INTERNATIONAL JOURNAL OF BUSINESS, 16(1), 2011 ISSN: 1083−4346

# Search Activities for Innovation: An Attention-Based View

Chuan-Chuan Tseng[a], Shih-Chieh Fang[b], Yen-Ting Helena Chiu[c]

[a] *Department of Business Administration and Graduate Institute of International Business, National Cheng-Kung University*
*No.1, University Rd., Tainan, Taiwan 701, R.O.C*
*sherry.tseng@msa.hinet.net*

[b] *Department of Business Administration and Graduate Institute of International Business, National Cheng-Kung University*
*No.1, University Rd., Tainan, Taiwan 701, R.O.C*
*fangsc@mail.ncku.edu.tw*

[c] *Department of Marketing and Distribution Management*
*National Kaohsiung First University of Science and Technology*
*No.2 Jhuoyue Rd., Nanzih District, Kaohsiung City, Taiwan 811, R.O.C.*
*helena@ccms.nkfust.edu.tw*

**ABSTRACT**

Previous studies have not fully explored how firms' search behaviours may be heterogeneous when managers' attention for innovations is different, in turn, influence innovative competence. We bridge this gap by integrating an attention-based view (ABV) to study firms' knowledge search behaviours for innovation. Attention-based theories of the firm suggest that managerial attention is the most precious resource of an organization and the decision to allocate attention to particular activities is a key to explain why some firms are able to both adapt to changes in their external environment and to introduce new products and processes. In response to this theory, we collect a longitudinal patent data of 26 major LCD manufacturers from 1980 to 2001 for empirical study and find two insights. First, firms with complementary attention when searching knowledge will correlate negatively to domain impact. Second, firms using explorative attention when searching knowledge will correlate positively to domain impact and overall impact.

*JEL Classification: M10*

*Keywords: Knowledge Search; Attention-Based; LCD Industry; Patents, Innovation*

## I. INTRODUCTION

Innovation is among the essential processes for success, survival, and renewal of organizations, particularly for firms in either fast-paced or competitive markets (Brown and Eisenhardt, 1995). A central part of the innovation process involves search for new ideas that have commercial potential. Investigating search has also become a key element in efforts to explain innovative performance. Accordingly, a variety of empirical studies have indicated that two divergent search strategies can significantly influence firms' innovative performances (Cohen and Levinthal, 1990; Katila, 2002; Katila and Ahuja, 2002; Laursen and Salter, 2006). On the one hand, a firm must center its attention within its own technological trajectory, which is called "internal search strategy" (Cohen and Levinthal, 1990; Katila, 2002; Katila and Ahuja, 2002). On the other hand, a firm must acquire knowledge extensively that will serve as the seed for future technological developments, which is called "external search strategy" (Laursen and Salter, 2006).

Indeed, the above researchers strongly suggest that searching internally and externally across a variety of search channels can provide ideas and resources that help firms exploit or explore innovative opportunities. However, knowledge search is not without cost. It can be time consuming, expensive and laborious. Firms often invest considerable amounts of time, money and other resources in the search for innovative opportunities, but additional search becomes unproductive. This is evident in Katila and Ahuja's (2002) finding that 'over-search' may indeed hinder innovation performance. Koput (1997) also provides three related reasons why over-searching may have a negative influence on performance. First, there may be too many ideas for the firm to manage and choose (the absorptive capacity problem). Second, many innovative ideas may come at the wrong time and in the wrong place to be fully exploited (the timing problem). Third, although there are so many ideas, few of them are taken seriously or given the required level of attention or effort to bring them into implementation (the attention allocation problem).

As implied by the name, the attention allocation problem is the key element in attention-based theories of the firm (Simon, 1947; Ocasio, 1997). This theory suggests that managerial attention is the most precious resource inside the organization and that the decision to allocate attention to particular activities is a key factor in explaining why some firms are able to both adapt to changes in their external environment and to introduce new products and processes. Central to this approach is to highlight the pool of attention inside the firm and how this attention is allocated. According to the theory, decision-makers need to concentrate their energy, effort and mindfulness on a limited number of issues in order to achieve sustained strategic performance (Ocasio, 1997). Contrarily, a poor allocation of managerial attention can lead to firms engaging in too many (or too few) external and internal communication channels. Thus, it is essential that knowledge sources require careful management so that search efforts are not dispersed across too many search channels. Choosing the right amount of resources to allocate to search and innovation is often a critical decision for organizations.

Gavetti and Levinthal (2000) classify firm search behaviour into two decision models: backward looking and forward looking. The backward-looking search model reflects incremental trial-and-error learning and the adaptive selection of routines. The decision rules used in the backward-looking approach are dominated by experience and

perfomance feedback (Greve, 2003). The forward looking search model, in contrast, focuses on the evaluation of alternatives based on decision makers' understanding of the future and the probable outcomes of engaging in planned behaviour. It regards the cognitive representations of the future as critical determinants of organizational choices and actions (Gavetti and Levinthal, 2000). With recognition of the bounded rationality of decision makers and the goal-directed, rule-based nature of organizations, Chen (2008) develops a behavioural forward-looking search model by incorporating prospect theory, organizational risk literature, and the logic of the behavioral theory of the firm. Chen's model suggests that comparing firms' performance expectation and performance target translates the cognitive representation of the firms' future into their subsequent actions.

A behavioural forward-looking search model, on the other hand, implies that firms translate a cognitive image of the future into firms' actual behaviour (Gavetti and Levinthal, 2000). Firms tend to increase their search intensity with firm's past performance above firm-based aspiration (historical comparison) but decrease when they outperform industry-based aspiration (social comparison) (Chen, 2008). However, previous literatures have not fully explored how firms' knowledge search behaviours may be heterogeneous when managers' attention for innovations varies that, in turn, influences innovation performances. In order to bridge this gap, we use an attention-based view (ABV) (Ocasio, 1997) to explain heterogeneity in managers' attention to knowledge searching activities for innovations. Therefore, this paper has two objectives. First, it introduces a typology of knowledge search activities that recognize the managers' attention allocation among different types of organizational boundary knowledge and technological boundary knowledge. Second, in order to test this attention-based view (ABV), we use patent citation data from global liquid crystal display (LCD) firms to empirically explore how these four types of knowledge search attention affect firms' innovation performances.

