

Unbundling the effect of prior invention experience from firm size on future exploratory and exploitative search

Feibo Shao^{a†1} and Timothy A. Hart^{b†}

^aSpears School of Business, Oklahoma State University, Stillwater, United States; ^bDepartment of Management and Marketing, Collins College of Business, The University of Tulsa, Helmerich Hall, South Tucker Drive, Tulsa

ABSTRACT

This paper examines the role of prior invention experience on future search activities within the pharmaceutical industry. Specifically, we examine to what extent prior invention experience influences future exploratory and exploitative search behavior by firms. The results indicate there is a negative relationship between prior experience and future exploratory search, but a positive effect of prior experience on future exploitative search. Additionally, we find that these effects are moderated by firm size. Specifically, firm size mitigates the negative relationship between prior experience and future exploratory search, and also weakens the positive relationship between prior experience and future exploitative search.

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1. Introduction

To resolve problems generated by a lack of knowledge, firms engage in search behaviors to acquire new knowledge (Chang, 1996). Organizational search, processes by which organizations seek out new knowledge (Cyert & March, 1963), is a critical component of organizational learning (Huber, 1991), particularly in knowledge intensive industries. The extent to which firms can efficiently recognize, acquire, and exploit new knowledge influences their competitive advantage (Grant, 1996; Teece, Pisano, & Shuen, 1997).

There are two broad categories of organizational search through which firms can discover new knowledge: exploratory and exploitative search (March, 1991). Firms in knowledge intensive industries typically must simultaneously engage in both types of search to remain competitive, a concept known as ambidexterity (O'Reilly & Tushman, 2008; Tushman & O'Reilly, 1996). However, because of the differing capabilities required for each type of search (He & Wong, 2004) and the risks involved in switching between exploration and exploitation (Swift, 2016), firms may emphasize one type of search over another at different times. These choices are influenced by their existing knowledge base, strategies, varying levels of innovation capacity, and the nature of the external environment (Garcia-Granero, Vega-Jurado, & Alegre, 2014; Posen & Levinthal, 2012).

CONTACT Timothy A. Hart  tim-hart@utulsa.edu

[†]The authors contributed equally to this paper.

¹Current Address: Department of Management, College of Business, Missouri State University, 901 South National Avenue, Springfield, MO 65897, United States.

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Given the different mechanisms that support each type of learning behavior, what factors impact which types of search firms will engage in? In this study, we argue that firms' prior invention experience and firm size impact their future search behaviors. Following Fleming and Sorenson (2001), we define invention as a process of recombinant search over knowledge and technology landscapes. We argue that the impact of firms' prior invention experience on future exploratory and exploitative search is multi-faceted.

The present study takes a specific look at whether firms' prior invention experience predicts comparatively more exploratory or exploitative search and how organizational size moderates those relationships. We argue that prior invention experience is a significant predictor of greater future exploitative search and less exploratory search. However, these relationships are contingent on firm size. We conduct this study by exploring patenting behavior by firms in the pharmaceutical industry.

2. Theoretical background and research hypotheses

2.1. *Prior invention experience and future search*

The concept of organizational learning suggests that, while individuals comprise firms and can learn and gain new knowledge, so too can firms (Levitt & March, 1988). Firms learn through the collective experience of their members (Fiol & Lyles, 1985) and retain the lessons from those experiences in their organizational memory (Huber, 1991). They also create routines and processes that allow them to build upon prior experiences and that helps guide their future actions (Argote, 2011).

One important such action is the way in which organizations go about searching for new knowledge (March, 1991). Organizational learning scholars distinguish between two dimensions of organizational search efforts: exploratory search and exploitative search. The notion of exploration and exploitation has received much attention since it was first introduced in March's (1991) seminal paper (Lavie, Stettner, & Tushman, 2010). Exploration refers to "search, variation, risk taking, experimentation, play, flexibility, discovery, innovation," whereas exploitation is defined as "refinement, choice, production, efficiency, selection, implementation, execution" (March, 1991, p. 71). Applying this concept to the knowledge search domain, Levinthal and March (1993) define exploration as new knowledge search and define exploitation as the refinement and extension of existing knowledge and technologies (Benner & Tushman, 2003; He & Wong, 2004).

In the present study, we define exploratory search as search behaviors that seek to gather new knowledge and technologies and define exploitative search as search behaviors that seek to refine and better understand existing knowledge and technologies of the firm. Although the two types of search behaviors differ, many firms develop complementarities between them and are able to engage in both exploratory and exploitative search, to varying degrees (He & Wong, 2004; Katila & Ahuja, 2002). We examine the contexts which lead to a relative emphasis on exploration or exploitation, but not to the exclusion of either type of search.

