

How innovators resolve the exploitation-exploration trade-off? Evidence from the Japanese Pharmaceutical Industry

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Abstract. Successful innovation calls for both exploitation of existing knowledge and exploration of new knowledge, or organizational ambidexterity, but we still know little about how organizations manage innovation by resolving the trade-off relationship between exploitation and exploration. We aim to address this research gap by examining the relationship between an organization's degree of exploitation orientation and its subsequent degree of organizational ambidexterity. We argue that organizations' exploitation orientation negatively influences subsequent achievement of organizational ambidexterity because exploitation precludes subsequent exploration. However, this trade-off relationship between prior exploitation and subsequent exploration is attenuated when organizations are characterized by problemistic search, deliberate learning, or by speciation. Accordingly, these organizations' degree of exploitation orientation more positively influences subsequent achievement of organizational ambidexterity. Our empirical analyses of 32 Japanese pharmaceutical firms' new product developments over 1991 to 2000 support the argument. Our findings show that organizations may increase their degree of organizational ambidexterity by resolving, rather than circumventing, the trade-off relationship between exploitation and exploration, thereby proposing an alternative explanation of ambidexterity antecedents.

Keywords. Innovation, knowledge management, new technology, business management, pharmaceutical industry, research and development.

1. Introduction

One of the major challenges in innovation management is to exploit existing knowledge at the same time exploring new knowledge, or to achieve organizational ambidexterity (Andriopoulos and Lewis, 2009; Birkinshaw and Gupta, 2013; Duncan, 1976; Levinthal and March, 1993; Nosella, Cantarello and Filippini, 2012; O'Reilly and Tushman, 2008; Turner, Swart and Maylor, 2013). If organizations only exploit their existing knowledge, their products and services will quickly grow obsolete (Benner and Tushman, 2002; Sørensen and Stuart, 2000), and unprofitable. On the contrary, excessive pursuit of exploration may endanger organizations' reliability and accountability (Glasmeier, 1991; Hannan and Freeman, 1984), because it often is very difficult to appropriately manage risk and uncertainty associated with exploration. Accordingly, organizational ambidexterity is an important enabler of innovation.

However, balancing exploitation and exploration is not easy, because exploitation crowds out exploration (March, 1991). Accordingly, prior research tries to uncover how organizations can circumvent such trade-off relationship between exploitation and exploration (Nosella et al., 2012; Turner et al., 2013). For example, entrepreneurial teams who explore new knowledge may be separated from the rest of the organization that exploits existing knowledge (Tushman and O'Reilly, 1996).

Alternatively, managers may grow unique organizational contexts that forces (as well as encourages) organizational members to simultaneously pursue exploitation and exploration vigorously (Gibson and Birkinshaw, 2004; Lubatkin, Simsek, Ling and Veiga, 2006).

These works show that organizations may skillfully reduce the likelihood that the trade-off relationship between exploitation and exploration disturbs organizations' innovation initiatives. On the other hand, the possibility that organizations may resolve (rather than circumvent) the latent antagonistic relationship between exploitation and exploration is not addressed quite effectively. In this manuscript, we aim to address this research gap by employing concepts originating from the behavioral theory of the firm (Cyert and March, 1963), organizational learning theory (Zollo and Singh, 2004; Zollo and Winter, 2002), as well as theory of technological evolution (Adner and Levinthal, 2000; Cattani, 2006; Levinthal, 1998).

More specifically, we employ concepts originally established by the related, but distinct theoretical disciplines to uncover boundary conditions under which the degree to which an organization focuses on exploitation, or exploitation orientation, is less negatively associated with subsequent degree of exploration, thereby increasing subsequent degree of organizational ambidexterity. We argue that an organization's exploitation orientation is negatively associated with subsequent increases in its degree of organizational ambidexterity. We also argue that this negative relationship is attenuated when the organization is characterized by problemistic search, deliberate learning, or by speciation. Our empirical analyses of 32 Japanese pharmaceutical firms' new product developments from 1991 to 2000 support our argument. With these findings, we show the possibility of hitherto underexplored mechanisms in which organizations increase subsequent degree of their organizational ambidexterity by resolving an inherent trade-off relationship between exploitation and exploration. Our argument employs behavioral theory of the firm, theory of organizational learning, and the theory of technological evolution to uncover a dynamic process through which organizations improve their innovation capacity.

2. Theory and Hypothesis

2.1. Exploitation orientation and organizational ambidexterity

In this manuscript, we rely on research conducted by March (1991) and a number of other scholars (Benner and Tushman, 2002; Bierly and Chakrabarti, 1996; Crossan, Lane and White, 1999; Katila and Ahuja, 2002; Puranam, Singh and Zollo, 2006; Rosenkopf and Nerkar, 2001; Sørensen and Stuart, 2000; Sidhu, Commandeur and Volberda, 2007; Wu, 2012; Zhou and Wu, 2010) to define exploitation and exploration as alternative modes of organizational learning underlying innovation initiatives. More specifically, we define exploitation as the use and refinement of existing knowledge within an organization's internal domains. The term, exploration, is used to describe the search for and pursuit of new knowledge within an organization's external domains. Accordingly, organizational ambidexterity (i.e., an organizational capability to simultaneously pursue exploitation and exploration), can be defined as an organization's learning behaviors that are based on both existing and novel knowledge (Birkinshaw and Gupta, 2013; Raisch and Birkinshaw, 2008).