The paper is structured as follows. Section II reviews prior literature and Section III develops research model and hypotheses. Section IV discusses research methodology. Section V reports the results from our empirical analysis. In Section VI, implications for research and practice are discussed.

## II. LITERATURE REVIEW

### A. Attention-Based Theory Of The Firm

Attention constitutes a broad field of research that spans several disciplines and fields of inquiry (Jones and Baumgartner, 2005; Thornton, 2004). For most organizational scholars, attention refers to the set of elements (events, trends, ideas and, in our case, knowledge search) that occupies the consciousness of managers (Dutton et al, 1989; Fiske and Taylor, 1984). The emerging attention-based view of the firm (Ocasio, 1997; Ocasio and Joseph, 2005; Yadav et al, 2007; Bouquet and Birkinshaw, 2008) portrays attention as a meta-construct. Attention is defined to encompass the noticing, encoding, interpreting and focusing of time and effort by organizational decision-makers on both issues and answers. Thus, to explain firm behaviour is to explain how organizations

channel and distribute the attention of their managers (Ocasio, 1997).

The attention-based view of the firm is revitalized by Ocasio's (1997) contribution based on Simon's (1947) attention perspective on administrative behavior. He further integrates and extends prior theory on managerial and organizational cognition (Daft and Weick, 1984). Ocasio (1997) develops three principles of the attention-based view of the firm. The first principle refers to the *focus of attention*. The focus of attention includes that decision makers focus their attention on a limited set of issues and answers, and that the issues and answers they attend to and enact determine what they do. The *situated attention* represents the second principle where it incorporates that the attention of decision-makers is situated in the firm's procedural and communication channels. The third principle refers to the *structural distribution of attention*. The distributed focus of attention among decision makers participating in the firm's procedural and communication channels is generated by the rules, resources, players, and social positions of the firm (Ocasio, 1997). All three principles are based on cognitive processes such as cognitive diversity, comprehensiveness, and extensiveness reflecting the mental models of managers (Miller et al., 1998; Cho and Hambrick, 2006).

By drawing on the attention-based theory of the firm, this article offers a different but complementary perspective on knowledge search for innovation. It concentrates on the neglected roles of management attention and situated attention. By investigating both roles, an additional explanation why firms with different knowledge search attention will have different innovative competence is offered.

### B. Knowledge Search and Attention

Knowledge search is a problem-solving activity (Nelson and Winter, 1982). In knowledge search, firms solve problems by combining knowledge elements with the goal of creating new products. Essentially, knowledge search is a type of organizational learning process (Huber, 1991) whereby organizations can improve upon their current technologies (Nelson and Winter, 1982), learn and develop new skills (Mahadok and Walker, 1996), as well as adapt to environmental changes (Cyert and March, 1963). In other words, firms may be innovative because they productively translate their internal knowledge into new products, or because they capture knowledge spill over from other firms or from academia.

One innovation challenge involves the mastery of two divergent tasks (March, 1991; Nerkar and Roberts, 2004). On the one hand, a firm must centre its attention on a bounded set of techniques in order to cultivate valuable and commercially viable products; the task here is local search or exploitation (Leonard-Barton, 1992; March, 1991). On the other hand, a firm must continually acquire a diverse and novel body of knowledge that will serve as the seeds for future technological developments; here, the firm's task is distant search or exploration (March, 1991; Nelson and Winter, 1982). Although firms are generally adept at local search, distant search often proves challenging (Henderson and Clark, 1990; Tushman and Anderson, 1986). A firm's accumulated capabilities delimit the scope of search as well as the capacity to comprehend and apply new knowledge (Cohen and Levinthal, 1990; Nelson and Winter, 1982). Furthermore, in carrying out distant search, firms must often span organizational boundaries, yet knowledge is especially difficult to identify and acquire through market

mechanisms (Teece, 1980; Von Hippel, 1994). In doing so, a manager is required to allocate attention between organizational and technological boundaries in knowledge search activities.

Attention-based theories (Simon, 1947; Ocasio, 1997) suggest that managerial attention is the most precious resource inside an organization. The decision to allocate attention to particular activities is a key factor that explains why some firms are able to both adapt to changes in their external environment and to introduce new products and processes. Central to this approach is the ability to focus the pool of attention inside the firm and determine how this attention is allocated. According to the ABV theory, managers are required to 'concentrate their energy, effort and mindfulness on a limited number of issues' in order to achieve a firm's sustained innovation success (Ocasio, 1997).

Therefore, this study proposes a typology of knowledge search attention that takes place both within and across organizational and technological boundaries. Moreover, this research focuses on the types of knowledge search attention that will impact a firm's innovation competence. Such findings can help managers allocate their limited attentional capacity to the correct knowledge search boundary and not be constrained by their current frames of reference. From the attention perspective, organizational members have a limited attentional capacity (Simon, 1947), a constraint with implications for how issues facing an organization are addressed. Attentional capacity can be limited by decision makers' general receptivity to stimuli as well as their ability to focus on competing sensory inputs (Ocasio and Joseph, 2005). Ocasio and Joseph also suggest that organizational attention is both backward and forward looking; it seeks to solve organizational problems and failures while providing links with perceived opportunities and threats in the environment.