Experience is a primary source of learning within organizations (March, 1991). However, the linkage between prior experience and subsequent organizational outcomes is uncertain (Pisano, Bohmer, & Edmondson, 2001). Dosi (1988) found that the influence of prior invention experience on firms is contingent on how prior invention affects the applicability of firms' existing capabilities, and how invention development is managed within firms. In the

present study, we define firms' invention experience as firms' experience with synthesizing existing and new technologies to refine a previous technology combination (Fleming, 2001; Henderson & Clark, 1990). Some prior work in this area examines the ultimate product that goes to market as the result of invention behaviors (e.g., Greve, 2007). However, to maintain our focus on the internal exploratory and exploitative search efforts of firms, we examine firms' invention experience (i.e., prior patenting history) and the citations within their patents.

2.2. Prior invention experience and exploratory and exploitative search

Prior invention experience helps establish organizational learning routines and procedures that facilitate the application of knowledge and provide mechanisms that increase the efficiency of learning processes (Bierly, Damanpour, & Santoro, 2009; Huber, 1991; Jansen, Van Den Bosch, & Volberda, 2006). Grant (1996) suggested that prior experience will deepen knowledge related to particular technological areas. In addition, firms with more prior invention experience will be more efficient in applying existing knowledge, and the self-reinforcing nature of learning leads to firms focusing more on known technologies (i.e., exploitative search) (Benner & Tushman, 2003; Rosenkopf & Almeida, 2003; Sorensen & Stuart, 2000).

Additionally, accumulated learning from prior invention experience enables firms to generate insights into further efficient exploitation of internal knowledge. As firms gather more invention experience, they become better able to use such experiences in future projects (Rosenkopf & Nerkar, 2001). Given that both the utilization of knowledge and the realization of the potential value of knowledge depend on firms' relevant capabilities (Khoury & Pleggenkuhle-Miles, 2011), we argue that as firms' capabilities to utilize knowledge increases as a result of the accumulation of invention experience, firms will increase their exploitative search.

In contrast to factors that promote exploitative search, firms with less invention experience will not "appreciate the significance of new technological opportunities in related areas" (Sorensen & Stuart, 2000, p. 87) because they lack the knowledge base of the particular set of technologies. Even if firms recognize the local opportunities, firms with insufficient background knowledge will lack the requisite learning routines to effectively conduct exploitative search (Cohen & Levinthal, 1990). Rather, firms with less prior experience will allocate more of their search efforts towards exploring for new knowledge (i.e., exploratory search).

Firms with less invention experience are less likely to have detailed information filters or heuristics for effective problem solving (Leiblein & Madsen, 2009). They also typically have less to lose and the cost for such firms to take risky search (i.e., exploratory search) would be less than that in firms with more accumulated experience. Accordingly, firms with less prior experience spend more time engaging in exploratory search in an effort to develop their internal knowledge base.

Also, firms with a higher level of prior invention experience have less incentive to engage in risky exploratory search (Lavie et al., 2010). When firms have accumulated substantial invention experience in particular technological domains, it is challenging, though not impossible, for them to assimilate additional new knowledge into their existing knowledge bases (Zhou & Wu, 2010). The costs associated with new knowledge assimilation by unlearning their existing knowledge (Levinthal & March, 1993) often encourage firms to somewhat

decrease their focus on exploratory search (March, 2006). For these reasons, we argue that firms with less prior invention experience will engage in more exploratory search and firms with more prior invention experience will engage in more exploitative search. Therefore,

H1: Prior invention experience is negatively related to exploratory search.

H2: Prior invention experience is positively related to exploitative search.

2.3. Moderating role of firm size

In addition to examining the impact of prior invention experience on future search behaviors, we also seek to more particularly examine the moderating role of firm size on these relationships. The literature on the relationship between firm size and invention activity has been plagued with diverse and often conflicting results. Some studies find a positive association between firm size and invention productivity (Cohen & Klepper, 1996). However, some scholars find a negative effect of firm size (Chakrabarti, 1991; Graves & Langowitz, 1993). Still other scholars examine the boundary conditions under which large or small firms have a relative invention advantage and suggest that the main effect between firm size and organizational search behaviors is moderated by absorptive capacity (Lee & Sung, 2005) or an industry's degree of concentration (Acs & Audretsch, 1987). We seek to further investigate this relationship by examining the moderating role of firm size on organizational search behaviors.