One notable aspect of path-dependency (Arthur, 1988; David, 1985, 1990; Levitt and March, 1988) with respect to organizational learning concerns the trade-off relationship between exploitation and exploration. More specifically, most organizations increase their degree of exploitation at the expense of exploration. Exploitation crowds out subsequent exploration because an organization's

exploitation of existing knowledge is a more certain source of organizational competence (Levitt and March, 1988; Nelson and Winter, 1982; Teece, 1982). A behavioral perspective posits that boundedly rational managers continue to exploit their existing knowledge, thereby entrapping themselves in a local peak of their performance landscape (Levinthal, 1997; Levitt and March, 1988). Consequently, their organization avoids the exploration of new peaks because a move away from the local peak causes a temporal performance decline.

An alternative explanation based on a structural or institutional perspective suggests that stakeholders select exploitation-oriented organizations over exploration-oriented ones. From the perspective of stakeholders, the former is more reliable and accountable (Hannan and Freeman, 1984) because exploitation-oriented organizations are characterized with the increasingly tighter coupling among an organization's "choices with respect to activities, policies, and organizational structures, capabilities, and resources" (Siggelkow, 2001, p. 838). The stakeholders' influence even forces an organization to abandon seemingly attractive and promising new business opportunities because these opportunities sometimes appear to be excessively exploratory (Christensen and Bower, 1996; Glasmeier, 1991).

Therefore, we argue that organizations' exploitation orientation negatively influences subsequent achievement of organizational ambidexterity because exploitation-oriented organizations grow more exploitation-oriented as they exploit their existing knowledge. This greater increase in exploitation disturbs the balance between exploitation and exploration, and decreases the degree of organizational ambidexterity.

Hypothesis 1. The degree of an organization's exploitation orientation is negatively associated with its subsequent achievement of organizational ambidexterity.

2.2. Exploitation orientation and problemistic search

The foregoing discussion assumes that organizations are risk averse (March, 1991). Consequently, they prefer exploitation to exploration because most incidents of exploitation are successful in that anticipated consequences are achieved (Abernathy, 1978; Benner and Tushman, 2003; Holland, 1975; March, 1991; McGrath, 2001). However, this may not necessarily be the case in an environment where competitive requirements change quickly. For example, in a dynamically-changing and competitive environment, knowledge that once enabled favorable performance quickly grows obsolete (Sørensen and Stuart, 2000; Stuart, 1999). As a result, exploitation-oriented organizations may not be able to achieve their performance aspirations. Organizations then initiate problemistic search (Ahuja, Lampert and Tandon, 2014; Bromiley and Washburn, 2011; Cyert and March, 1963; Gaba and Joseph, 2013; Levinthal and March, 1981; Wennberg and Holmquist, 2008) because of this type of performance shortfall.

According to the behavioral theory of the firm (Cyert and March, 1963), organizations initiate problemistic search, or "search that is stimulated by a problem (usually a rather specific one) and is directed toward finding a solution to that problem" (ibid., p.121), when they realize that existing solutions to their problems are unsatisfactory. More formally restated, organizations employ problemistic search when their performance fails to reach their aspiration level (Lant, 1992; Lant and Montgomery, 1987; Shinkle, 2012). Organizations form their aspirations in reference to their close competitors' performance (Fiegenbaum, Hart and Schendel, 1996; Ocasio, 1997), as well as in reference to their own past performance (Greve, 1998). If achieved performance continues to meet their aspiration levels, organizations will not initiate problemistic search because they are satisfied with their current solutions. On

the other hand, if achieved performance falls short of aspiration levels, the organizations discard current solutions, and search for alternative solutions to their problems.

In general, the theory of problemistic search (Cyert and March, 1963; Levinthal and March, 1981) is applied to the search for alternative solutions that include knowledge, methods, or strategy. However, organizations also search for alternative learning patterns, or alternative “search rules” (Cyert and March, 1963, p. 174) when they realize that current learning performance is unsatisfactory (Baum and Dahlin, 2007; Bingham and Davis, 2012; Sitkin, 1992). Therefore, with respect to organizations that have primarily been involved in exploitation of existing knowledge who then find their performance unsatisfactory, we argue that they must initiate problemistic search for more exploratory learning patterns. Conversely, we expect that problemistic search by exploration-oriented organizations is motivated by their need to identify exploitative learning patterns.

Therefore, we argue that when exploitation-oriented organizations initiate problemistic search, they are more likely to adjust their learning patterns to increase their degree of exploratory learning. This increase in exploratory learning patterns may help balance exploitation and exploration and increase their subsequent degree of organizational ambidexterity.

Hypothesis 2. The degree of an organization’s exploitation orientation is more positively associated with its subsequent achievement of organizational ambidexterity when the organization is more strongly characterized by problemistic search.

2.3 Exploitation orientation and deliberate learning

Organizations may also increase exploratory learning even before a decline in their performance occurs. As discussed above, unsatisfactory performance motivates organizations to search for alternative learning patterns because unsatisfactory performance calls organizational members’ attention to limitations of their existing knowledge. Similarly, even before a performance shortfall, deliberate efforts to learn (Berghman, Matthysens, Streukens and Vandenbempt, 2013; Heimeriks, Schijven and Gates, 2012; Muehlfeld, Sahib and Witteloostuijn, 2012; Zollo and Singh, 2004; Zollo and Winter, 2002) may help organizations recognize limitations of existing knowledge and motivate them to find new knowledge through exploratory learning.