### C. Innovative Competence－Domain Impact and Overall Impact

Put differently, managers capture the appropriate attention in order to search for complementary knowledge and novel solutions will accelerate the innovative competence, which refers to the discovery of new methods or materials (Freeman and Soete, 1997) rather than its subsequent commercialization. More specifically, Quintana-Garcia and Benavides-Velasco use invention as a proxy indicator of innovative competence (Quintana-Garcia and Benavides-Velasco, 2008), since invention is the creation of new products and process through the development of new knowledge or the combination of existing knowledge (Grant, 2002). Studying the determinants of inventions is of importance because they represent valuable sources of competitive advantage (Barney, 1991). Recent advances in databases and search techniques also have enabled forward searches that allow researchers to investigate the impact of an invention (Bogner and Bansal, 1998; Sorensen and Stuart, 2000). Forward-looking citation counts are good proxies for the impact of inventions. Furthermore, highly cited patents lead to more economic profits than patents that are less frequently cited (Harfhoff et al., 1999). Therefore, we use the term 'impact' (Rosenkopf and Nerkar, 2001) to denote the innovative competence of a firm.

#### a. Domain Impact

Domain impact reflects a firm's innovative competence to influence in a specific technological arena (Rosenkopf and Nerkar, 1999**).** Specifically, firm-level technological trajectories influence, and are influenced by, both the trajectories of other firms and the overall evolution of the product class. In other words, firms do not make decisions about which technological options to pursue without regard to the actions of other firms; technological evolution is generated by communities of organizations (Rosenkopf and Tushman, 1998; Tushman and Rosenkopf, 1992). To capture this interdependent evolution of firm-level exploration trajectories, we need to understand if knowledge generated by one firm is assimilated by others. We use the term 'domain impact' to denote knowledge retained and built upon as technology continues to evolve. Domain impact may be evaluated within a specific technological domain or more broadly. If the patents of a focal firm were cited by other firms involved in the development of the same technology, the focal firm will extend the impact of innovation on subsequent technological development (Rosenkopf and Nerkar, 2001) and maintain technological leadership within the particular product class arena and its associated technological community.

### b. Overall Impact

In contrast to influencing a specific technological domain, some new knowledge may be influential beyond its focal technological domain. In contrast to domain impact, overall impact represents a firm's innovative competence to create broadly useful technological developments (Rosenkopf and Nerkar, 1999**).** While these developments may not be harnessed for their commercial potential by the firm, they represent possible avenues whereby the firm may choose to diversify. Thus, we are likely to observe that certain knowledge search attention may result in higher overall impact at the expense of domain impact, or vice versa.

Therefore, domain impact and overall impact can represent innovative competence in certain ways. Also, it has been shown that innovative competence differences between firms are based on the varying capabilities in allocating attention for knowledge search. Furthermore, investigative search has also become a key element in efforts to explain innovative competence.

## III. RESEARCH MODEL AND HYPOTHESES

### A. Four Types of Knowledge Search Attention

In Figure 1, four types of knowledge search attention are generated by considering whether the knowledge search is internal or external to the firm (the *x*-axis), as well as whether the knowledge search is derived from similar or distant technology (the *y*-axis). Implicit in this typology is the notion that knowledge searching behaviour is undertaken by some technological subunit of the firm, which then faces the choice of whether or not to integrate knowledge from distant technological domains or to focus on similar technological knowledge. It also faces the choice of whether to search for knowledge within the firm (either its own knowledge or that of other technological subunits in the firm) or from external sources. From the attentional perspective, a firm is tasked with choosing which type of knowledge search attention that is worth the allocation of innovative effort across various technologies. The following sections present the

relationships between different types of knowledge search attention and innovative competence as shown in the research framework depicted in Figure 2.

**Figure1**
Four types of knowledge search attention

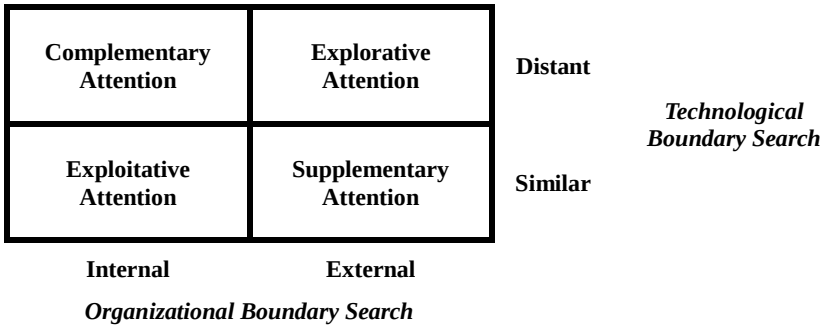
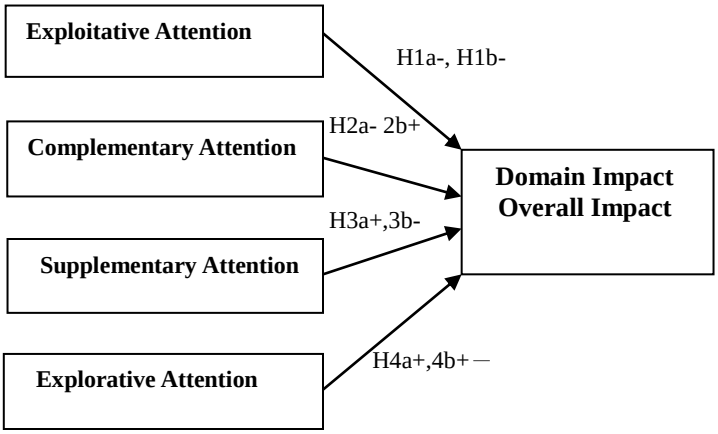



**Figure 2**
Research framework




### a. Exploitative Attention and Impact

"Exploitative attention" refers to the amount of attention devoted to searching for similar knowledge within the firm. March (1991) argued that to survive, firms need to engage in both exploitation and exploration. Exploration concerns the degree with which an organization accumulates new knowledge, while exploitation concerns the leverage of old knowledge. Thus, neither organizational nor technological boundary knowledge is scanned during this type of exploitative attention where all knowledge search activity is contained within the firm and within technological boundaries. During

exploitative attention, a firm focuses on similar technology residing within the firm. However, the focus that sustains such first-order competence can lead firms to develop "core rigidities" (Leonard-Barton, 1992) or fall into "competence traps" (Levitt and March, 1988). Thus, the more exploitative attention, the less ability for a firm to influence in a specific technological arena and the less ability for a firm to create broadly useful technological developments.

