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Optimal ambidexterity and exploration valuableness: balancing short-term and long-term trade-off in pharmaceutical products development

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One of the most challenging resource allocation tasks for managers is to balance short-term and long-term products development initiatives, since exploitative (i.e., short-term focused) resource allocation patterns prevent managers from recognizing the existence or significance of exploratory (i.e., long-term focused) opportunities. Recent research on organizational ambidexterity promises the potential to overcome this trade-off relationship, but they lack clear indications concerning the mix of exploitation and exploration that would result in an optimal degree of ambidexterity. Through the analysis of a unique data set on development resource allocation patterns for 231 new pharmaceutical products, as well as on the economic value of those products, we show that pharmaceutical companies realize a higher exploration degree of valuableness and hence an optimal level of ambidexterity by allocating roughly 1.5 times more development resources to exploitative products than to exploratory ones.

Since the seminal articles by Teece (1982) and Wernerfelt (1984), scholars argue that firm idiosyncratic "resources" are key determinants of firm performance and competitive advantage. Firms are bundle of resources, and those resources per se, as well as how they are combined and deployed, significantly affect firm performance. Consequently, decisions on resource allocation should be a core element of strategic thinking in managing business organizations.

One of the most challenging resource allocation tasks for managers is to balance short-term and long-term products development initiatives. As classic studies on the trade-off relationship between exploitation and exploration (Levinthal & March, 1993; March, 1991) suggest, scholars emphasize that too exploitative (i.e., short-term focused) resource allocation patterns prevent managers to recognize the existence or significance of particular exploratory (i.e., long-term focused) opportunities (Benner & Tushman, 2002; Christensen & Bower, 1996; Gilbert, 2005; Staw, Sandelands, & Dutton, 1981).

This is particularly problematic for global ethical pharmaceutical companies, because the quickly changing competitive situation requires both continuous adjustments to current products and radically new break-through products. The former calls for firms to extensively exploit libraries of existing chemical entities, whereas the latter requires that firms engage in a highly uncertain and lengthy exploration for novel NCEs (new chemical entities). This leads to our basic research question of what is the optimal balance between exploitative and exploratory product development activities for firms?

One of the most notable aspects of today's ethical pharmaceutical industry is increased pressure on firms from competition on price and time to market (Pisano & Rossi, 1994). Pharmaceutical firms apply counter pressure to the market through development of pipelines of potential pharmaceutical drugs. These pipelines of potential pharmaceutical drugs consist of derivatives of existing chemical entities and pipelines that are based on new chemical entities (NCE). An example of a pharmaceutical drug that came from a new chemical entity is Eli Lilly's

Prozac, while its descendents, such as Sarafem is an example of a derivative from the same chemical entity called fluoxetine. Initially, fluoxetine was successfully 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.

Often in addressing the pressure, pharmaceutical firms exploit their core competencies by reusing existing chemical entities so that they can quickly launch incrementally new products that are targeted to an existing market. However, too much reliance on exploitation erodes a firm's capability to develop radically new break-through products based on NCEs. One of the unintended consequences of an over reliance on exploitation is that a firm's pipelines grow obsolete and shrink in number due to insufficient exploration for NCEs. This would threaten the long-term survival of the firm unless it found an outside source for NCEs. It could be argued that firms that follow a generic drug strategy are examples of a pure exploitation strategy in that 100 percent of these firms' products come from existing chemical entities and these firms are dependant on other ethical pharmaceutical companies to develop NCEs.

When, on the other hand, firms excessively explore for NCEs, they are likely to be quickly out-competed in the short-term due to not having enough pharmaceutical drugs available for the current market. This would result in the firm gradually be starved of resources, such as cash, thus, threatening sustainable development of identified NCEs which would become marketable in the future. This situation of following a pure exploration strategy is most common in entrepreneurial start-up firms that may be devoting 100 percent of their resources towards some NCE in the hope that it will become a blockbuster drug. These firms must pay close attention to their "burn rate" of current resources, and these must be refreshed from alternative sources such as venture capital markets.

In other words, only through an appropriate balance between exploitation and exploration can pharmaceutical companies sustain their value creation activities of developing innovative new products, since exploitation and exploration inherently preclude each other. Consequently, it is critical to the survival of firms that they find a balance between exploitation and exploration that results in an optimal level of ambidexterity and avoid being doomed to either over-exploit at the risk of losing major innovation opportunities (Levitt & March, 1988), or over-explore not fulfilling the potential of identified innovation opportunities (Anderson & Tushman, 2001). Most major ethical pharmaceutical companies do not follow either a pure exploitation or pure exploration strategy, but attempt to mix their product development activities. These firms are engaging in an ambidextrous strategy in order to maintain a pipeline that provides for both current and future market competition.

