (1.665, $p<.01$), supporting Hypothesis 2a. In contrast, the coefficient estimate of *Performance below aspiration* in the model is negative, significant (3.74, $p<.10$), providing support for Hypothesis 2b. These suggest the pattern of a firm's technological search is contingent on its performance relative to aspiration. Specifically, a firm is less likely to draw upon the technological knowledge developed by other firms in the industry that the firm had not used before when its performance is above its aspiration. Yet, a firm is more likely to exploit the technological knowledge developed by other firms in the industry that the firm had not used when it experienced poor performance.

Regarding the moderating effects of the technological knowledge network of an industry, we included the interaction terms, *Performance below aspiration* x *Out-degree centrality* and *Performance above aspiration* x *Out-degree centrality* in Model 2 to test Hypotheses 3a and 3b, respectively. The negative coefficient estimate for *Performance below aspiration* x *Out-degree centrality* (-1.631, $p<.01$) and the non-significant coefficient estimate for *Performance above aspiration* x *Out-degree centrality* fail to support the hypotheses. To better appreciate the significant interaction effect of *Performance below aspiration* x *Out-degree centrality*, we used the observed data range and the coefficients in the model to show the effect in Figure 2. As shown in Figure 3, the effect of performance above aspiration on the quantity of patent citations is negative. The negative effect becomes stronger when a firm's out-degree centrality in the network increases.

<<Insert Table 3, Figures 2 and 3 about here>>

In terms of the moderating effects of the network density proposed in Hypotheses 4a and 4b, we included the two interaction terms, *Performance below aspiration* x *Network density* and *Performance above aspiration* x *Network density* to examine their effects in Model 3. The positive, significant coefficient estimate for *Performance below aspiration* x *Network density* provides support for Hypothesis 4a (.0247, $p<.01$). However, the positive but non-significant coefficient estimate for *Performance above aspiration* x *Network density* does not support Hypothesis 4b. To show the significant interaction effect, we plotted the interaction graph in Figure 3 by using the observed data range in our sample. As shown in Figure 3, the effect of performance above aspiration remains negative. However, the magnitude of the negative effect becomes weaker as the network density increases. These imply that a firm with performance above aspiration becomes more likely to search for patents developed by other firms in the industry when network density increases.

Finally, the effects of several control variables are worth mentioning. The number of patents owned by a focal firm has a negative effect on its likelihood to increase the rate of new patent search above the industry average and has no effects on a firm's direction of technological search. The number of alliances a firm decreased not only the firm's likelihood to increase the rate of new patent search but also the rate of citing new patents owned by other firms in the industry. However, a firm's centrality in the industry alliance network exerted positive influences on both the rate of new patent search and the rate of citing new patents owned by other firms.

DISCUSSION AND CONCLUSION

How organizations adjust their behaviors in response to their performance is a central question in organizational learning theories and the performance feedback model in particular (Cyert & March, 1963; Greve, 2003a). While past research has made significant progress to demonstrate that performance relative to aspiration leads to organizational adaptation, the understanding of the detailed processes by which decision makers act upon performance aspiration to adjust their behaviors remains limited. Particularly, there are inconsistent findings in past studies on the effects of performance relative to aspiration on organizational behavior and outcomes. As well, there is limited evidence of how performance relative to aspiration influences the patterns of organizational adaptation.

In this study, we built upon prior research on the performance feedback model by decomposing decision making of organizational adaptation into two sequential processes. Using patenting activity of semiconductor firms, we showed that performance relative to aspiration not only exerted great influence on a firm's motivation to change its technological search routines but also shaped how the firm searched for technological knowledge that was new to the firm. In comparison to prior studies, our analysis of the sequential processes reveals interesting results. Specifically, our analysis of the motivation to respond to performance aspiration is broadly consistent with what the performance feedback model would predict (Cyert & March, 1963;

Greve, 2003a) and with findings reported by prior studies examining the probability of organizational change (Iyer & Miller, 2008; Greve, 1998). Particularly, we provide an additional evidence to support that decision makers are less likely to modify their organizational routines when their performance is above aspiration. Success breeds managerial complacency, which in turn may lead to organizational inertia and competency trap (Levintal & March, 1993).

