NEVER TOO EARLY, NEVER TOO LATE: EFFECTS OF SEARCH TIMING ON PRODUCT INNOVATION

RIITTA KATILA
ERIC L. CHEN
Department of Management Science and Engineering
Stanford University
Stanford, CA 94305

Katila, R. and Chen, E. 2006. Never too early, never too late: Effects of search timing on product innovation.* Academy of Management Best Paper Proceedings, *OMT: O1-O6. Atlanta: Academy of Management.

INTRODUCTION

A significant stream of research has emerged to study search (i.e., problem-solving) in organizations, and several insights have been discovered through this work. One is that firms search close to their current knowledge-bases (Nelson and Winter, 1982), and that searching further than that is rare and risky (Katila, 2002). Another is that successful search often combines knowledge that is known to the firm with knowledge that is new to it (March, 1991; Katila and Ahuja, 2002). However, the dominant view on search has been one that is firm-centric. For example, in the above studies the firm's search activities are measured in the context of its own past behavior. But such studies, although valuable, do not take into account that the firm's competitors search as well. These competitor searches are likely to set important but understudied constraints as well as opportunities for search.

In this paper we propose that the next step is to consider search in the context of competitive interaction. In particular, we explore a focal firm's search timing in relation to competitor searches, and test how this timing affects the firm's ability to introduce innovative products. Search timing is particularly attractive to explore because it allows us to juxtapose two partly contradictory views on competitive interaction: the resource-based view that emphasizes the value of searching early and avoiding competition and the inter-organizational learning view that emphasizes the value of searching late and exploiting competition.

Recently, a handful of search scholars have started to examine the role of competition (e.g., Greve and Taylor, 2000), but several issues remain unexplored. One is that the studies do not discuss whether firms only trail behind their competitors, or also anticipate their moves. More broadly, timing relative to competitors has not been studied. The second issue is that prior studies often have broad measures of competitive interaction, such as co-location in the same market or network, or proxies such as search output, but relatively little is actually learned about the types of knowledge that are searched in relation to competitors' knowledge. Third, these studies are often descriptive. They identify common patterns of search, or triggers that activate search, but do not explicitly examine the effects on search performance. We address these gaps.

HYPOTHESES

In this study we develop hypotheses to explain whether firms introduce more innovative products when their search timing depends on that of their competitors. The first set of hypotheses (Moving early) draws from the resource-based view and focuses on searching

technological knowledge earlier than competitors. The second set (Moving late) draws from the inter-organizational learning view and focuses on searching technological knowledge later than competitors. A third set (Moving early *and* Moving late) integrates the previous two sets.

Moving Early

Searching for technological knowledge earlier than competitors—which we label moving early—can allow the firm to develop innovative products for two reasons. First, such search focuses on new raw material (new knowledge) and thus extends the range of available technological options from which the firm can select the most innovative ones. The second mechanism that makes moving early valuable is its potential to solve critical problems (Hughes, 1983). Critical problems cannot be solved with the knowledge that is currently available in the industry, but may be solved by knowledge that exists elsewhere. Therefore, firms that search technological knowledge before their competitors are in a good position to identify and solve such critical problems, resulting in innovative new products that were previously not possible.

> **Hypothesis 1.** Moving early has a positive relationship with the innovativeness of the firm's new products.

In addition to searching knowledge early, it may also be beneficial for firms to retain exclusive access to that knowledge, that is, to search it repeatedly when competitors are not (yet) searching it. Exclusivity is beneficial because when competitors are slow to catch up, firms are motivated to build a competence around knowledge that they search exclusively. Excessive exclusive search can have negative consequences, however. In the long run, engineers often become limited in their ability to form different combinations from the same knowledge, and indeed find difficult to combine it in radically different ways. We propose:

> **Hypothesis 2.** Exclusivity has a curvilinear relationship (taking an inverted U shape) with the innovativeness of the firm's new products.

We also argue that exclusivity is likely to moderate the relationship between moving early and innovativeness. Because early-mover knowledge (i.e., knowledge that the firm searches before its competitors) is new to the industry, it is fundamentally risky and its productivity unknown. Thus, we would expect that as the proportion of early-mover knowledge in the firm's search increases, searching that knowledge productively is easier if the firm has prior experience with it. Therefore, we hypothesize a positive interaction:

> **Hypothesis 3.** Exclusivity moderates the effect of moving early on innovativeness of the firm's new products.

Moving Late

While firms may introduce innovative products by moving early, the inter-organizational learning stream suggests that they may do so also by moving late, i.e., by searching technological knowledge later than competitors. Firms become better innovators by observing the search of

their competitors because competitors are usually more varied in their experience than a single firm is. In contrast with the prior resource-based hypotheses, these ideas suggest the following:

> **Hypothesis 4.** Moving late has a positive relationship with the innovativeness of the firm's new products.