With respect to size, the primary advantage of small firms is speed (Allocca & Kessler, 2006) and flexibility (Gopalakrishnan & Damanpour, 2000). Simpler and less bureaucratic structures of small firms facilitate effective communication across different divisions and functional areas throughout the organization (Gopalakrishnan & Bierly, 2006). Small firms with less internal resistance are usually more flexible to transfer external knowledge throughout the organization (Rosenkopf & Nerkar, 2001).

As firms grow larger, they develop multiple layers of administrative staff and formal rules of communication (Kasarda & Janowitz, 1974; Terrien & Mills, 1955). Large firms are more likely to be influenced by bureaucratic inertia, which may distract R&D professionals from concentrating on search activities that can lead to inventions (Acs & Audretsch, 1991). Large firms tend to build on existing knowledge bases via exploitative search to extend previous technological trajectories (Rosenkopf & Nerkar, 2001).

Despite the challenges of size, large firms also have certain advantages, such as the possession of critical assets, strong bargaining power, a growing body of tangible and intangible resources, and an infrastructure to support research activities (Teece, 1986). As firms grow in size, they also have more control over the external environment and can influence the trajectory of technological development (Darnall, Henriques, & Sandorsky, 2010; Haase & Franco, 2011).

With broader research capabilities, managers and R&D professionals in larger firms have sufficient knowledge frameworks by which they can assess, interpret, and assimilate new knowledge (Rosenkopf & Nerkar, 2001). Because of this, larger firms are more likely to have both greater access and abilities to explore for new knowledge. Thus, we argue that the negative slope between invention experience and exploratory search becomes less precipitous in large firms than in small firms. Therefore,

H3a: Firm size moderates the relationship between prior invention experience and exploratory search, such that the negative relationship between prior invention experience and exploratory search is mitigated.

Size can also serve as an important moderator of the relationship between prior invention experience and exploitative search. Firms of larger size usually have greater structural complexity, such as multi-hierarchical levels (Blau & Schoenherr, 1971). Within the organizational sociological paradigm, a variety of studies on size and organizational structure indicate that increases in firm size are associated with increases in communication and coordination problems (Blau & Schoenherr, 1971). Communication and coordination costs related to internal knowledge flow increase with hierarchical levels of the organization (Gopalakrishnan & Bierly, 2006). Relatively speaking, smaller firms usually have better and more effective communication across different R&D divisions and across different functional areas because of a simpler and less bureaucratic structure (Cordero, 1991). Larger firms, however, lack efficiency during the process of internal knowledge utilization and refinement because of their more hierarchical and complicated structures.

Therefore, large firms with complicated organizational structures and multiple levels of hierarchy influence the efficiency of knowledge application within the organization. Accordingly, there is a negative moderating effect of firm size on the positive association between prior invention experience and exploitative search. Such that, the positive slope between prior invention experience and exploitative search becomes less precipitous in large firms than in small firms. Therefore,

H3b: Firm size moderates the relationship between prior invention experience and exploitative search, such that the positive relationship between prior invention experience and exploitative search is weakened.

3. Methodology

3.1. Sample

To test these hypotheses, we gather data from the pharmaceutical industry, one of the most scientific and technologically-intensive industries in the world (Sorensen & Stuart, 2000), which has one of the highest propensities to conduct both exploratory and exploitative search (Dunlap-Hinkler, Kotabe, & Mudambi, 2010). The pharmaceutical industry is believed to represent a fertile ground for research into organizational search behaviors (Bianchi, Chiaroni, Chiesa, & Frattini, 2011), as firms seek to be competitive in the industry by continuously investing in exploration- and exploitation-focused R&D projects.

The sample is comprised of pharmaceutical firms that engage in research, discovery, development, and commercialization of new drugs. We first searched for all firms in the pharmaceutical industry (identified as being in Standard Industrial Classification (SIC) 2834 or North American Industry Classification System (NAICS) 325412). From there, we removed firms for which pharmaceutical sales accounted for less than half of their total sales (Bierly & Chakrabarti, 1996). In order to examine firms for which the choice of exploratory and exploitative search is a real choice, we excluded firms in the pharmaceutical industry that focused primarily on generic drugs (Gassmann, Reepmeyer, & von Zedtwitz, 2004).