Our analysis on the pattern of organizational search induced by performance relative to aspiration provides valuable additions to the research of the performance feedback model and technological innovation. Chen (2008) showed that performance relative to aspiration exerted great influence on R&D intensity. Park (2007) reported that organizations were more likely to model their resource allocation after successful organizations when their performance was below aspiration. Here, we showed that semiconductor firms were increasingly likely to expand the scope of their technological search when the distance of performance relative to aspiration increased. Yet, the direction of technological search differs between performance above and below aspiration. Specifically, we found that semiconductor firms were more likely to search technological knowledge of other firms in the industry when their performance was below aspiration and less likely to search such knowledge when their performance was above aspiration. Accordingly, we provide additional insights into how performance relative to aspiration affects the pattern of organizational search. Prior studies have implied performance aspiration influences the direction of organizational search (Baum & Dahlin, 2007; Greve 2003a; Park 2007). Baum and his colleagues (2005) showed that investment banks were more likely to chose another bank with which they had not work with when the distance of their performance relative to aspiration increased. Our study made one step further to show that performance relative to aspiration led to differential non-local search activities.

Moreover, our examination of the moderating effects of the technological knowledge network of an industry sheds light on the call for research on contextual factors that influence the effect of performance aspiration on organizational behavior (Gavetti et al., 2007). Our results revealed that the technological knowledge network had little effect on the relationship between performance below aspiration and searching for technological knowledge of other firms in the industry. Yet, the network exerted interesting influence on the effect of performance above aspiration on searching for other firm's technological knowledge. Occupying a central position in the network allows an organization to enhance its recombinative capability that has potential to help the organization to explore knowledge that is new to its industry when its performance is above aspiration. Yet, being situated in a highly dense network constrains an organization from exploring new knowledge by directing its attention to the knowledge within the industry when its performance is above aspiration.

Our study also provides important implications to research on technological innovation. Katila and her colleagues (Katila, 2002; Katila & Ahuja, 2002; Katila & Chen, 2008) documented how the variety of technological search dimensions of an organization affected its product innovation. We showed that how such technological search could be driven by performance aspiration. Fleming (2001) pointed to the importance of recombinative search in shaping technological innovation of an organization. We provided some evidence as to how recombinative search was developed through an organization's response to its performance aspiration. Notwithstanding, our study has limitations due to our data and research design, which provide avenues for future research. Prior studies have explored the effect of organizational slack on how an organization responds to its performance aspiration (Chen, 2008; Greve, 2003b; 2008). Our data limits us to explore such an effect on the pattern of organizational search. Nor do our data allow us to examine the effect of the distance to bankruptcy on organizational search behavior (Chen, 2008; Chen & Miller, 2007; March & Shapira, 1992). Future research into such effects is warranted. Our research design did not explore the consequent performance (either market or technological performance) after an organization responds to its performance aspiration. This would be an important theoretical and practical question – whether organizational search induced by performance aspiration is beneficial for the organization in terms of future performance. Future research exploring such a question will be fruitful for our understanding of organizational learning and adaptation. To that end, we see there are many ways to build upon our analysis of the relationship between performance aspiration and organizational search to better understand organizational behavior.

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Figure 1. A subset of the technological knowledge network of patenting activity of semiconductor firms between 1996 and 2000.