In addition to the benefits of moving late, it is also important to understand the extent to which competitors have repeatedly searched the knowledge before the firm selects it for search—which we label crowding. We propose that crowding has a nonlinear, inverted U relationship with innovativeness. This is because at first, late movers can avoid the mistakes of prior searches as well as make causal inferences from them. However, late movers face growing competition and fewer opportunities as more and more firms search the knowledge before them. Such excessive crowding eventually becomes harmful. We propose:

> **Hypothesis 5.** Crowding has a curvilinear relationship (taking an inverted U shape) with the innovativeness of the firm's new products.

We also argue that crowding is likely to moderate the relationship between moving late and innovativeness. As the proportion of crowded late-mover knowledge in the firm's search increases, the firm increasingly searches in areas well-known to others that are close to technological exhaustion. At the same time, because late-mover knowledge is new to the firm, its fit with the firm's existing knowledge is unknown and so requires resource-consuming integration, leading to the following negative interaction hypothesis:

> **Hypothesis 6.** Crowding moderates the effect of moving late on innovativeness of the firm's new products.

Moving Early and Moving Late

In the hypotheses so far, the two types of search timing, early and late, have been treated as separate and distinct sources of innovative products. However, it is possible that firms could capitalize on their interrelationships. In hypothesis 7 we propose a positive interaction between searching early and late. One source of innovative products is when the firm is able to see old knowledge differently. Using this logic, we propose that early and late-mover knowledge are mutually reinforcing, because the firm can use experiences from its early searches to challenge the way the knowledge that it is searching late has been viewed and used in the industry, resulting in new combinations. Second, firms benefit from combining early and late-mover knowledge in their searches because they can take advantage of division of labor. Complex product technologies (such as robotics) require a variety of expertise and are often developed by several firms. So combinations of early and late-mover searches provide an opportunity to integrate knowledge developed by the firm with the knowledge developed by others.

> **Hypothesis 7.** There is a positive interaction between moving early and moving late on the innovativeness of the firm's new products.

METHOD

The sample for the study is industrial automation companies that developed industrial robots during the 1984-1998 time period in Japan, Europe and the U.S. We collected data on all the new robot introductions by these companies in 1984-1998. There were new product introductions by 71 companies in 293 firm-years. These firms represent a wide range: one company introduced new products 14 years in a row, whereas 22 of these firms introduced products in only one year. On average, the firms introduced new products in 4.1 firm-years.

Three primary data sources were used. For new products, we used a "literature-based innovation output indicator" method with trade publications and product catalogs as the main source (Coombs et al., 1996). Altogether, over 30 different publications over a 15-year period were searched. For patent data, we used custom-programmed C code to retrieve the data from the U.S. Patent and Trademark Office database and to assemble it into the patent variables. For firm financial and operational data, we assembled data from databases such as Compustat, Worldscope and DIR Analyst's guide.

Our dependent variable was the innovativeness of the firm's new product portfolio, which we measured as the improvement in those product design characteristics that were important to users. We used four core design characteristics of robots: repeatability, speed, load capacity, and degrees of freedom. We compare the average performance characteristics of the firm *i*'s robots in year t with the first robot introduced in the industry. Consistent with prior work, the variable is constructed as a sum of the differences between year t and first robot characteristic values divided by first robot values, and averaged across the four characteristics.

Assembling longitudinal data to measure timing of search is a major challenge. Because each patent describes a technological problem and a solution to that problem, patents are a particularly good source for measuring how firms solve problems, i.e., search (Katila, 2000, 2007). The patents and the patents cited in them form each firm's annual technological knowledge base. We used these knowledge bases to form the independent variables. We measured *Moving early* as the proportion of those prior art patent citations in the firm *i*'s current year's patents that cannot be found in its competitors' but can be found in its own past five years' technological knowledge bases. We measured *Exclusivity* through the number of times that firm *i* has used these early-mover citations in the past. We measured *Moving late* as the proportion of those prior art patent citations in the firm *i*'s current year patents that can be found in the competitors' technological knowledge bases during the past five years but not in the firm's knowledge base. Finally, we measured *Crowding* through the number of times that firm *i*'s competitors have used these late-mover citations in the past.

Prior studies suggest that we include several control variables in our analyses, including *firm R&D*, *firm size* (number of corporate employees), *nationality* (Japanese, European, U.S. firm), *year* (1984-1997) and *self-selection* (c.f., Katila and Shane 2005). In the analyses, we used a random effects model because we had multiple observations for each firm. To facilitate causal inference, the independent and control variables were lagged.

RESULTS

All but one of our hypotheses were strongly supported. The effect of moving early is positive and significant confirming hypothesis 1. The results also provide support for the inverted U-shaped prediction between exclusivity and innovativeness in hypothesis 2. Consistent

with hypothesis 3, we also find that the positive relationship between moving early and innovativeness is stronger at higher levels of exclusivity.

Regarding hypothesis 4, the positive effect of moving late confirms that searching knowledge later than one's competitors increases innovativeness. Thus, it appears that both early and late searches are more likely to be a source of innovation than keeping in sync with competitors. In contrast, Hypothesis 5 is not supported, but instead we find that innovativeness increases sharply with crowding, at least after a potential initial decline at low levels. Finally, the results support a negative interaction between moving late and crowding, as predicted in hypothesis 6, and hypothesis 7 that proposed that firms create the most innovative portfolios when they combine high levels of both early and late-mover searches.