Because the pharmaceutical industry is rife with acquisitions, we tracked corporate affiliations for each year so that patenting activity could be appropriately attributed. For

example, assume that company X owns companies Y and Z. We aggregate all patents by companies X, Y, and Z and track them as from company X. This additional step of sample construction allowed for a more precise view of total prior invention experience by each company. This step also reduced the number of unique firms in the data-set because when firms were acquired, their patents then became the property of the acquiring firm. It is also important to note that if firms did not file patents in a given year, or were no longer publicly traded, they were not included in that year. Ultimately, these steps result in a final data-set of 101 publicly traded firms, beginning in 1996 until the end of 2005, comprised of 443 firm-year observations. The number of years in which firms were included ranged from 1 to 10 years. Forty-three firms were included between 1–3 years, 37 firms included between 4–7 years and 21 firms were included between 8–10 years.

3.2. Measurement of variables

3.2.1. Dependent variables

We use patent data to derive a number of variables to test the hypotheses because patent documentation provides valuable information about the search processes utilized by firms in their invention activities. Patenting, while not the only means by which firms can protect their intellectual property (Seldon, 2011), is clearly one of the most important ways, especially in the pharmaceutical industry (Dunlap-Hinkler et al., 2010). Further, although patent citation data may only capture codified knowledge flows and fail to capture tacit knowledge (Phene, Fladmoe-Lindquist, & Marsh, 2006), tacit knowledge flows and codified knowledge flows are closely related and complementary to each other (Mowery, Oxley, & Silverman, 1996). Because we focus on only one industry, we avoid the potential limitation that patenting varies across industries. Furthermore, patents embrace know-how into the product and process technologies (Kogut & Zander, 1993) and the extant research strongly indicates the appropriateness of using patent data to measure search behaviors (Cantwell, 1989). Thus, to examine the impact of prior invention on future exploratory and exploitative search, the use of pharmaceutical patent data is appropriate (Dunlap-Hinkler et al., 2010). To collect the patent and citation data in the pharmaceutical industry in the United States, we use data from Delphion (now part of Thomson Reuters) which is a subscription-based patent data website (Thomson Reuters, 2016).

Research in this area uses a variety of operationalizations to measure exploration and exploitation. For example, some scholars define an exploratory invention as one in which a focal firm did not have any other patents filed in the same technological class in the preceding five years (and exploitation if they did) (Lin & Chen, 2014; Nooteboom, Van Haverbeke, Duysters, Gilsing, & van den Oord, 2007). In another study, scholars identify exploratory inventions as those that cite *no* other patents at all (Ahuja & Lampert, 2001), while exploitative inventions are those that include one or more citations (Quintana-Garcia & Benavides-Velasco, 2008). In a related vein, (Stettner & Lavie, 2014) consider exploration and exploitation from the perspective of product introductions, where every product is classified as one or the other. Moreover, some studies even differentiate between two types of exploitation (Piao & Zajac, 2016) and four types of exploration (Rosenkopf & Nerkar, 2001).

All of these definitions and operationalizations are useful and appropriate for examining various research questions. However, in the present study, we focus on exploratory search, which refers to the search for new knowledge and technologies, and not the ultimate

outcomes of that search. To measure the propensity to which firms engage in exploratory search, we use the variable exploratory search, operationalized as the degree to which firms cite patents that they have not cited in prior patent applications within the preceding five years. This measure captures an important aspect of how firms seek to discover new technologies.

We utilize the method created by Katila and Ahuja (2002) which recognizes that exploration and exploitation are not two ends of one continuum, but are “two distinct dimensions” (2002, p. 1183). This means that, while challenging to do, firms are able to simultaneously engage in both exploratory and exploitative search, which they referred to as search scope (how broadly firms search for new knowledge) and search depth (how extensively firms search within previously used knowledge). Scholars have built off their idea and have examined the financial impacts of engaging in both exploration and exploitation (He & Wong, 2004), in relation to alliances (Stettner & Lavie, 2014), sequencing of exploration and exploitation (Mudambi & Swift, 2011), as well as a variety of other studies.

In the present case, we utilize their measure to examine how prior invention experience affects future exploratory and exploitative search. Building on Katila and Ahuja’s (2002) methods, we measure exploratory search as a ratio, which ranges from 0 to 1, and is calculated as the proportion of new citations out of the total citations within a focal year. The formula is listed below:

$$\text{Exploratory Search}_{it} = \frac{\text{new citations}_{it}}{\text{total citations}_{it}}$$

A high value for exploratory search indicates that firms’ new patents are more heavily weighted towards including knowledge that the firm has not previously used, while a low exploratory search value suggests that firms are not including new knowledge in their current patenting activities.