Exploitation-oriented organizations sometimes overestimate the usefulness of existing knowledge (Henderson and Clark, 1990; Leonard-Barton, 1992), thereby inappropriately applying existing knowledge in novel contexts where new knowledge would be more appropriate (Miller, 1993). This “negative experience transfer” (Gick and Holyoak, 1987) is a consequence of “premature cognitive commitment” (Langer, 1989) to existing knowledge. It prevents organizations from expanding their scope of learning. An organization’s focus on exploitation is a typical example of such satisficing learning strategy to simplify experiences and to specialize adaptive responses (Levinthal and March, 1993). Because managers’ cognitive capacity is so bounded (March and Simon, 1958) organizations focus on exploitation to ignore complex aspects of their experiences and narrow their adaptive responses.

Deliberate learning is one example of exercising such bounded cognitive capacity more effectively (Zollo and Singh, 2004; Zollo and Winter, 2002). Put differently, organizations can alleviate drawbacks associated with inappropriate focus on exploitation (Heimeriks et al., 2012) with deliberate efforts to learn. The risk of misapplying existing knowledge to new tasks can only be compensated for by the implementation of a second-order observation, or observers’ reflections on “potential failures and maladjustments” (Schreyögg and Kliesch-Eberl, 2007, p. 926). In

addition, “the hazards of inappropriate generalization can only be attenuated via explicit cognitive effort,” or “retrospective sense-making” (Zollo and Winter, 2002, p. 348) to make inferences about the applicability of lessons learned from experience. Therefore, although perceptions of success associated with prior exploitation may hamper effective learning by stimulating dysfunctional reactions such as superstition (Zollo, 2009), the dominance of these dysfunctional reactions may be alleviated by deliberate learning (Muehlfeld et al., 2012).

Specifically, when organizations try to learn deliberately, they can more precisely understand why and how existing knowledge is useful. Accordingly, organizations may try to engage in deliberate learning by their articulation and codification of their experiential learning (Heimeriks et al., 2012; Zollo, 2009; Zollo and Singh, 2004; Zollo and Winter, 2002). For example, some organizations spend time and effort on debriefing sessions and detailed postmortem analyses so that they can deliberately learn from their experiences (Heimeriks et al., 2012; Zollo, 2009; Zollo and Singh, 2004; Zollo and Winter, 2002). By articulating individually-held tacit knowledge, organizations can facilitate *ex post* sense-making to discover the precise cause-and-effect relationship that might exist between their past actions and associated outcomes (Kale and Singh, 2007; Zollo and Winter, 2002). The codification of task-related knowledge involves critical analysis and abstraction of experiences associated with a specific activity or task (Zollo and Winter, 2002). Thus, organizational members gain “a crisper understanding of what works, or what does not work and why, in the context of managing certain tasks” (Kale and Singh, 2007, p. 985) by the process of codification. As a consequence, deliberate efforts to learn can resolve superstitious learning (Zollo, 2009) or help organizations appropriately apply prior learning across significantly heterogeneous contexts such as acquisitions (Heimeriks et al., 2012; Zollo and Singh, 2004) or alliances (Kale and Singh, 2007).

In sum, deliberate efforts to learn help organizations understand the precise cause-and-effect relationships that underlie exploitation of existing knowledge and its consequences. Consequently, organizations can avoid inappropriate applications of existing knowledge by precisely recognizing how widely they can (or cannot) apply their existing knowledge. This recognition can also motivate organizations to address the need for new knowledge, because it simultaneously serves as an “enhanced recognition of the need for more fundamental change” (Zollo and Winter, 2002, p. 342). Conversely, we expect that such influences of deliberate learning are less explicit for exploration-oriented organizations because effective articulation and codification would be difficult to the extent that the focal knowledge is diversified and heterogeneous.

Therefore, we argue that exploitation-oriented organizations are more likely to involve themselves in subsequent exploratory learning if they are characterized by deliberate efforts to learn. This increase in exploratory learning may help balance exploitation and exploration and increase their degree of organizational ambidexterity.

Hypothesis 3. The degree of an organization’s exploitation orientation is more positively associated with its subsequent achievement of organizational ambidexterity when the organization is more strongly characterized by deliberate efforts to learn.

2.4 Exploitation orientation and speciation

In addition to organizations’ risk preference and bounded rationality, stakeholders’ influence may encourage organizations to exploit existing knowledge and technologies. For example, suppliers and distributors select organizations that exploit existing knowledge and technologies because exploitation-oriented organizations are

more reliable and accountable (Hannan and Freeman, 1984). Conversely, organizations' efforts to shift to a drastically new domain of knowledge hardly win supports of their suppliers and distributors (Glasmeier, 1991). Likewise, customers prefer incrementally improved products enabled by sustaining technologies (Christensen and Bower, 1996). Even competitors mutually strengthen their existing understanding of competitive conditions (Abrahamson and Fombrun, 1994). In short, organizations exploit to satisfy their stakeholders. Put differently, exploitation-oriented organizations may switch to explore when they free themselves from existing stakeholders' influences by shifting to new competitive contexts. Therefore, we argue that exploitation as speciation (Eldredge and Gould, 1972), or the exploitation of existing knowledge across multiple distinct contexts, increases the degree of organizational ambidexterity by helping organizations prepare for subsequent exploration.

Biologists originally developed the concept of speciation to explain how species evolve. According to Eldredge and Gould (1972), species evolve by the creation of derivative species appropriate for niches peripherally isolated from the original species. In these peripherally-isolated niches, resources available for survival may differ from those available in the original niche. In addition, criteria for the selection of surviving populations may also differ. Consequently, peripherally-isolated populations that possess different characteristics from the original population will be favorably selected. As peripherally-isolated populations accumulate these different characteristics, they eventually evolve into new species.