DISCUSSION

We started this paper by proposing that the next step for search research is to incorporate competitive interaction. In particular, we identified search timing (relative to that of competitors) as a significant open issue. Juxtaposing two theoretical perspectives on competitive interaction, the resource-based and inter-organizational learning views, we then operationalized and tested how different types of search timing, i.e., moving early, moving late and moving simultaneously with competitors affects innovativeness of a firm.

There are several findings. First, firms that are out of sync with their competitors (i.e., search early and/or search late) are more innovative than firms that search simultaneously with them. For search research, our results thus provide empirical evidence that fully understanding the value of search requires understanding of competitive interaction. Second, the results suggest searching late as a surprisingly opportune (but understudied) time to search. These findings on late search thus add to inter-organizational learning literature by showing that searching later than one's competitors can improve not only efficiency and ability to avoid errors (e.g., Haunschild and Ni, 2002), but also the ability to innovate. Third, the results show that firms that search technological knowledge sooner than their competitors introduce more innovative products. These firms also remain innovative (at least up to a point) if they subsequently manage to exploit the knowledge exclusively. Thus, the results confirm the resource-based expectations that searching early and avoiding competition are beneficial (c.f., Wernerfelt, 1984), once again not only in terms of efficiency and survival, but also in terms of innovativeness.

These results have interesting implications for theories of innovation search, resources, and inter-organizational learning. A central, overall contribution is to extend work on innovation search to include the competitive interaction perspective. We add to previous empirical search studies that have started to incorporate external elements, and in particular to Greve and Taylor (2000) who found that changes in competitors' markets triggered changes in the focal firm but suggested that further work was needed to test the actual search processes and resource allocations. We addressed this gap, and also extended research to search timing and its effects on search performance that have not been studied.

Our study also contributes to the resource-based view. We show that firms that search resources early are more innovative. Our findings are based on unusually detailed measures of knowledge resources and directly testing their search relative to competitors. In addition, we provide evidence of a variable that is not yet well-understood: exclusivity. While some scholars (such as Roberts, 1999) have shown that firms that avoid competition perform poorly, such prior work has focused on exclusivity in product markets. In contrast, the results of our study show

that exclusivity in resource markets is beneficial (as expected by the resource-based scholars), at least up to a point. Taken together, these results suggest then that firms should avoid (or delay) competition in resource markets but seek competition in product markets.

We also contribute a new perspective to inter-organizational learning research. Consistent with the learning theorists, we find that organizations learn from others' experience. We show this result by using more precise measures than prior studies (i.e., uniquely measuring the process of inferential learning through patent data), instead of using output as a proxy for learning. We also add to learning literature by showing that inferential learning from one's competitors can improve not only efficiency, ability to avoid errors, and survival (Haunschild and Ni, 2002), but also surprisingly the ability to innovate.

We also have several methodological contributions. Our analysis is based on a unique dataset that tracks the product development and product introduction behaviors of robotics companies over time and across three continents. This dataset combines numerous hardcopy and electronic sources to provide a comprehensive history of the robotics firms' search efforts. Consequently, it also provides a unique opportunity to test search timing hypotheses.

REFERENCES

Coombs, R., Narandren, P., & Richards, A. 1996. A literature-based innovation output indicator. **Research Policy**, 25: 403-413.

Greve, H., & Taylor, A. 2000. Innovations as catalysts for organizational change: Shifts in organizational cognition and search. **Administrative Science Quarterly**, 45: 54-80.

Haunschild, P., & Ni, B. 2002. Learning from complexity: Effects of prior accidents and incidents on airlines' learning. **Administrative Science Quarterly**, 47: 609-643.

Hughes, T. 1983. Reverse salients and critical problems. In T. Hughes (Ed.), **Networks of power**. Baltimore: John Hopkins University Press.

Katila, R. 2000. Measuring innovation performance. **International Journal of Business Performance Measurement**, 2: 180-193.

Katila, R. 2002. New product search over time: Past ideas in their prime? **Academy of Management Journal**, 45: 995-1010.

Katila, R., & Ahuja, G. 2002. Something old, something new: A longitudinal study of search behavior and new product introductions. **Academy of Management Journal**, 45: 1183-94.

Katila, R., & Shane, S. 2005. When does lack of resources make new firms innovative? **Academy of Management Journal**, 48: 814-829.

Katila, R. 2007. Measuring innovation performance. In Neely, A. (Ed.), **Business Performance Measurement – Theory and Practice**, 304-317. Cambridge, UK: Cambridge University Press (2nd edition).

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

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

Roberts, P. 1999. Product innovation, product-market competition and persistent profitability in the U.S. pharmaceutical industry. **Strategic Management Journal**, 20: 655-670.

Wernerfelt, B. 1984. A resource-based view of the firm. **Strategic Management Journal**, 5: 171-180.