While the aforementioned studies indicate the risks of relying on exploitative attention, we suggest that:

**H1a:** Knowledge search with exploitative attention will be negatively related to domain impact.
**H1b:** Knowledge search with exploitative attention will be negatively related to overall impact.

### b. Complementary Attention and Impact

"Complementary attention" refers to the amount of attention devoted to scanning technologically distant knowledge residing within the firm. The technological subunit utilizes knowledge from a different technological domain but is able to obtain knowledge from another subunit within the firm. Here, 'complementary' is used to reflect the dissimilarity between existing knowledge and searching knowledge. The purpose of complementary attention is to widen the knowledge scope of the technological subunit and can enable a firm to extend both its knowledge range and strengthen its competitiveness and innovative competence in the marketplace. In other words, the more complementary attention, the less these developments will impact the specified technological domain and the more these developments will impact subsequent technological evolution beyond the domain. Thus, we propose:

**H2a:** Knowledge search with complementary attention will be negatively related to domain impact.
**H2b:** Knowledge search with complementary attention will be positively related to overall impact.

### c. Supplementary Attention and Impact

"Supplementary attention" refers to the amount of attention devoted to the knowledge search activities of other organizations close to the technology of a firm's own interest. The technological subunit identifies knowledge from its own technological domain but obtains that knowledge from other firms. The purpose of supplementary attention is to deepen the knowledge specialization rather than broadening its knowledge scope of the firm. Thus, firms with supplementary attention when searching knowledge can be used to improve an existing product/service or can be used as a springboard to help launch a new product/service. In other words, the more supplementary attention, the more these developments will impact the specified technological domain, and the less these developments will create broadly useful technological developments.

Drawing on these arguments, it is suggested:

**H3a:** Knowledge search with supplementary attention will be positively related to domain impact.
**H3b:** Knowledge search with supplementary attention will be negatively related to overall impact.

### d. Explorative Attention and Impact

"Explorative attention" refers to the amount of attention devoted to knowledge search activities from distant technologies that exist outside of the firm. The technological subunit utilizes knowledge from different technological domains outside the firm; thus, both organizational and technological boundaries are spanned during this type of explorative attention. As mentioned above, March (1991) argues that to survive, firms need to engage in both exploitation and exploration. Exploration has to do with the degree to which a firm accumulates new knowledge, while exploitation concerns the leverage of old knowledge. Firms with explorative attention when searching knowledge will not only improve an existing product/service but will also explore possible avenues where the firm may choose to diversify. In other words, the more explorative attention, the more these developments will impact the specified technological domain, and the more these developments will create broadly useful technological developments.

**H4a:** Knowledge search with a high level of explorative attention will be positively related to domain impact.
**H4b:** Knowledge search with a high level of explorative attention will be positively related to overall impact.

## Ⅳ. RESEARCH METHODOLOGY

### A. Patent Citation

To examine our hypotheses, we measured impact using patent data. A patent document provides valuable information about innovation from the firm generating the innovation (assignee), the location of innovation (inventor location), the date of innovation (date when the patent was filed for), and the technology of innovation (technology class). Each patent document also has information about the patents it cites (cited patents) and the patents citing it (citing patents) filed under the U.S. Patent System. Patent citation data enable us to identify the external knowledge used to generate the patent and examine the impact of a particular innovation. Each patent contains citations to previous patents ('prior art'). Thus, the overall pattern of citations to *earlier* patents provides a credible record of built-upon knowledge which we examine on a yearly basis. At the same time, patents granted to a firm in any year that are *subsequently* cited by other firms, permit the construction of domain impact measures.

The findings of Stolpe's study (2002) can be summarized as follows: patent citations in LCD technology and the knowledge spill over, to which they point, are not random. The study thus confirms there is an opportunity to use patent information to explore the changing nature of diffused knowledge and ideas in innovative economies.

## B. Sample

Thus, we began our data collection by establishing the patent classes that circumscribe liquid crystal display technology. The data for this study was taken from US patent class 349 "Liquid Crystal Cells, Elements and Systems". A total of 8584 patents were granted in this field between 1980~2001. To facilitate statistical analyses, we selected the leading 26 firms that accounted for almost 50 percent of the total patent activities. This focus trimmed our set of patents to 4493 patents issued by those firms. By sorting these 4493 patents, we were able to create a 22-year longitudinal record of the patenting activity in the liquid crystal display domain for each firm. For our final analyses, the unit of analysis was the firm-year. As each firm did not necessarily file patents in every year of the sample period, a total of 419 firm-year observations were analyzed. A distribution of the number of patents owned by each of these most-active firms along with the number of years in which each firm filed for patents is displayed in Table 1. Thus, the findings may be biased toward the experiences of large firms and should be interpreted accordingly.