Exploitative search refers to the refinement and extension of existing knowledge and technologies and, again, does not take into account the ultimate outcomes of such efforts. Similar to the measurement of exploratory search, we again utilize the measure created by Katila and Ahuja (2002) and calculate this measure by counting the total number of repeated citations in the prior five years divided by the total citations within a focal year to measure the degree to which firms engage in exploitative search. The five year cut-off reflects the reality that the value of knowledge in high technology firms depreciates quickly and can lose tremendous value in a five year period (Argote, 1999). This measure indicates to what extent firms rely on core bodies of knowledge and technologies. The formula is stated as:

$$\text{Exploitative Search}_{it} = \frac{\sum_{y=t-5}^{t-1} \text{repetition count}_{iy}}{\text{total citation}_{it}}$$

For exploitative search, a high value indicates that firms repeatedly use familiar knowledge in their new patents, while a low value indicates that they do not reuse knowledge as often.

Utilizing the exploratory and exploitative search measures created by Katila and Ahuja (2002) is appropriate because the constructs of exploratory search and exploitative search in our model are defined and applied in a similar way as Katila and Ahuja (2002) used them. These measures have also been applied in the same way in other management studies (Leone & Reichstein, 2012; Wu & Shanley, 2009).

3.2.2. *Independent variables*

In this study, we treat prior invention experience as an important predictor of the propensity of exploratory and exploitative search, rather than as simply a control variable. We count the total number of patent applications in the preceding five years as a measure of the prior invention experience of firms. Due to the wide range of the number of prior applications, we utilized a log transformation of this variable.

Prior research has primarily utilized firm size as a control variable (Cohen & Klepper, 1996). In contrast, we examine the moderating effect of firm size on the relationship between prior invention experience and future organizational search. Firm size is traditionally measured with assets (Agrawal & Knoeber, 1996) or organizational sales (Acs & Audretsch, 1991). Because of the long lag between initial inventions and ultimate commercialization of products within the pharmaceutical industry (Banholzer & Vosejka, 2011; Gambardella, 1995), we believe that firm assets is a more suitable measure of firm size within the pharmaceutical industry because it indicates the level of resources that firms have directed towards invention, rather than the sales many years in the future. Additionally, we use the log form of assets due to the wide disparity of the assets among firms.

Control variables

Considering the strong correlation between R&D intensity and both types of organizational search (i.e., exploratory and exploitative), we control for R&D expenses that firms devote to their search efforts (Katila & Ahuja, 2002). R&D intensity is measured with R&D ratio that captures the proportion of R&D expenditures to total sales. We also control for firms' capital structure to rule out the effect caused by the overall financial position of firms. Firm age can be related to patent citation (Sorensen & Stuart, 2000), thus we also control for firm age. Following prior studies (Chun, Kim, Morck, & Yeung, 2008; Fama & French, 2004; Shumway, 2001), we calculate firm age as the number of years since public listing. In addition, to further rule out the effect influenced by the external factors, we control for the performance of firms relative to their peers. Specifically, for each year, we calculate the average ROA, then subtract each firm's ROA from the industry average ROA to give an indication of how well each firm is doing compared with their peers. We also control for the industry average sales to account for fluctuations in overall sales in the entire pharmaceutical industry.

Other control variables include Tobin's Q and ROA to account for prior market and accounting performance. Research is mixed and on-going as to the extent to which financial performance drives exploration and exploitation (Cyert & March, 1963; Levinthal & March, 1981). Likewise, the effect that varying levels of exploration and exploitation (or a balance of both) have on firm performance is mixed with studies finding positive (He & Wong, 2004), negative (Lavie, Kang, & Rosenkopf, 2011), or curvilinear results (Uotila, Maula, Keil, & Zahra, 2009). Thus, in order to control the complicated effects of firm performance, which is usually measured with ROA and Tobin's Q, we control for both of them in the model.

3.3. Analysis and results

Our data consist of unbalanced panels of observations. Thus, ordinary least squares regression analysis would have resulted in correlated error terms, understated standard errors, and inflated t-statistics. We use the Breusch-Pagan test (Breusch & Pagan, 1979) to assess whether heteroskedasticity is present in our data. Results reject the null hypotheses, which indicate that heteroskedasticity is present. Therefore, we employ a cross-sectional time series estimation model, using the *xtgls* procedure in Stata with robust standard errors.

Descriptive statistics and the correlation matrix are presented in Table 1. As expected, prior invention experience is negatively correlated to exploratory search. Also, the correlation between prior invention experience and exploitative search is positive. It is interesting that R&D intensity is negatively correlated with exploitative search, prior invention experience, and firm size. While the meaning of the negative correlations with R&D intensity are beyond the scope of the present investigation, we do encourage future work to investigate these relationships more fully.