This concept of speciation is applied to the case of technological evolution (Adner and Levinthal, 2000; Cattani, 2006; Levinthal, 1998). In this context, speciation describes the application of existing technological knowledge to new domains of application. According to Levinthal (1998), new domains of application are characterized by resource abundance and selection criteria that differ from the original application. Therefore, engineers must adjust the original technology so that they can best leverage available resources in new application domains. Adjustments to the original technology are also necessary because unique selection criteria in the new application domains must be taken into account. These adjustments entail exploration of new knowledge because they eventually transform the original technology and develop a new technological "lineage" (pp. 220-221). It is important to note that Levinthal (1998) characterizes the initial shift to new application domains as "quite minor" technological changes, or even "no change in technology," to emphasize these shifts' exploitative nature (p. 218). However, because speciation is a "separation of reproductive activity" (p. 218) that is repeated across time, speciation may "trigger a divergent evolutionary path" (p. 218), thereby forcing organizations to learn in exploratory manners.

Other scholars argue that technological knowledge is not the only type of knowledge that undergoes a process characterized as speciation. For example, operational routines or business model "templates" are only imperfectly replicated (or exploited) across multiple sites (Feldman, 2000; Feldman and Pentland, 2003; Rerup and Feldman, 2011; Winter and Szulanski, 2001; Winter, Szulanski, Ringov and Jensen, 2012) because existing knowledge is "situated" (Suchman, 1987) or "embedded" (Orlikowski, 1996) to the original context. This imperfect replication allows experimental adjustments to accommodate local requirements of distinct sets of customers, competitors, and suppliers. Some local adjustments may fail, but others may result in useful novel ideas. Consequently, exploratory learning of new knowledge occurs at the level of the entire organization (Winter and Szulanski, 2001; Winter et al., 2012). Put differently, local adjustments to routines influence even "schematic" or "ostensive" aspects of organizational routines, enabling system-wide changes (Feldman and Pentland, 2003).

In short, an act of exploration can be prepared and enabled (sometimes as an unintended consequence) by speciation, or exploitation of existing knowledge across multiple distinct contexts (Nooteboom, 2000). Speciation particularly enables subsequent exploration to the extent that the original and new contexts are distinctly different. Accordingly, we argue that the positive association between speciation and subsequent exploration is more explicit for exploitation-oriented organizations because exploitation-oriented organizations apply their existing knowledge irrespective of contextual differences. On the other hand, exploration-oriented organizations apply their existing knowledge only when contextual differences are too small to warrant their pursuit of new knowledge.

Therefore, we argue that exploitation-oriented organizations are more likely to involve themselves in subsequent exploratory learning when they exploit their existing knowledge across multiple distinct contexts. This increase in exploratory learning may help organizations balance exploitation and exploration, thereby enabling organizations to increase their degree of ambidexterity.

Hypothesis 4: The degree of an organization's exploitation orientation is more positively associated with its subsequent achievement of organizational ambidexterity when the organization is more strongly characterized by speciation.

3. Methods

3.1. Sample

We tested the hypotheses with data from the Japanese pharmaceutical industry. We particularly leveraged data on their new pharmaceutical products development to operationalize our sample firms' degree of organizational ambidexterity, as well as exploitation orientation. Because the Japanese market is the second largest country market for pharmaceutical products, most global pharmaceutical firms actively compete there. Furthermore, the data on the Japanese pharmaceutical firms' new products development are appropriate for our study for following two reasons.

Firstly, upon the approval of all new ethical drugs, independent specialists determine whether each new pharmaceutical contains an NCE (new chemical entity) or not. This classification is useful for our operationalization, because an NCE-based pharmaceutical product is traditionally thought to represent exploration of new knowledge in the context of new pharmaceutical development, while a non-NCE-based pharmaceutical product is thought to represent exploitation of existing knowledge (Bierly and Chakrabarti, 1996; Cardinal, 2001; Dunlap-Hinkler, Kotabe and Mudambi, 2010; Suzuki and Methé, 2011). An NCE represents a totally new chemical entity that did not exist as an ethical pharmaceutical drug before. Therefore, finding an NCE requires a search beyond known libraries of active ingredients, while a non-NCE reuses NCEs already approved for medical use. An example of a pharmaceutical drug based on a new chemical entity is Eli Lilly's Prozac, while its descendants, such as Sarafem is an example of a non-NCE-based pharmaceutical developed from the same chemical entity called fluoxetine. Initially, fluoxetine was developed as an anti-depressant (Prozac), and later, Eli Lilly redeveloped it for a different indication of premenstrual dysphoric disorder (Sarafem) upon Prozac's patent expiration.

Secondly, rich data on sample firms' new product development activities are available. Pharmaceutical firms are required to report on their clinical trial activities to the regulatory agency, which then discloses the information to the public. Leveraging these disclosed data, we are able to objectively measure sample firms'

degree of exploitation orientation, as well as ambidexterity. A professional medical magazine, called *New Current*, has been publishing exhaustive lists of pharmaceuticals under development (or pipelines) on a quarterly basis since 1990. The list shows each pharmaceutical firm's detailed pipeline information, including the name of pipelines, targeted therapeutic indications, stages of clinical trials, and whether each pipeline contains an NCE or not.

Our database consists of 32 Japanese pharmaceutical firms who gained new pharmaceutical approvals during January 2001 to December 2010 in the Japanese market. Combined revenue of these 32 firms represents 88.0% of the total Japanese market as of 2000. We constructed a panel database on these 32 firms over 10 years (from 1991 to 2000). After removing nine observations due to missing values in at least one variable of interest, we end up with a final dataset of 311 firm-years.