**Table 1**
Distribution of patents and firm-year observations for sample

| Firm | Total Patents | Total Firm-Year |
|---|---|---|
| Canon Kabushiki Kaisha | 649 | 21 |
| Sharp Corporation | 814 | 21 |
| Hitachi Ltd. | 319 | 21 |
| Seiko Corporation | 289 | 16 |
| U.S. Philips Corp. | 168 | 19 |
| Semiconductor Energy Laboratory | 245 | 16 |
| Kabushiki Kaisha Toshiba | 243 | 20 |
| Matsushita Electronics Corporation | 207 | 20 |
| Casio Computer, Ltd. | 120 | 17 |
| Thomson Consumer Electronics, Inc. | 79 | 21 |
| IBM | 43 | 11 |
| Chisso Corp. | 85 | 19 |
| NEC Corporation | 216 | 16 |
| Mitsubishi Denki K.K. | 77 | 14 |
| The Secretary of State for defence | 94 | 17 |
| Fujitsu Ltd. | 100 | 13 |
| Fuji Photo Film Co. Ltd. | 101 | 19 |
| Citizen Watch Co. | 80 | 17 |
| Merck Patent GmbH | 114 | 18 |
| Alps Electronic Co., Ltd. | 62 | 17 |
| Sony Corporation | 26 | 10 |
| Samsung Electronics Ltd. | 207 | 12 |
| Eastman Kodak Company | 27 | 13 |
| Sanyo Electric Co., Ltd. | 9 | 4 |
| Nitto Denki Corporation | 28 | 9 |
| Industrial Technology Research Institute | 45 | 9 |
| Dai Nippon Printing Co. Ltd. | 46 | 9 |
| Total | 4493 | 419 |

There are a number of limitations to using patent citation data to capture innovation or the external knowledge utilized. First, patents are a partial measure of organizational knowledge production and external knowledge utilization: they may capture codified knowledge flows but not necessarily tacit knowledge (such as that embedded in organizational routines). However, Mowery et al. (1996) point out that codified knowledge flows (represented by patents) and tacit knowledge flows are closely linked and complementary to each other. Another potential drawback in using patent data is that patenting itself is a strategic choice; not all technological innovations may be patented. However, the nature of competition in the industry encourages the active patenting of innovations. The use of patent data is very appropriate in the liquid crystal display industry because patents form the intellectual capital of the industry (Ernst and Young, 1993; Shan and Song, 1997). Thus, despite some limitations associated with the use of patent data, the uniformity and availability of the data have led to their increasing use in strategic management research aiming to capture organizational innovations and external knowledge utilization (Ahuja, 2000; Rosenkopf and Nerkar, 2001; Sorensen and Stuart, 2000; DeCarolis and Deeds, 1999).

## C. Variables

The descriptive statistics and correlations of all variables of interests are shown in Table 2.

### a. Dependent Variables

#### 1. Domain Impact

We measured the impact of firm i's patents in year t on subsequent technological evolution by tracking all patents that cited the focal patents. For each firm i in each year t, we took the set of liquid crystal patents and performed a search to find all patents citing the focal patents over the subsequent five years. The domain impact for firm i in year t equals the number of citations from liquid crystal display patents (that is, citing patents classified in any of our initial liquid crystal display subclasses) received by firm i's patents granted in year t.

#### 2. Overall Impact

Overall impact is the total number of citations from non-LCD patents received by firm i's patents granted in year t. For both of these measures, self-citations were excluded. Since both types of impact are likely to correlate with the total number of patents issued by the firm during that year, we controlled for this annual number of patents in our analyses.

**Table 2**
Descriptive statistics and correlation matrix

| N=419 | Mean | Std. Deviation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Patent Count | 11 | 14.6448 | 1.000 | | | | | | | |
| 2. Citation Age | 4.8967 | 1.5463 | 0.2214** | 1.000 | | | | | | |
| 3. Exploitative Attention | 5.3053 | 13.4104 | 0.6960** | 0.1261** | 1.000 | | | | | |
| 4. Complementary Attention | 10.1818 | 38.6424 | 0.5939** | 0.1912** | 0.7179** | 1.000 | | | | |
| 5. Supplementary Attention | 17.1794 | 23.3466 | 0.8097** | 0.1576** | 0.6647** | 0.3330** | 1.000 | | | |
| 6. Explorative Attention | 44.2004 | 70.8377 | 0.9299** | 0.2659** | 0.5645** | 0.5561** | 0.6610** | 1.000 | | |
| 7. Overall Impact | 42.3123 | 56.1921 | 0.9369** | 0.2314** | 0.6396** | 0.5055** | 0.7192** | 0.7721** | 1.000 | |
| 8. Domain Impact | 35.1748 | 68.6001 | 0.8587** | 0.1525** | 0.4662** | 0.3748** | 0.6029** | 0.8555** | 0.6189** | 1.000 |

** All coefficients are significant

### b. Independent Variables

#### 1. Attention

We classified the types of attention based on the knowledge search activities of firm i in year t by classifying and tabulating all citations included in the firm's LCD patents in year t. Note that these citations are for patents issued earlier than the focal patents during year t. Each citation to another patent was traced to determine if the built-upon patent was assigned to the same firm, and whether the built-upon patent was classified in one of our LCD technology classes. This classification enabled the construction of several variables, each of which is denoted in Figure 3. The four cells correspond to the four types of attention: exploitative, complementary, supplementary, and explorative. Each citation was tabulated into only one of these four cells. Summing the rows yielded a count of the total number of citations by firm i in year t both to LCD technology and non-LCD technology. Similarly, summing the columns yielded counts of the total number of self-citations by firm i in year t as well as the total number of non self-citations. The grand total represents the total number of citations made by firm i's optical disk patents in year t. Due to the additive nature of all the exploration variables, we controlled for total citations in all regressions to reduce the correlation between these measures. As such, the reported correlations in Table 2 represent partial correlations.

**Figure 3**
Relationships between attention variables

| | | |
|---|---|---|
| **Complementary Attention** | **Explorative Attention** | **Non-LCD Citations** |
| **Exploitative Attention** | **Supplementary Attention** | **LCD Citations** |
| **Self Citations** | **Non-Self Citation** | **Total Citations** |

### c. Control Variables

#### 1. Patent Count

*Ceteris paribus*, patents granted in earlier years are likely to have more citations than patents granted in later years as they are at risk for citations during a longer time period. We controlled for this bias by using a patent count variable. The total patents for which firms were granted in each year from 1980~2001 were controlled.