We further investigate whether there is a potential multicollinearity problem by computing variance inflation factors (VIFs). We find that for all variables VIF is substantially below the rule-of-thumb cutoff of 10.00 for regression models (Ryan, 1997). Therefore, multicollinearity is not a problem in our results (Hair, Anderson, Tatham, & Black, 1998). To reduce multicollinearity in the interactions, we mean-center the independent variables before generating interaction terms (Aiken & West, 1991). Tables 2 and 3 display GLS regression models.

We first ran the base model with control variables. In Model 1, we set exploratory search as the dependent variable, while in Model 4, we set exploitative search as the dependent variable. We then included predictors in the model, denoted as Models 2 and 5. Finally we added the mean-centered interaction terms, denoted as Models 3 and 6.

Hypothesis 1 argues that prior invention experience is negatively associated with exploratory search. The coefficient for prior invention experience in Model 2 is negative and statistically significant at $p < 0.001$, supporting H1. H2 asserts that prior invention experience is positively associated with exploitative search. The coefficient for prior invention experience in Model 5 is positive and statistically significant at $p < 0.001$, supporting H2.

These results provide strong support for our argument that at early stages of invention development, firms with insufficient invention experience tend to conduct exploratory search to accumulate knowledge base. However, with the accumulation of invention experience and knowledge base, firms tend to engage in more exploitative search.

H3a examines the moderating effect of firm size on the relationship between prior invention experience and exploratory search. The interaction coefficient between firm size and experience in Model 3 is positive and statistically significant at $p < 0.001$ in support of H3a. This moderated relationship is depicted below in Figure 1. This figure shows that, as hypothesized in H1, prior invention experience has a negative effect on exploratory search. As argued in support of H3a, in larger firms, this negative relationship is mitigated, suggesting that the negative effect of prior experience on exploratory search is not as dramatic in larger firms.

H3b argues that firm size moderates the relationship between prior invention experience and exploitative search. The coefficient of interaction term in Model 6 is negative and



Table 1. Descriptive statistics and correlations.

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1. Exploratory search	0.090	0.142	1.000										
2. Exploitative search	0.284	0.226	0.326	1.000									
3. Performance relative to peers	0.457	1.390	-0.100	-0.018	1.000								
4. Industry average sales	6.914	0.689	-0.116	0.136	-0.088	1.000							
5. Firm age	13.984	17.335	-0.080	-0.053	0.148	0.086	1.000						
6. R&D intensity	0.357	0.510	0.122	-0.088	-0.597	-0.203	-0.212	1.000					
7. Capital structure	2.270	9.081	-0.021	0.054	0.044	-0.005	0.033	-0.008	1.000				
8. Tobin's Q	5.165	4.297	0.102	0.002	-0.175	-0.075	-0.084	0.190	-0.065	1.000			
9. ROA	-0.363	0.904	-0.124	0.080	0.636	0.217	0.217	-0.933	-0.011	-0.115	1.000		
10. Firm Size	5.226	2.404	-0.204	0.024	0.303	0.209	0.713	-0.463	0.037	-0.252	0.472	1.000	
11. Prior invention experience	3.527	1.827	-0.429	0.214	0.168	0.186	0.614	-0.281	0.066	-0.142	0.309	0.816	1.000

Notes: N = 443. |Correlations| > .09 are statistically significant at $p < 0.05$. |Correlations| > .08 are significant at $p < 0.1$.

Table 2. Effects of prior invention experience on exploratory search.

Variables	Model 1 (controls)	Model 2 (main)	Model 3 (full)
(Constant)	0.228*** (0.052)	0.205*** (0.049)	0.228*** (0.046)
Performance relative to peers	-0.011*** (0.003)	-0.012*** (0.003)	-0.011*** (0.003)
Industry average sales	-0.020** (0.007)	-0.014* (0.007)	-0.010 (0.006)
Firm age	0.001*** (0.000)	0.001*** (0.000)	0.000 (0.000)
R&D intensity	0.027 (0.017)	0.051*** (0.012)	0.045*** (0.011)
Capital structure	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Tobin's Q	0.002** (0.001)	0.003*** (0.001)	0.002** (0.001)
ROA	0.031** (0.01)	0.035*** (0.008)	0.042*** (0.007)
Firm Size	-0.008*** (0.001)	0.020*** (0.002)	0.014*** (0.003)
Prior invention experience		-0.046*** (H1) (0.003)	-0.051*** (0.003)
Prior invention experience X Firm Size			0.006*** (H3a) (0.001)
Wald chi2	100.747***	330.838***	893.988***
Change in Wald chi2		231.21***	62.23***
Observations (N)	443	443	443

Standard errors in parentheses.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

statistically significant at $p < 0.001$ in support of H3b. This relationship is depicted below in Figure 2.