Recent advances in our understanding of ambidextrous organizations (Adler, Goldoftas, & Levine, 1999; Gibson & Birkinshaw, 2004; He & Wong, 2004; Kane & Alavi, 2007; Lavie & Rosenkopf, 2006; Lubatkin, Simsek, Ling, & Veiga, 2006; Sheremata, 2000; Siggelkow & Levinthal, 2003; Tushman & O'Reily, 1996; Tushman, Anderson, & O'Reily, 1997; Wang & Li, 2008) provide potential solutions for this dilemma. Organizations can be ambidextrous through such levers as managerial interventions (Tushman, Anderson, & O'Reily, 1997), unique organizational contexts (Gibson & Birkinshaw, 2004), or top management team's behavioral integration (Lubatkin, Simsek, Ling, & Veiga, 2006) in that they can exploit, as well as explore at the same time.

Unfortunately, the work of these scholars has opened an important question that has yet to be clarified; that is, what is the optimal balance of resource allocation between exploitative and exploratory initiatives. Considering the fact that most organizations pursue both exploitation and exploration to a certain extent (i.e., perfectly exploitative or exploratory resource allocation is unrealistic), this lack of understanding on the optimal resource allocation is problematic. This is because although managers know pursuing both exploitation and exploration is important for ensuring favorable innovation performance, it is unclear whether they should increase or decrease resources allocated to exploitative (or, exploratory) initiatives. Therefore, as we noted above, our primary research question is what is the optimal balance of resource allocation between exploitative and exploratory initiatives. By answering this question, we will make more explicit a guideline by which managers can adjust their current resource allocation between exploitative and exploratory pharmaceutical product development initiatives and develop an optimal level of ambidexterity in product development activities.

Research on ambidextrous organizations also predominantly focuses on one aspect of performance benefits earned by ambidextrous organizations, while neglecting another important aspect. More specifically, previous research focused

on aspects of quantitative growth that are less directly a measure of an innovation's economic value and incorporate all aspects of the business value chain activities that support an innovation, as well as competitive factors that affect the price of an innovation in the market. Measures such as sales increase (He & Wong, 2004), growth in sales and market share (Lubatkin, Simsek, Ling, & Veiga, 2006), profitability (Knott, 2002; Lubatkin, Simsek, Ling, & Veiga, 2006), or Tobin's q (Wang & Li, 2008) reflect the supporting activities of marketing, financing and distributing the innovation as well as the value of the innovation itself. On the other hand, a more direct measure of new value creation, or exploration degree of valuableness has been rarely emphasized, because of the difficulty in obtaining such direct measures. So, our second research question is whether organizational ambidexterity is beneficial for new value creation at the level of the pharmaceutical drug itself.

One of the main stumbling blocks to generating a more detailed understanding of the optimal balance between exploitation and exploration is the difficulty in obtaining fine-grained data that can objectively operationalize these constructs. The lack of studies on the source of more valuable exploratory innovation is also ascribed to the difficulty with precisely measuring the economic value of an innovation. While we recognize that exploration and exploitation can occur along any dimension of the business value chain, we restrict our interests to technological exploitation and exploration. Doing so allows us to leverage a detailed data on new pharmaceuticals development performance.

From this more fine-grained data set we intend to show as our conclusion that organizational ambidexterity is also beneficial in terms of exploratory innovation valuableness, and that the optimal balance between exploitation and exploration lies slightly toward exploitation. The next section reviews preceding research and provide theoretical underpinnings for our arguments. Our sample and research methods are discussed in a succeeding section. After reporting our findings, the paper concludes with some practical, as well as theoretical implications.

Theoretical Background

The Classic Trade-off between Exploitation and Exploration

As is stylized by Holland (1975), and then formalized by March (1991), the relationship between exploitation and exploration is defined as a trade-off. More precisely, exploitation is said to crowd out exploration. As organizations engage in more exploitative activities they would subsequently generate less exploratory activities (Abernathy, 1978; Argyris & Schon, 1978; Benner & Tushman, 2002; Henderson & Clark, 1990; Leonard-Barton, 1992; Levinthal & March, 1993; Prahalad & Bettis, 1986; Sull, 1999; Sorensen & Stuart, 2000). Although not explicitly stated in these studies, there is an implicit assumption that this is a one for one trade-off, with each unit of exploitative activity reducing exploratory activity by one unit.