#### 2. Citation Age

We included a measure of the average age for all citations made in each year by each

firm. This measure is intended as a control, because the tendency for patents with older citations to generate less impact has been noted (Sorenson and Stuart, 2000); this measure may serve as a proxy for competence traps.

### 3. Analyses

Since our dependent variable was a non-negative count variable with over dispersion, the Negative Binominal models were employed for this situation (Hausman, Hall, and Griliches, 1984). Our panel data covered 26 firms over 22 years; the patent count and citation age for each firm-year were employed to control the variance across firms and years in the sample period.

Recall that we had missing observations in years where firms did not patent because there were no citations with which to construct the independent variables. As a test, we generated pseudo observations for the 419 non-patent firm-years by setting all citation-related counts to zero and the average citation age to its maximum value. The results were not considerably different.

## V. EMPIRICAL RESULTS

### A. Hypothesis Testing

**Table 3**
Negative binomial regression of searching behaviour on domain impact ($n$ = 419)

| Variable Description | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Patent Count | 0.867*** | 1.048*** | 1.067*** | 1.362*** | 1.091*** |
| Citation Age | -0.039 | -0.047** | -0.038 | -0.03 | -0.043** |
| Exploitative Attention | | -0.257*** | -0.188*** | -0.006 | 0.020 |
| Complementary Attention | | | -0.117*** | -0.293*** | -0.293*** |
| Supplementary Attention | | | | -0.394*** | -0.341*** |
| Explorative Attention | | | | | 0.230*** |
| N | 419 | 419 | 419 | 419 | 419 |
| Log Likelihood | -1556.3055 | -1545.9078 | -1544.004 | -1543.7407 | -1543.1598 |
| Chi-square | 562.22*** | 675.62*** | 697.00*** | 685.63*** | 686.29*** |

*p<0.1, **p<0.05, ***p<0.01

Table 3 and Table 4 report the results of the regression analysis on the effects of knowledge search attention on domain impact. In summation, our hypotheses: H2a, H4a, and H4b were supported. Knowledge search with complementary attention is positively related to overall impact (H2a) and knowledge search with explorative attention is positively related to domain impact and overall impact (H4a and H4b).

In Table 3, Model 1 is the baseline equation containing the control variables. In Model 2, we included exploitative attention. A significantly negative coefficient on this variable indicates that when firms allocate only exploitative attention, the knowledge searching focus will have a negative influence on domain impact. In Model 3, we simultaneously included exploitative attention and complementary attention. A significant coefficient for these two variables, respectively, indicates that when firms allocate exploitative attention and complementary attention, the knowledge searching focus will have a negative influence on domain impact. In Models 4 and 5, we also determined that H2a and H4a were supported, and others were not. In Table 3, we found an unexpected result with a significantly negative coefficient for the supplementary attention variable, showing that knowledge search with supplementary attention has a negative impact on the specified technological domain rather than a positive impact on the specified technological domain as predicted by our hypothesis 3a[1].

**Table 4**
Negative binomial regression of searching behavior on overall impact ($n$ = 419)

| Variable Description | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Patent Count | 0.815*** | 0.726*** | 0.736*** | 0.652*** | 0.427*** |
| Citation Age | 0.051* | 0.055** | 0.059** | 0.057** | 0.047* |
| Exploitative Attention | | 0.127*** | 0.163*** | 0.112** | 0.133*** |
| Complementary Attention | | | -0.06 | -0.010 | -0.010 |
| Supplementary Attention | | | | 0.111*** | 0.155*** |
| Explorative Attention | | | | | 0.191** |
| N | 419 | 419 | 419 | 419 | 419 |
| Log Likelihood | -1686.1882 | -1685.3812 | -1681.6623 | -1677.3274 | -1677.2025 |
| Chi-square | 294.56*** | 298.26*** | 321.45*** | 324.63*** | 325.13*** |

*p<0.1, **p<0.05, ***p<0.01

In Table 4, Model 2, we included exploitative attention. A significantly positive coefficient for this variable indicates that when firms allocate only exploitative attention, the knowledge searching focus will have a positive influence on overall impact. In Model 3, we simultaneously included exploitative attention and complementary attention. A significantly positive coefficient on the exploitative attention indicates that when firms allocate exploitative attention and complementary attention, the exploitative attention will have a positive influence on overall impact. In Models 4 and 5, however, only 4b was supported, and others were not. In summary, we found an unexpected result with a significantly positive coefficient for the supplementary attention variable, indicating that knowledge search with supplementary attention positively creates broadly useful technological developments rather than negatively impacts the specified technological domain as predicted by our hypothesis $3b^2$.

## Ⅵ. IMPLICATIONS AND DISCUSSIONS

This paper studies firms' knowledge search behaviours for innovation in terms of attention-based view (ABV). Attention-based theories of the firm (Simon, 1947; Ocasio, 1997) suggest that managerial attention is the most precious resource of an organization and that the decision to allocate attention to particular activities is a key to explain why some firms are able to both adapt to changes in their external environment and to introduce new products and processes. In response to this theory, we collected a longitudinal patent data of 26 major LCD manufacturers from 1980 to 2001 for empirical study and provided two pieces of evidence for the knowledge searching activities of firms in the liquid crystal display industry. First, knowledge search for firms using complementary attention correlates negatively to domain impact. Second, knowledge search for firms using explorative attention correlates positively to both domain impact and overall impact.

What do these results imply for the innovation searching activities of firms? According to our results, a manager is required to concentrate his/her energy and efforts while allocating the correct amount of attention when searching for knowledge in order to achieve a firm's sustained innovation success. Our results imply two practical insights.

First, managers should not allocate the amount of attention devoted to scanning technologically distant knowledge residing within the firm, since our empirical results indicate that the more complementary attention a firm uses, the lower innovative competence for the firm to influence in a specific technological arena. On the other hand, managers should allocate the amount of attention devoted to knowledge search activities from distant technologies that exist outside of the firm, since the more explorative attention a firm uses, the higher innovative competence for the firm to influence in a specific technological arena and to create broadly useful technological developments. Therefore, our results strongly suggest that searching for knowledge across a variety of organizational and technological boundaries, managers should pay their attention to the appropriate channels that help firms gain and explore innovative opportunities.