Considering the contingent effect of firm size, exploration activities of larger firms would be less likely to be bounded by firms' prior invention experience. In addition, compared with smaller firms, larger firms would also be less likely to obtain the full benefits from the prior invention experience to focus on local exploitative search. Overall, all four hypotheses are strongly supported by the regression results.

4. Discussion

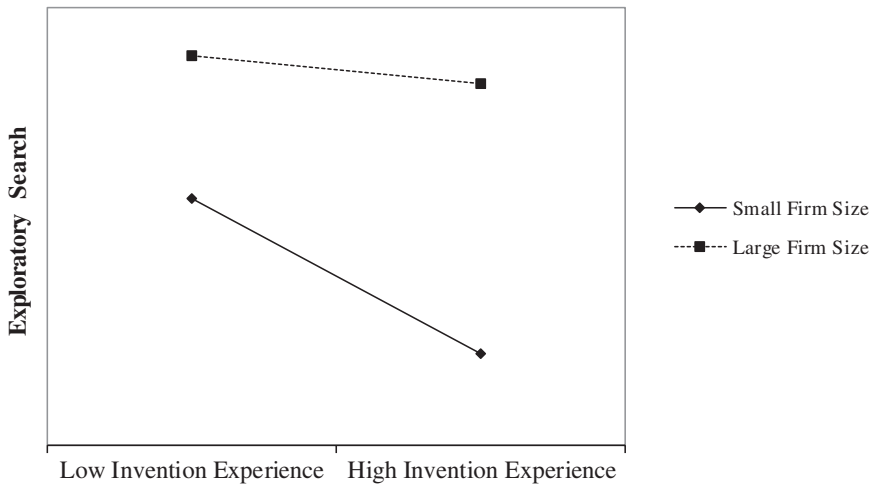
The present research highlights the nuanced relationships between prior invention experience, size, and future exploratory and exploitative search. Specifically, firms' prior invention experience is negatively related to exploratory search and positively related to exploitative search. Moreover, the association between prior invention experience and future search is contingent on firm size. We found that the negative relationship between prior invention experience and exploratory search is mitigated with firm size. Further, the positive relationship between prior invention experience and exploitative search is weakened with firm size.

Our study makes two contributions to the literature. First, we examine the unstated assumption of prior research by separating prior invention experience from firm size when examining drivers of organizational search. We build upon Nelson and Winter's (1982) ideas that firms are in a continuous state of search and examine the distinctive effects of

Table 3. Effects of prior invention experience on exploitative search.

	Model 4	Model 5	Model 6
Variables	(controls)	(main)	(full)
(Constant)	0.142	0.124	0.093
	0.076	0.07	0.067
Performance relative to peers	-0.017**	-0.011*	-0.011*
	0.006	0.005	0.005
Industry average sales	0.022*	0.023*	0.022*
	0.011	0.01	0.009
Firm age	-0.001***	-0.002***	-0.000
	0.000	0.000	0.000
R&D intensity	-0.09*	-0.086*	-0.118**
	0.04	0.038	0.038
Capital structure	0.001	0.001	0.001
	0.001	0.001	0.001
Tobin's Q	0.001	-0.001	0.001
	0.002	0.002	0.002
ROA	-0.011	0.003	-0.03
	0.025	0.024	0.024
Firm Size	0.005	-0.046***	-0.043***
	0.003	0.006	0.005
Prior invention experience		0.081*** (H2)	0.086***
		0.004	0.005
Prior invention experience X Firm Size			-0.008*** (H3b)
			0.001
Wald chi2	55.814***	531.322***	437.592***
Change in Wald chi2		373.66***	34.42***
Observations (N)	443	443	443

Standard errors in parentheses.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ **Figure 1.** Effect of invention experience on exploratory search, moderated by firm size.

prior invention experience on future exploratory search (McGrath, 2001) and exploitative search (Stuart & Podolny, 1996). We find that the influence of prior invention experience on exploratory search and exploitative search is more nuanced than previously argued.