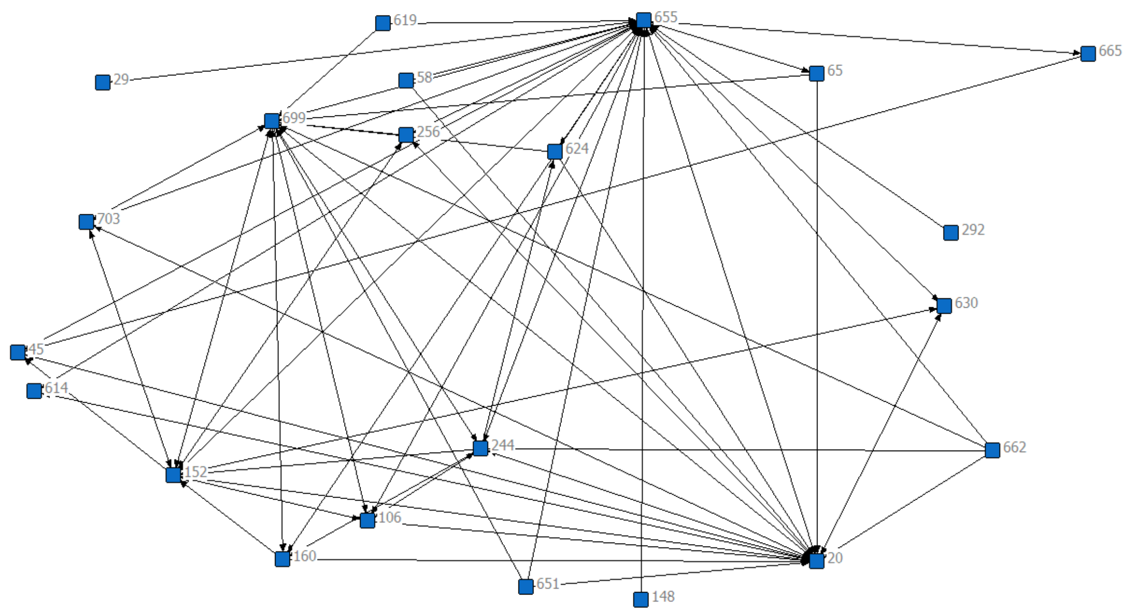

Figure 2. The moderating effect of out-degree centrality on the relationship between performance relative to aspiration and quantity of patents owned by other firms in the industry

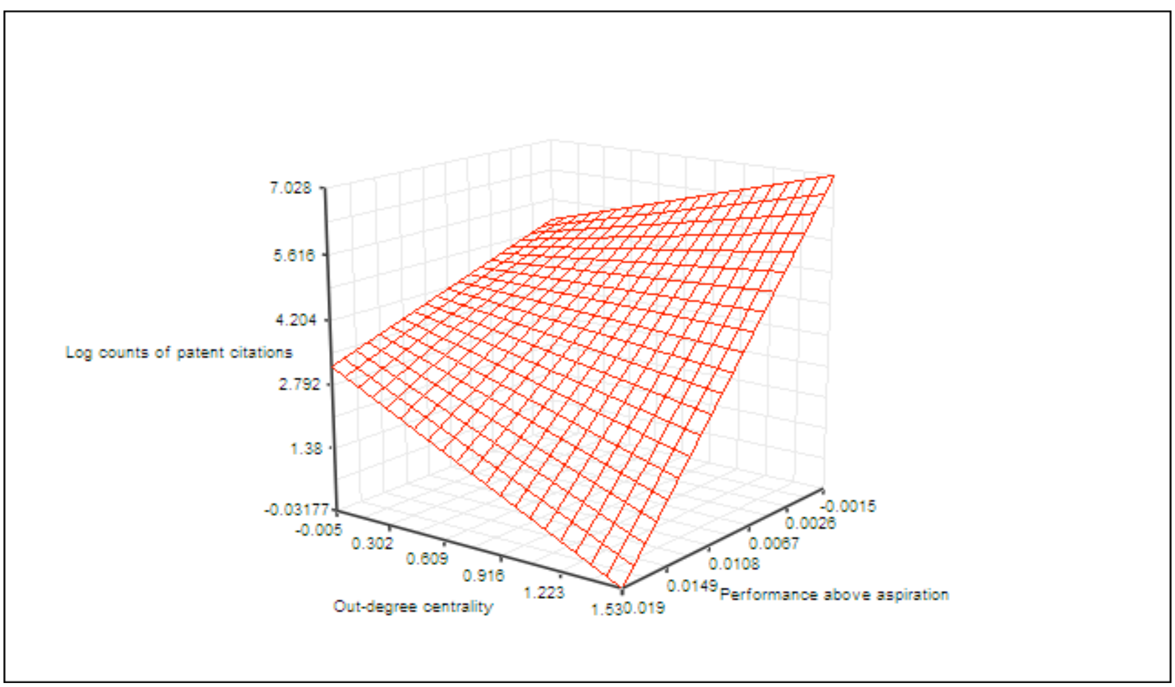

Figure 3. The moderating effect of network density on the relationship between performance relative to aspiration and quantity of patents owned by other firms in the industry