3.2. Variables and analysis

In order to test our hypotheses, we constructed a measure of exploitation orientation and tested its association with sample firms' increase in their degree of ambidexterity under moderating effects of problemistic search, deliberate learning, and speculation. The use of panel data helps us control for potential sources of unobserved heterogeneity. Because our models employ some time-invariant variables, we chose the random-effects generalized least squares (GLS) model, rather than the fixed-effects model because the fixed-effects model does not allow estimation of the coefficient for time-invariant regressors. Because panel data include multiple observations per sample firm, observations for the same firm are likely to be correlated. Such a serial correlation of errors within cross-section may deflate standard errors and inflate significance levels. Although Wooldridge's test for serial correlation (Drukker, 2003; Wooldridge, 2010) did not reject a null hypothesis of no serial correlation ($p = 0.3728$), we calculated standard errors using the robust clustered estimator (Arellano, 1987; Huber, 1967; White, 1980) because it produces consistent standard errors (Froot, 1989; Williams, 2000). This estimation is also robust to heteroskedasticity, another concern associated with panel data analysis (Cameron and Trivedi, 2009). Below, we describe variables employed in our model.

Our dependent variable, Δ Ambidexterity is a measure of Y_t to Y_{t+1} increase in sample firms' degree of organizational ambidexterity, which is operationalized by a percentage of exploitative pipelines (over total pipelines) multiplied by that of exploratory pipelines. As discussed above, we follow prior works to operationalized exploration and exploitation in the context of the pharmaceutical industry with NCE-based and non-NCE based pipelines, respectively (Bierly and Chakrabarti, 1996; Cardinal, 2001; Dunlap-Hinkler et al., 2010; Suzuki and Methé, 2011). Then we multiply them to operationalize sample firms' degree of organizational ambidexterity (Gibson and Birkinshaw, 2004; He and Wong, 2004).

Our independent variable is exploitation orientation, which is a measure of sample firms' degree of exploitation orientation, operationalized by a percentage of exploitative pipelines (over total pipelines) at Y_t . We employed an instrumental variable method (Bascle, 2008; Wooldridge, 2010), because our independent variable may be an endogenous variable. Specifically, a set of instrumental variables, including interest rates, long-term orientation, asset turn, and ROA are employed to gain fitted values of exploitation orientation, which then is used to estimate our dependent variable, or Δ Ambidexterity.

Interest rates are long-term interest rates on government bonds at the time of Y_t . We expect interest rates are negatively associated with exploitation orientation, because higher interests rates, or higher costs of capital encourage firms to pursue more risky investment initiatives. Firms may also be less exploitation-oriented to the extent that

they are characterized with long-term orientation, which is operationalized by their share of pipelines at a phase 1 of clinical trials or before (over total pipelines) at Y_t . Furthermore, it is possible that firms are more exploitation-oriented to the extent that their resources are tied to tangible manufacturing facilities (Abernathy, 1978). Therefore, we employed asset turn as a (reverse) measure of each sample firm's degree of tangible assets intensity. Finally, because sample firms' profitability may also influence their degree of exploitation orientation, each firm's return on assets (ROA) at Y_t is also included. Weak identification tests by Cragg-Donald Wald F statistic (Cragg and Donald, 1993) reveal that we can reject the null hypothesis that our instruments are weak, or only marginally relevant. Tests of overidentifying restrictions by Hansen J statistic (Hansen, 1982) indicate that the null hypothesis that all instruments are valid is not rejected ($p=0.1295$). Furthermore, n times the R^2 from the first stage of two-stage least squares ($311 * 0.14$) is much larger than the number of instruments (four), indicating that two-stage least squares tends to be less biased than ordinary least squares for our model (Murray, 2006).

Problemistic search is our first moderator variable. It is a measure of the degree of performance shortfall, operationalized by sample firms' social attainment discrepancy or historical attainment discrepancy (Greve, 1998; Lant, 1992), whichever is greater. We measured social attainment discrepancy with the difference between the Japanese market growth and sample firms' revenue growth from Y_{t-1} to Y_t . As for historical attainment discrepancy, we divided sample firms' average revenue over Y_{t-3} to Y_{t-1} with current revenue at Y_t . Because some authors indicate that the relationship between attainment discrepancy and the degree of subsequent search behaviors may not be linear (Audia and Greve, 2006; Baum and Dahlin, 2007; Miller and Chen, 2004; Osborn and Jackson, 1988; Staw, Sandelands and Dutton, 1981), we tested a concave relationship and a convex relationship in addition to a linear relationship and confirmed that there were no significant changes in the econometric results obtained. Below, we report the concave version that shows the highest fit.

Our second moderator variable is deliberate learning, a measure of the extent to which sample firms articulate and codify their learning from their new product developments. One of the most typical ways with which pharmaceutical firms articulate and codify their knowledge is patenting. Accordingly, we operationalized sample firms' degree of deliberate learning with their annual count of applied U.S. patents (divided by research and development expenditure to control for firm size differences) at Y_t .

Thirdly, we also employed a measure of the extent to which sample firms involve themselves in speciation. Scholars operationalize product market segments (or underlying technological areas) in the pharmaceutical industry with therapeutic areas (Hoang and Rothaermel, 2010; Macher and Boerner, 2006; Nerkar and Roberts, 2004). Across therapeutic areas, there are substantial differences in terms of product development approaches, physicians' needs, and market size for pharmaceutical products (ibid.). Therefore we operationalized speciation by a percentage of pipelines launched in therapeutic areas where they had no pipelines in a preceding year (over total pipelines), at Y_t .