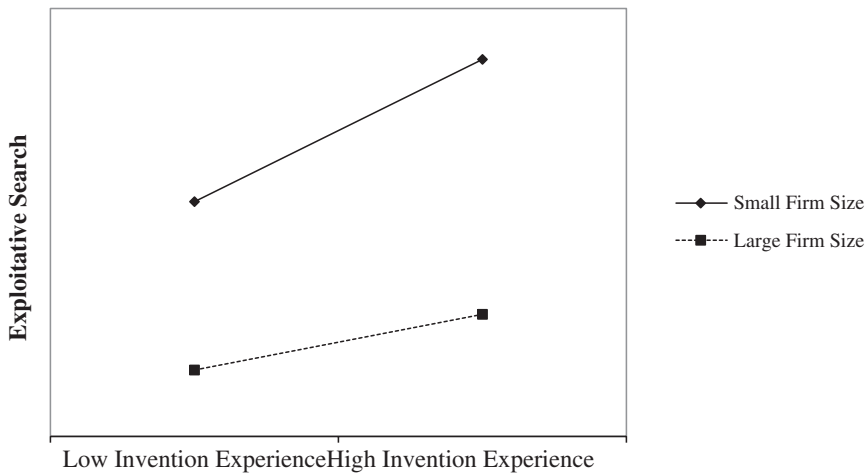


Figure 2. Effect of invention experience on exploitative search, moderated by firm size.

These findings contribute a more fine-grained understanding of the role of prior invention experience on future organizational search behaviors.

Second, through unbundling the effect of invention experience from that of firm size, we also contribute additional insight into the role that firm size plays in future exploration and exploitation activities. Specifically, firm size mitigates the negative impact of prior invention experience on exploratory search and also weakens the positive influence of invention experience on exploitative search. By examining this boundary condition, this study helps to clarify the separate roles that prior invention experience and firm size each have on future search activities.

4.1. Limitations and future research directions

Our measures of organizational search behaviors focus on patent data. Although patent data is used extensively for these purposes (Dunlap-Hinkler et al., 2010), prior work has noted that while patents reflect a great deal of codified knowledge, not all knowledge used to document a patent is codified (Phene et al., 2006). However, tacit and explicit knowledge flows are tightly related and complementary to each other, thus mitigating this potential limitation (Mowery et al., 1996).

In this work, we focus on accuracy and simplicity (Weick, 1969). Thus, these results should be interpreted in the context of the United States pharmaceutical industry. The conclusions generated from this study may not generalize to other industries or other countries because the relative importance and the interaction effect between invention experience and firm size may be different in different industries or institutional environments. However, to the extent that other industries place a high value on inventions and utilize patents as an integral part of that process, we argue that these results are likely generalizable to those industries.

Our research provides a finer-grained analysis of how prior invention experience and size combine to impact future exploration and exploitation activities. The findings from this work indicate that additional research in this area is still needed. Our research context

is the United States, an institutional environment quite different from that in emerging economies such as China (Peng, 2003). To extend the generalizability of the findings, future research should further investigate the exploratory and exploitative search within different political, social, and business contexts whose institutional environments are different from those of American companies. If these results do not hold in different institutions, then executives in global companies should take caution in extending the implications generated from United States public firms to foreign subsidiaries.

Additionally, we examine how prior invention experience in general affects future exploration and exploitation activities. We encourage future studies to build upon our work and examine other finer-grained aspects of these relationships. For example, future work should examine the differing impacts of prior exploratory and exploitative experience on future exploratory and exploitative search activities. Argote and Miron-Spektor (2011) suggested the importance of understanding the relationships between different types of experience and future organizational search. Gino, Argote, Miron-Spektor, and Todorova (2010) found that direct task experience, rather than indirect or vicarious experience, predicts more creative activities. Accordingly, future studies can separate different types of specific invention experience from the general to enrich the literature.

Future studies can also continue to examine how other moderators impact these relationships. For example, future studies can examine the moderating effect of different organizational forms, such as virtual firms versus non-virtual firms. Argote (2011) suggested that firms with new organizational forms have more difficulty in interpreting experience. In virtual firms, members are geographically distributed across countries, and thus learning can be challenging (Argote, 2011) because virtual firms communicate through electronic means instead of face-to-face (Gibson & Gibbs, 2006). However, virtual organizations with geographically distributed units can also be exposed to broader external environment, thus providing more opportunities to recognize and explore external new knowledge. We encourage future research to explore moderators such as organizational forms to shed further light on these questions.

In sum, this study builds upon existing literature by examining the moderating effect of different levels of firm size on the relationship between prior invention experience and exploratory and exploitative search. Our findings suggest that firm size mitigates the negative association between prior invention experience and exploratory search and also weakens the positive association between invention experience and exploitation. We extend prior work by separating the effect of prior invention experience from firm size and encourage future work to continue to explore the differing effects of these two important factors.

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