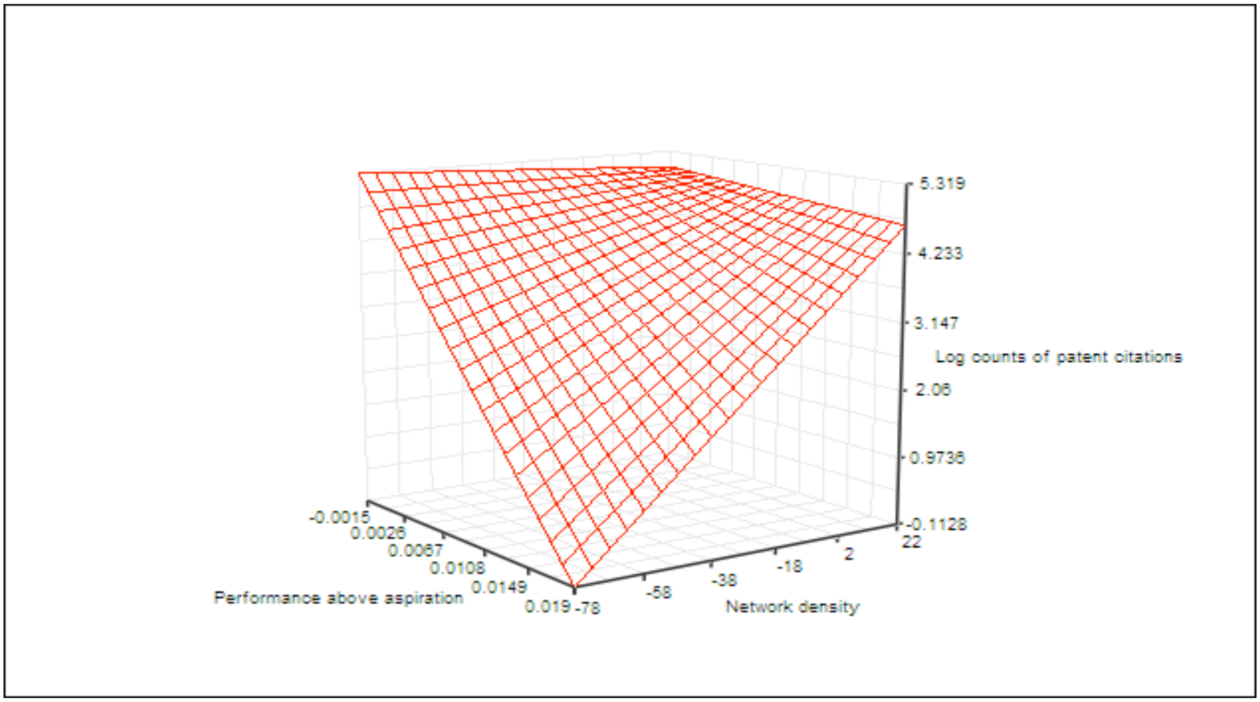

Table 1. Descriptive statistics and correlations for theoretical and control variables

Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9
1 Performance above aspiration	0.308	0.792	1.00								
2 Performance below aspiration	0.028	0.049	-0.22	1.00							
3 Firm size	5.980	1.583	0.63	-0.55	1.00						
4 Degree of market diversification	0.909	0.800	0.31	-0.23	0.51	1.00					
5 Multi-market firm dummy	0.752	0.432	0.16	-0.14	0.32	0.65	1.00				
6 Number of patents	3.135	2.047	0.42	-0.32	0.59	0.32	0.17	1.00			
7 Degree of patent class diversification	1.770	1.008	0.28	-0.19	0.44	0.34	0.18	0.82	1.00		
8 Degree centrality in the industry alliance network	0.095	0.279	0.32	-0.16	0.36	0.31	0.13	0.32	0.38	1.00	
9 Number of alliances	5.683	17.705	0.38	-0.14	0.37	0.36	0.13	0.40	0.41	0.74	1.00
10 Localized competition	0.093	0.071	-0.31	0.84	-0.55	-0.14	-0.04	-0.35	-0.16	-0.20	-0.16

Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11
1 Performance above aspiration (centered)	0.000	0.367	1.00										
2 Performance below aspiration (centered)	0.000	0.054	-0.29	1.00									
3 Out-degree centrality (centered)	0.000	0.156	0.58	-0.15	1.00								
4 Network density (centered)	0.000	21.816	-0.40	0.14	-0.51	1.00							
5 Firm size	5.723	1.357	0.74	-0.55	0.50	-0.38	1.00						
6 Degree of market diversification	0.857	0.750	0.48	-0.14	0.31	-0.27	0.43	1.00					
7 Multi-market firm dummy	0.752	0.432	0.15	-0.02	0.12	-0.01	0.18	0.66	1.00				
8 Number of patents	2.648	1.515	0.41	-0.31	0.48	-0.34	0.59	0.20	0.06	1.00			
9 Degree of patent class diversification	1.660	0.832	0.18	-0.12	0.35	-0.23	0.37	0.22	0.12	0.78	1.00		
10 Degree centrality in the industry alliance network	0.056	0.235	0.33	-0.16	0.42	-0.22	0.35	0.31	0.10	0.26	0.28	1.00	
11 Number of alliances	2.956	10.932	0.44	-0.17	0.42	-0.21	0.40	0.36	0.11	0.24	0.23	0.85	1.00
12 Localized competition	0.106	0.072	-0.36	0.83	-0.26	0.19	-0.54	-0.05	0.10	-0.33	-0.10	-0.18	-0.18

Table 2. GEE Logit Models of Firm's Response Likelihood

	Model 1	Model 2
Theoretical variables		
H1a		
Performance above aspiration		-.882*
		[.399]
H1b		
Performance below aspiration		5.965+
		[3.122]
Control variables		
Firm size	0.146	0.352**
	[0.098]	[0.125]
Degree of market diversification	0.050	0.135
	[0.180]	[0.196]
Multi-market firm dummy	0.023	0.051
	[0.236]	[0.251]
Number of patents	-0.603**	-0.537**
	[0.093]	[0.098]
Degree of patent class diversification	0.260+	0.201
	[0.153]	[0.163]
Degree centrality in the industry alliance network	0.774+	0.809+
	[0.408]	[0.449]
Number of alliances	-0.022*	-0.024*
	[0.010]	[0.011]
Localized competition	-0.700	-4.037
	[1.516]	[2.461]
Constant	-1.413	-2.445*
	[1.078]	[1.120]
Observations	911	911
Number of firms	197	197
wald chi_sq	72.39	59.85

Standard errors in brackets
** p<0.01, * p<0.05, + p<0.1

Table 3. Random-effects of Negative Binomial Regression Models of Patent Citations

	Model 3	Model 4	Model 5
Theoretical variables			
H2a			
Performance above aspiration (centered)	-1.665**	-.955*	-.723+
	[.343]	[.397]	[.388]
H2b			
Performance below aspiration (centered)	3.740+	3.086	3.268
	[1.970]	[2.465]	[2.097]
H3a			
Performance above aspiration (centered) x		-1.631**	
Out-degree centrality (centered)		[.394]	
H3b			
Performance below aspiration (centered) x		-3.385	
Out-degree centrality (centered)		[5.023]	
H4a			
Performance above aspiration (centered) x			.0247**
Network density (centered)			[0.005]
H4b			
Performance below aspiration (centered) x			0.0143
Network density (centered)			[.031]
Control variables			
Out-degree centrality (centered)	-0.155	0.989*	0.767*
	[0.331]	[0.436]	[0.344]
Network density (centered)	-0.001	-0.000	0.001
	[0.002]	[0.002]	[0.002]
Firm size	0.579**	0.477**	0.489**
	[0.134]	[0.138]	[0.134]
Degree of market diversification	0.173+	0.137	0.176+
	[0.096]	[0.097]	[0.094]
Multi-market firm dummy	0.008	-0.006	0.009
	[0.122]	[0.121]	[0.120]
Number of patents	0.175	0.190	0.135
	[0.176]	[0.176]	[0.176]
Degree of patent class diversification	-0.024	-0.015	0.026
	[0.104]	[0.103]	[0.103]
Degree centrality in the industry alliance network	1.257**	0.986*	1.355**
	[0.401]	[0.416]	[0.394]
Number of alliances	-0.028**	-0.026*	-0.035**
	[0.011]	[0.011]	[0.011]
Localized competition	-2.237	-1.793	-1.922
	[1.484]	[1.827]	[1.572]
mills_1	-1.882**	-1.659**	-1.880**
	[0.518]	[0.519]	[0.514]
Constant	-5.335**	-4.318**	-4.671**
	[1.547]	[1.562]	[1.538]
Observations	412	412	412
Number of firms	143	143	143
log-likelihood	-1813.39	-1809.54	-1808.64

Standard errors in brackets
** p<0.01, * p<0.05, + p<0.1