We also employed several control variables. Δ Organizational size is our sample firms' Y_t to Y_{t+1} increase in their number of employees. R&D intensity is also employed as a measure of the degree of sample firms' absorptive capacity operationalized by their research and development (R&D) expenditure divided by their revenue. We also included sample firms' age to control for effects of sample firms' senescence. A dummy variable that indicates whether sample firms experienced mergers and acquisitions in Y_t (M&As) controls for influences of drastic changes in their pipelines. We also employed a measure of competitive intensity observed in sample firms' niches, operationalized by the increase in patent applicants

to the United States Patent and Trademark Office's 3-digit technological classes to which sample firms filed patents. Finally, sample firms' time-invariant characteristics are controlled for by dummy-coding the variable as 1 when sample firms are diversified chemical firms and 0 otherwise.

4. Results

Table 1 shows descriptive statistics and a correlation matrix for all the variables employed in our models. Overall, the independent, moderator, and control variables show considerable variability, and most correlations among the variables range from small to moderate. We also checked the VIF (variance inflation factors) for all variables and none of them exceeds 10.0, which is the rule of thumb threshold of potential multicollinearity (Cohen, Cohen, West and Aiken, 2003).

Table 1. Descriptive Statistics and Correlations

	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Δ Ambidexterity	0.39	4.73														
2. Interest rates	3.42	1.54	.13													
3. Long-term orientation	0.27	0.15	-.06	-.11												
4. Asset turn	0.76	0.23	.03	.01	.08											
5. ROA	8.12	4.75	.02	-.16	-.17	-.10										
6. Δ Organizational size	1.04	0.14	.04	-.10	.08	.07	.06									
7. R&D intensity	8.67	4.62	-.01	-.03	.01	-.49	-.02	-.06								
8. Age	93.74	65.66	.07	.00	-.18	-.20	.21	-.06	-.17							
9. M&As	0.00	0.06	.01	-.04	-.01	.03	.01	.13	.01	-.03						
10. Competitive intensity	1.07	0.08	.02	.17	-.10	.01	.04	-.07	.03	.01	.05					
11. Diversified	0.27	0.45	.02	-.04	.19	.43	-.22	.11	-.65	-.24	-.03	-.11				
12. Problemistic search ^a	2.65	1.09	-.13	.04	.10	-.10	-.15	-.01	.15	-.03	-.01	-.02	-.02			
13. Deliberate learning ^a	0.16	0.26	-.05	.02	.21	.13	-.18	-.03	-.44	-.03	-.01	-.01	.45	.04		
13. Speciation ^a	0.06	0.09	-.08	.04	.02	.09	-.09	.08	-.08	-.03	.00	-.01	.14	.15	.03	
15. Exploitation orientation ^a	0.30	0.07	-.16	-.52	-.26	-.57	-.20	.08	.09	-.04	.02	-.06	-.11	.28	.02	.06

*a mean-centered for calculating correlations; * p < 0.05*

Table 2 reports the results of our tests of hypotheses. Model 1 shows the first stage model, where we regress instrumental and exogenous variables against our independent variable. All instrumental variables show strong association with exploitation orientation. We used fitted values of exploitation orientation to estimate its association with our dependent variable (Δ Ambidexterity) in models 2a to 2f.

As model 2c shows, the coefficient for our independent variable is negative and significant ($p < .05$ or smaller), supporting hypothesis 1. We also find a support for our second hypothesis in model 2d, that shows a positive and significant ($p < .05$) coefficient for the interaction term between exploitation orientation and problemistic search. Because the slope of the regression of Δ Ambidexterity on exploitation orientation on a single value of our moderators, or α_{xit} is given by

$$\alpha_{xit} = \alpha_{main} + \alpha_{int} * \beta$$

where α_{main} is main effect's coefficient, α_{int} is interaction term's coefficient, and β is the value of the moderator, the positive α_{int} indicates that *exploitation orientation* is more positively associated with *Δ ambidexterity* as our moderator increases (Aiken and West, 1991). Likewise, model 2e shows a positive and significant ($p < .05$) coefficient for the interaction term between *exploitation orientation* and *deliberate learning*, lending a support for our third hypothesis. Finally, our fourth hypothesis is also supported by a positive and significant ($p < .001$) coefficient for the interaction term between *exploitation orientation* and *speciation* in model 2f.

Table 2. Results of the 2SLS GLS random effects instrumental variables regression analysis for the effects of exploitation orientation on increases in organizational ambidexterity