In addition to practical implications, this study makes two contributions to

organizational research. First, Gavetti and Levinthal (2000) conceptualized the forward-looking search model as cognitive-based; i.e., decision makers have mental models of the future and believe in certain links between choice of action and the subsequent outcome of actions. Since Gavetti and Levinthal's theory does not specify how organizations interpret the cognitive representation and translate it into actual behaviour, Chen (2008) develops a behavioural forward-looking search model by incorporating prospect theory, organizational risk literature, and the logic of the behavioural theory of the firm. However, previous studies have not fully explored how firms' search behaviours may be heterogeneous when managers' attention for innovations is different. We bridged this gap by integrating an attention-based view (ABV) to introduce a typology of knowledge search behaviours that recognize the managers' attention allocation between organizational boundary knowledge and technological boundary knowledge. Moreover, we used patent citation data from global liquid crystal display (LCD) firms to empirically explore how these four types of knowledge search attention affect firms' innovative competence. Second, we made contribution to the "attention markets" in organizations (Dutton and Ashford, 1993; Hansen and Haas, 2001; Ocasio, 1997). We provided a reasonable operationalization of attention in a knowledge search context. Despite the considerable amount of research on attention management in recent years, there have been few serious attempts to operationalize the core constructs. This paper thus provided an example of operationalizing knowledge search attention and extended existing knowledge on knowledge search for innovation in the LCD firms.

This study has two main limitations that we should acknowledge. The first limitation is that patent data can only track the exploration patterns of innovation successful enough to have resulted in patents. Firms certainly undertake exploratory activities that do not result in granted patents. Detailed, painstaking fieldwork should be undertaken to determine whether this unmeasured activities could bias our results. On the other hand, we recognize that our study, limited to a single technology focus, may not be fully generalized. Our results are more likely to apply in high-technology contexts where the technology, like liquid crystal display, is systemic. In systemic contexts, knowledge-building evolves hand in hand with the socio-technical coalitions that shape technological evolution. Stronger regulatory contexts may also moderate the relationship between knowledge search attention and innovative competence. Future efforts to compare and contrast these behaviours in varying technological contexts will be fruitful.

## ENDNOTES

1. This unexpected result indicates that the innovative competence of a firm to influence in a specific technological arena is not easy as to create broadly useful technological developments, since firms with the aim to develop radical innovations are obviously not able to develop all knowledge internally, but they have to strongly rely on complementary external sources.
2. Please refer to footnote 1.

## REFERENCES


Ahuja, G., 2000, "Collaboration, Networks, Structural Holes, and Innovation: A Longitudinal Study," *Administrative Science Quarterly*, 45(3), 425–455.

Barney, J., 1991, "Firm Resources and Sustained Competitive Advantage," *Journal of Management*, 17(1), 99-121.

Bouquet, C., J. Birkinshaw, 2008, "Weight versus Voice: How Foreign Subsidiaries Gain Attention from Corporate Headquarters," *Academy of Management Journal*, 51(3), 577-601.

Bogner, W., and P. Bansal, 1998, *Integration of Technological Knowledge and the Creation of Competitive Advantage in Knowledge-Based Industries*. In Hitt, M., Ricart, J. and Nixon, R. (Eds), *Managing Strategically in an Interconnected World*. London: John Wiley and Sons, 167–184.

Brown, S.L., and K.M. Eisenhardt, 1995, "Product Development: Past Research, Present Findings, and Future Directions," *Academy of Management Review*, 20(2), 343-378.

Chen, W.R., 2008, "Determinants of Firms' Backward and Forward Looking R&D Search Behavior," *Organization Science*, 19(4), 609-622.

Cho, T.S., and D.C. Hambrick, 2006, "Attention as the Mediator between Top Management Team Characteristics and Strategic Change: the Case of Airline Deregulation," *Organization Science*, 17(4), 453–469.

Cohen, W., and D. Levinthal, 1990, "Absorptive Capacity: a New Perspective of Learning And Innovation," *Administrative Science Quarterly*, 35(1), 128–152.

Cyert, R. and J. March, 1963, *A Behavioral Theory of the Firm*, Englewood Cliffs, NJ: Prentice-Hall.

Daft, R.L. and K.E. Weick, 1984, "Toward a Model of Organizations as Interpretation Systems", *Academy of Management Review*, 9(2), 284-95.

DeCarolis, D. and D. Deeds, 1999, "The Impact of Stocks and Flows of Organizational Knowledge on firm performance: an empirical investigation of the Biotechnology Industry," S*trategic Management Journal*, 20(10), 953–968.

Dutton, J. E., E.J. Walton, and E. Abrahamson, 1989, "Important Dimensions of Strategic Issues: Separating the Wheat from The Chaff," *Journal of Management Studies*, 26(4), 379–396.

Dutton, J.E., and S.J. Ashford, 1993, "Selling Issues to Top Management," *Academy of Management Review*, 18(3), 397–428.

Ernst and Young, 1993, *Biotech 93* Arthur Young High Technology Group: San Francisco, CA.

Fiske, S. T., and Taylor, S, 1984, *Social Cognition*, New York: Random House.

Freeman, C., and L. Soete, 1997, *The Economics of Industrial Innovation*, MIT Press, Cambridge, MA.

Gavetti, G., and D.A. Levinthal, 2000, "Looking Forward and Looking Backward: Cognitive and Experimental Search," *Administrative Science Quarterly*, 45(1), 113-137.

Grant, R., 2002, *Contemporary Strategy Analysis: Concepts, Techniques, Applications*, 4th edition. Oxford: Blackwell.