The fundamental assumption for this argument is that exploitation requires distinctively different cognitive and behavioral patterns from exploration (Anderson & Tushman, 2001). Exploitation is usually related to improvements, increased efficiency and incremental adjustments, while exploration is closely linked with variety generation, distinctly new possibilities, distant search, and radical or revolutionary change (March, 1991). Therefore, although both of these activities are required for long-term organizational adaptation, organizations either over-exploit at the risk of losing major change opportunities (Levitt & March, 1988), or over-explore not fulfilling the efficiency increase potential of an innovation (Anderson & Tushman, 2001).

It is further asserted that the proportion of over-exploitative or over-exploratory activity in an organization is not equally valued. Initiatives associated with exploitation are preferentially selected by organizations, since they involve less risk, and promise more certain benefit in the shorter-term. Exploitation is more cognitively favored by managers, and from a behavioral point of view, fits better into the existing standard operating procedures. Consequently, organizations tend to engage in more exploitative activity than exploratory activity.

As is clearly shown in the above arguments, those who see a substitutional relationship between exploitation and exploration focus on the resource allocation trade-off between exploitation and exploration. The more resources an organization allocates to exploitative activities, the less the organization is motivated to allocate resources to exploratory ones, resulting in fewer exploratory achievements compared to exploitative ones. In other words, exploitation hinders an organization's ability to engage in exploration. This challenge confronting organizations and how organizations attempt to answer the challenge is critical to both their short-term and long-term survival. We next turn our attention to research that examines how organizations are confronting this challenge.

An Emerging Perspective: Organizational Ambidexterity

Although the trade-off relationship between exploitation and exploration is well established, recent research on organizational ambidexterity has uncovered that not all organizations are the victims of such a constrained either-or choice. The central thesis of this research on organizational ambidexterity contends that there are some common antecedents for exploitation and exploration irrespective of their ultimately mutually contradicting nature. These researchers start from the traditional assumption of the trade-off relationship between exploitation and exploration. However, they then try to identify some managerial interventions (Tushman, Anderson, & O'Reily, 1997), unique organizational contexts (Gibson & Birkinshaw, 2004), or top management team's behavioral integration (Lubatkin, Simsek, Ling, & Veiga, 2006) that resolves this trade-off relationship. As such, the burgeoning research on organizational ambidexterity potentially shows how organizations in general and global pharmaceutical companies in particular might both exploit the value of their libraries of existing chemical entities, as well as explore novel NCEs yet to be found.

One of the most familiar recommendations on how to reconcile these dichotomous resource allocation patterns is structural separation (Christensen & Bower, 1996; Cooper & Smith, 1992; Gilbert, 2005). Because exploitation and exploration cannot be simultaneously pursued in the same organization simultaneously, it is suggested that organizational units geared toward each of these activities should be separated. Based on this understanding, these scholars indicated that it is necessary to establish distinct organizational units with different orientations, i.e., one for exploitation (in most cases, an existing organizational unit), and another for exploration (again, in most cases a new organizational unit). This argument has received considerable empirical support (Afuah, 2001; Burgelman, 1983; McGrath, 2001; Puranam, Singh & Zollo, 2006; Rosenbloom & Christensen, 1994).

Another approach to address the trade-off relationship between exploitation and exploration is to temporally separate them. One of the most well known examples is the evolutionary pattern called punctuated equilibrium (Eldredge & Gould, 1972; Gersick, 1991; Tushman, Anderson & O'Reily, 1997; Tushman, Newman & Romanelli, 1986; Tushman & Romanelli, 1985). Seen from the punctuated equilibrium perspective, organizations are described to cyclically go through a period of convergence and a period of upheaval. The period of convergence is characterized by incremental improvements on knowledge, technology, or on organizational processes. The period of convergence is also associated with increasingly tighter coupling among decisions, actions, and organizational structures (Siggelkow, 2001). Whereas, the essence of this period is continuity, it is suddenly punctuated with episodic upheavals, or drastic reorientations (Tushman & Romanelli, 1985). The period of upheaval is full of drastic changes based on unknown fields of knowledge. Everything, including strategy, control systems, and the distribution of power is redefined. This redefinition undermines existing rules, standards, and structures. Since the magnitude of substantial changes is traumatic to organizational members, managers' heroic interventions are required to push through the disruptive changes required during the period of upheaval. In other words, without such heroic interventions, drastic reorientations and the resulting disruptive changes that are generated are doomed to fail due to organizational inertia. An organization is always under the pressure to repeat familiar procedures. Going beyond known fields requires disrupting an otherwise congealed web of mutually enhancing decisions, actions, and organizational structures that result in predictable behavioral results, enabling a firm to move into areas where the results are unpredictable.