	Model 1	Model 2a	Model 2b	Model 2c	Model 2d	Model 2e	Model 2f
Interest rates	-0.03 ^{***} [0.01]						
Long-term orientation	-0.14 [*] [0.06]						
Asset turn	-0.22 [*] [0.10]						
ROA	0.00 [†] [0.00]						
ΔOrganizational size	0.02 [0.04]	1.22 [1.50]	1.22 [1.51]	1.57 [1.42]	1.50 [1.47]	1.65 [1.49]	1.34 [1.61]
R&D intensity	-0.01 [0.01]	0.06 [0.07]	0.09 [0.06]	0.08 [0.07]	0.11 [†] [0.07]	0.07 [0.07]	0.09 [0.06]
Age	0.00 [0.00]	0.01 [*] [0.00]	0.01 [*] [0.00]	0.01 [†] [0.00]	0.01 [*] [0.00]	0.01 [†] [0.00]	0.01 [*] [0.00]
M&As	0.00 [0.02]	0.79 [0.55]	0.76 [0.56]	0.85 [0.58]	0.78 [0.60]	0.84 [0.61]	1.01 [0.66]
Competitive intensity	0.02 [0.08]	1.47 [2.92]	1.55 [2.96]	0.97 [2.97]	1.61 [3.08]	0.87 [2.97]	0.26 [3.18]
Diversified	-0.02 [0.07]	0.86 [0.64]	1.40 [*] [0.61]	1.08 [†] [0.60]	1.46 ^{**} [0.53]	1.13 [†] [0.59]	1.24 [†] [0.60]
Problemistic search ^b	0.02 ^{***} [0.00]		-0.56 ^{***} [0.13]	-0.40 ^{**} [0.14]	-1.74 ^{**} [0.64]	-0.42 ^{**} [0.14]	-0.81 ^{***} [0.17]
Deliberate learning ^b	0.02 [0.02]		-1.07 [1.13]	-0.90 [1.35]	-0.86 [1.34]	-1.50 [1.16]	-0.85 [1.32]
Speciation ^b	0.08 [0.07]		-3.72 [2.50]	-3.51 [2.51]	-3.94 [†] [2.38]	-3.51 [2.53]	-6.18 [*] [2.73]
Exploitation orientation ^b (H1)				-8.88 [*] [3.85]	-8.07 [*] [3.80]	-9.00 [*] [4.01]	-8.90 ^{**} [3.33]
Exploitation orientation ^b X Problemistic search ^b (H2)					4.90 [*] [2.08]		
Exploitation orientation ^b X Deliberate learning ^b (H3)						15.53 [*] [7.86]	
Exploitation orientation ^b X Speciation ^b (H4)							107.30 ^{***} [29.75]
Constant	0.62 ^{***} [0.18]	-3.92 [4.26]	-4.41 [4.21]	-3.88 [4.17]	-5.15 [4.32]	-3.81 [4.12]	-3.20 [4.46]
N firm-years	311	311	311	311	311	311	311
N Firms	32	32	32	32	32	32	32
R-squared (within)	0.22	0.00	0.02	0.04	0.05	0.04	0.06
R-squared (between)	0.12	0.14	0.35	0.23	0.29	0.23	0.30
R-squared (overall)	0.14	0.01	0.04	0.05	0.06	0.05	0.07

Note: Dependent variable for Model 1 is exploitation orientation, while that for Model 2a to Model 2f is Δambidexterity.

a. Robust standard errors adjusted for clustering by firm are in parentheses. Two-tailed tests for all effects.

b. Mean centered.

† p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

As for control variables, we observe that older and diversified firms grow more ambidextrous. The rest of the control variables do not show statistically significant coefficients.

5. Robustness Tests

We conducted two post hoc analyses in order to further verify our research findings. Firstly, we tested the relationship between sample firms' exploitation orientation and subsequent increase in their degree of organizational ambidexterity with the continuous-updating estimator (CUE), which is more robust to heteroskedasticity and autocorrelation (Bascle, 2008; Hansen, Heaton and Yaron, 1996). The results show that all hypothesized effects are supported by statistically significant coefficients (table 3). We also tested the hypothesized relationships with a larger sample (46 firms, 446 firm-years) that also includes pipelines developed in Japan by pharmaceutical firms headquartered outside Japan. The results are fully consistent with the original findings. Overall, our post hoc analyses indicate that the previously reported findings are robust.

Table 3. Results of the CUE (continuous-updating estimator) regression analysis for the effects of exploitation orientation on increases in organizational ambidexterity

	Model 3a	Model 3b	Model 3c	Model 3d	Model 3e	Model 3f
∠Organizational size	0.78 [1.80]	0.89 [1.77]	1.25 [1.66]	1.38 [1.69]	0.92 [1.71]	0.47 [1.98]
R&D intensity	0.06 [0.27]	0.14 [0.29]	0.25 [0.22]	0.38 † [0.22]	0.26 [0.22]	0.35 [0.25]
Age	0.03 [0.01]	0.03 † [0.01]	0.01 [0.01]	0.01 [0.01]	0.01 [0.01]	0.01 [0.01]
M&As	-1.03 [0.71]	-0.96 [0.78]	0.63 [1.24]	0.78 [1.19]	0.92 [1.20]	1.81 [1.36]
Competitive intensity	1.71 [3.14]	1.85 [3.22]	1.04 [3.18]	2.25 [3.22]	1.06 [3.22]	0.29 [3.44]
Problemistic search ^b		-0.45 ** [0.15]	-0.16 [0.21]	-1.00 † [0.46]	-0.13 [0.20]	-0.31 [0.25]
Deliberate learning ^b		-1.42 [2.45]	-0.94 [2.00]	-0.78 [2.07]	-3.84 [2.51]	-0.32 [2.27]
Speciation ^b		-4.00 [2.93]	-3.18 [2.90]	-3.80 [2.88]	-2.65 [2.92]	-10.12 † [5.88]
Exploitation orientation ^b (H1)			-17.28 *** [4.60]	-15.80 *** [4.71]	-18.72 *** [4.79]	-16.60 *** [4.96]
Exploitation orientation ^b X Problemistic search ^b (H2)				6.24 † [2.67]		
Exploitation orientation ^b X Deliberate learning ^b (H3)					23.61 † [9.35]	
Exploitation orientation ^b X Speciation ^b (H4)						96.55 † [45.65]
Constant	-5.18 [5.06]	-6.27 [5.25]				
N firm-years	311	311	311	311	311	311
N Firms	32	32	32	32	32	32
Log-likelihood	-915.68	-912.75	-871.88	-872.61	-870.76	-890.72

a. Robust standard errors adjusted for clustering by firm are in parentheses. Two-tailed tests for all effects.

b. Mean centered.