Greve, H. R., 2003, "A Behavioral Theory of R&D Expenditures and Innovation: Evidence from Shipbuilding," *Academy of Management Journal*, 46(6), 685–702.

Hansen, M.T., and M.R. Haas, 2001, "Competing for Attention in Knowledge Markets: Electronic document Dissemination in a Management Consulting Company," *Administrative Science Quarterly,* 46(1), 1–28.

Hausman, J., B. Hall, and Z. Griliches, 1984, "Econometric Models for Count Data with an Application to the Patents–R&D relationship," *Econometrica,* 52(4), 909–938.

Henderson, R. M., and K.B. Clark, 1990, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," *Administrative Science Quarterly,* 35(1), 9–30.

Huber, G., 1991, "Organizational Learning: The Contributing Processes and a Review of the Literatures," *Organization Science,* 2(1), 88-115.

Jones, B. D., and F.R. Baumgartner, 2005, *The Politics of Attention: How Government Prioritizes Problem*, Chicago: University of Chicago Press.

Katila, R., 2002, "New Product Search over Time: Past Ideas in Their Prime?" *Academy of Management Journal,* 45(5), 995–1010.

Katila, R. and G. Ahuja, 2002, "Something Old, Something New: a Longitudinal Study of Search Behavior and New Product Introduction," *Academy of Management Journal,* 45(6), 1183–1194.

Koput, K.W., 1997, "A chaotic model of innovative search: Some Answers, Many Questions," *Organization Science,* 8(5), 528–542.

Laursen, K., and A. Salter, 2006, "Open for Innovation: the Role of Openness in Explaining Innovation Performances among U.K. Manufacturing Firms," *Strategic Management Journal,* 27(2), 131–150.

Leonard-Barton, D., 1992, "Core capabilities and core rigidities: a paradox in Managing New Product Development," *Strategic Management Journal*, special issue 13, 111–126.

Levitt, B., and J.G. March, 1988, "Organizational Learning," *Annual Review of Sociology,*14, 319–340.

Makadok, R., and G. Walker, 1996, "Search and Selection in the Money Market Fund Industry," *Strategic Management Journal*, special issue 17, 39-54.

March, J., 1991, "Exploration and Exploitation in Organizational Learning," *Organization Science,* 2(1), 71-87.

Miller,C., L.Burke, and W. Glick, 1998, "Cognitive diversity among upper-echelon executives: Implications for Strategic Decision Process," *Strategic Management Journal*, 19(1), 39-58.

Mowery, D.C., J.E. Oxley, and B.S. Silverman, 1996, "Strategic Alliances and Interfirm Knowledge Transfer," *Strategic Management Journal*, special issue 17, 77–91.

Nelson, R., and S. Winter, 1982, *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.

Nerkar, A., and P.W. Roberts, 2004, "Technological and Product-Market Experience and the Success of New Product Introductions in the Pharmaceutical Industry," *Strategic Management Journal,* 25(8-9), 779–799.

Ocasio, W., 1997, "Towards an Attention-Based View of the Firm," *Strategic Management Journal*, special issue 18, 187–206.

Ocasio, W., and J. Joseph, 2005, "An Attention-Based Theory of Strategy Formulation: Linking Micro- and Macro Perspectives in Strategy Processes," *Advances in*

*Strategic Management: Strategy Process*, 22, 39-61.
Quintana-Garcia C., C.A. Benavides-Velasco, 2008, "Innovative Competence, Exploration and Exploitation: the Influence of Technological Diversification," *Research Policy*, 37(3), 492-507.
Rosenkopf, L., and A. Nerkar A, 1999, "On the Complexity of Technological Evolution: Exploring Coevolution within and across Hierarchical Levels in Optical Disc Technology," In *Variations in Organization Science: In Honor of D. T. Campbell*, Baum J, McKelvey W (eds). Sage: Thousand Oaks, CA; 169–183.
Rosenkopf, L., and M. Tushman, 1998, "The Coevolution of Community Networks and Technology: Lessons from the Flight Simulation Industry," *Industrial and Corporate Change*, 7(2), 311–346.
Rosenkopf, L., and A. Nerkar, 2001, "Beyond Local Research: Boundary-Spanning, Exploration, and Impact in the Optical Disk Industry," *Strategic Management Journal*, 22(4), 287–306.
Shan, W., and Song, J., 1997, "Foreign Direct Investment and the Sourcing of Technological Advantage: Evidence from the Biotechnology Industry," *Journal of International Business Studies*, 28(2), 267–284.
Simon, H.A., 1947, *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations* (2nd ed.), New York: Macmillan.
Sorenson, J., and T. Stuart, 2000, "Aging, Obsolescence and Organizational Innovation," *Administrative Science Quarterly*, 45(1), 81–112.
Stolpe, M., 2002, "Determinants of Knowledge Diffusion as Evidences in Patent Data: the Case of Liquid Crystal Display Technology," *Research Policy*, 31(7), 1181–1198.
Teece, D. J., 1980, "Economies of Scope and the Scope of the Enterprise," *Journal of Economic Behavior & Organization*, 1(3), 223–247.
Thornton, P. H., 2004. *Markets from Culture: Institutional Logics and Organizational Decisions in Higher Education Publishing*, Stanford: Stanford Business Books.
Tushman, M., and P. Anderson, 1986, "Technological Discontinuities and Organizational Environments*," Administrative Science Quarterly*, 31(3), 439–465.
Tushman, M., and L. Rosenkopf, 1992, "Organizational Determinants of Technological Change: toward a Sociology of Technological Evolution," *Research in Organizational Behavior*, 14, 311–347.
Von Hippel, E., 1994, "Sticky Information and the Locus of Problem-Solving: Implications for Innovation," *Management Science*, 40(4), 419–439.
Yadav, M.S., J.C. Prabhu, and R.K. Chandy, 2007, "Managing the Future: CEO Attention and Innovation Outcomes," *Journal of Marketing*, 71(4), 84-101.