† p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

6. Discussion and Conclusions

We aimed to uncover boundary conditions under which organizations may resolve the exploitation-exploration trade-off to achieve higher organizational ambidexterity, which is one of the most important enablers of innovation. Our empirical analysis of the pharmaceutical industry supports our argument by showing that a negative association between organizations' exploitation orientation and subsequent increases in organizational ambidexterity is attenuated by problemistic search, deliberate learning, and by speciation. Overall, we contribute to the theory of innovation, and to the theory of organizational ambidexterity in particular, by proposing that organizations may increase their degree of organizational ambidexterity by resolving the trade-off relationship between exploitation and exploration.

First, problemistic search enables exploitation-oriented organizations to increase their degree of organizational ambidexterity by encouraging a switch to the alternative organizational learning mode. In addition, exploitation-oriented organizations grow more ambidextrous when their efforts to learn deliberately allow them to recognize the limitation of exploiting existing knowledge. Finally, exploitation-oriented organizations are more likely to increase their degree of organizational ambidexterity if they exploit their existing knowledge across multiple distinct contexts. In short, the findings indicate that organizational contexts in which existing knowledge is exploited matter.

Furthermore, our findings attest the importance of a multidisciplinary perspective in the field of innovation research, because these boundary conditions are originally established by distinct scholarly disciplines, including the behavioral theory of the firm (Cyert and March, 1963), organizational learning theory (Zollo and Singh, 2004; Zollo and Winter, 2002), and the theory of technological evolution (Adner and Levinthal, 2000; Cattani, 2006; Levinthal, 1998), respectively. Our approach is justified by important roles played by behavioral dynamics, learning, as well as by technology in the process of innovation.

With these findings, we contribute to the scholarly dialogue on antecedents of organizational ambidexterity (Duncan, 1976; Gibson and Birkinshaw, 2004; Lubatkin et al., 2006; Tushman and O'Reilly, 1996 among others). In addition to antecedents identified by these prior works, we argue that organizational contexts in which existing knowledge is exploited significantly influence the extent to which organizations achieve ambidexterity. Our contribution is more than simply adding yet another set of ambidexterity antecedents. We offer an alternative and complementary explanation of ambidexterity antecedents by showing that some organizational contexts in which existing knowledge is exploited enable organizational ambidexterity in a distinctly different mechanism from alternative antecedents. Specifically, exploitation-oriented organizations characterized with problemistic search, deliberate learning, or by speciation increase their degree of ambidexterity by resolving the trade-off relationship between exploitation and exploration. On the other hand, antecedents uncovered by prior works help organizations circumvent the trade-off either by encouraging vigorous pursuit of both (Gibson and Birkinshaw, 2004; Lubatkin et al., 2006), or by physically and/or temporally separating exploitation and exploration (Duncan, 1976; Tushman and O'Reilly, 1996). In either case, the trade-off relationship is left unresolved. We owe our finding to our emphasis on examining temporal changes in organizations' degree of ambidexterity through employing a panel data analysis, that allows us to complement the prior work's cross-

sectional perspectives by offering a longitudinal perspective to understand organizations' dynamic efforts to better balance exploitation and exploration.

As for practical implications, our findings indicate several initiatives managers can take to increase their organization's degree of ambidexterity through exploitation. Firstly, it is important to maintain aggressive goals (or aspirations) so that managers are not satisfied with their performance too easily, thereby keeping their search for alternatives. Secondly, managers should encourage and recognize organizational members' efforts to articulate and codify their knowledge. Extensively supporting intra-organizational knowledge sharing may also be effective because exploiting existing knowledge across different contexts is the first step toward more active speculation.

Notwithstanding those important implications, the contributions of our study should be considered in light of its research limitations. Firstly, the usual caveat associated with the single industry study should be applied to our work. Testing the hypothesized relationships in other empirical contexts is an obvious next step. It also is important to note that we were not able to control for effects of alternative antecedents of organizational ambidexterity. Uncovering combined effects of alternative antecedents is an interesting future research agenda because there may be some interactions between alternative antecedents. As for our empirical analyses, our measure of *problemistic search* shares the same limitations with the prior work, in that the degree of attainment discrepancy is used as a proxy of problemistic search, rather than directly measuring it (Greve, 2007). We also acknowledge that our models explain rather limited portion of organizational ambidexterity's variance (as is indicated by R^2), perhaps due to the limited sample size. Finally, our findings indicate the possibility that the trade-off relationship between exploitation and exploration is resolved under some conditions, but uncovering a detailed underlying mechanism is beyond the scope of our paper. Longitudinal case study research is necessary to describe explicitly the ways in which organizations resolve, rather than circumvent, the antagonistic relationship between exploitation and exploration.

One may argue that prior degree of exploitation orientation, or the extent to which organizations are less ambidextrous, influences the magnitude of subsequent increase simply because less ambidextrous organizations should have larger improvement opportunities in their degree of ambidexterity. However, our results show more subtle relationships because we show that the manner in which organizations are less ambidextrous matters. Less ambidextrous organizations are, by definition, either over-exploratory or over-exploitative. By showing that organizations' degree of exploitation orientation is negatively associated with their subsequent degree of ambidexterity, we show over-exploratory organizations enjoy higher likelihood of increasing their degree of organizational ambidexterity, while over-exploitative organizations suffer from increasing difficulties in balancing exploitation and exploration unless some organizational contexts resolve the trade-off relationship between exploitation and exploration. Uncovering such differential influences enables us to explain dynamic processes underlying organizational ambidexterity more precisely.

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