While these arguments focus on how to divide exploitation and exploration either structurally or temporally, proponents for contextual ambidexterity argue organizations can be ambidextrous not by dividing exploitation and exploration, but by creating a unique organizational context supportive of both (Gibson & Birkinshaw, 2004). More specifically, under an organizational context characterized by a combination of stretch goals, discipline, managerial support and trust, organizational members belonging to a single organizational unit exploit and explore at the same time. The challenges of simultaneously pursuing exploitation and exploration cannot be fully attenuated even by this contextual ambidexterity. However, this unique organizational context empowers organizational members so they can strive for organizational ambidexterity more vigorously, by reducing concerns about the risks of failure in meeting stretch goals.

Although these arguments are theoretically sound and empirically verified, one critical question has not been adequately answered. We are beginning to understand how to pursue both

exploitation and exploration, but it is still not clear what the optimal balance between exploitation and exploration is or should be. Should organizations pursue equal amount of exploitation and exploration? If equal distribution were not the answer, what would be the optimal balance between them? The lack of understanding on the optimal degree of organizational ambidexterity is especially problematic for practitioners when they try to manage their organizations' resource allocation. Without knowing the optimal balance, managers have no clue whether they should increase (decrease) or decrease (increase) their resource allocation to exploitative (exploratory) initiatives.

Another shortcoming of the extant empirical work on organizational ambidexterity is that the performance benefits of innovations are measured in the more general terms of organizational growth, while direct measures of an innovation's economic value are not. Although such quantitative growth aspects, including sales increase (He & Wong, 2004), growth in sales and market share (Lubatkin, Simsek, Ling, & Veiga, 2006), profitability (Knott, 2002; Lubatkin, Simsek, Ling, & Veiga, 2006), Tobin's q (Wang & Li, 2008), or perceived well-being in terms of general firm performance (Gibson & Birkinshaw, 2004) are important parts of performance benefits, these reflect all the activities along the organization's value chain and have been used primarily because they are readily available. Measures of the direct economic value of an innovation should also be emphasized especially in the contexts of a firm's innovative behavior. For example, the aspect of new economic value creation is often more important in the context of product development. Originally, exploitation and exploration entail organizational learning and search (March, 1991). Therefore, it is surprising that existing research on organizational ambidexterity does not pay closer attention to the new economic value creation of an innovation. More generally, is organizational ambidexterity beneficial for generating new products with novel economic value? We intend to address this theoretically, as well as practically important question with a unique dataset on new pharmaceutical development in the Japanese market.

Methods

Sample

We address the question described above with data from new pharmaceutical development in the Japanese market. We focus on product development because organizational ambidexterity is defined as the ability to "simultaneously create both incremental and discontinuous innovation (Tushman & O'Reilly, 1997: 6)." Following this definition, prior studies operationalize organizational characteristics of ambidexterity by the extent to which firms simultaneously pursue both exploratory and exploitative product innovation (Benner & Tushman, 2003; He & Wong, 2004).

The Japanese market for new pharmaceuticals is quite appropriate for our purpose. All new ethical drugs need to be approved by the government (the Ministry of Health and Welfare), and an official reimbursement price is approved for each new pharmaceutical. This is quite different from the North American market where the Food and Drug Administration (FDA) approves all new pharmaceuticals, but there is no standard official price since each payer (i.e., insurance firms) decides its own reimbursement price. Although there are some other countries that use centralized pricing authorities to set the reimbursement price for pharmaceuticals, including Canada, France and Spain, Japan is by far the largest market among such countries, and hence most of global pharmaceutical firms actively participate in the Japanese market.

The second reason the Japanese new pharmaceutical market is appropriate for our study is that the official price for new ethical drugs is determined according to its degree of medical usefulness and effectiveness; which can be used as a proxy measure of the new pharmaceutical's degree of economic value. A pharmaceutical product is economically valuable to the extent that it effectively cures a patient's illness. Since the government is the biggest payer in Japan, new pharmaceutical's degree of economic value is primarily evaluated from the perspective of public welfare, including the health of the working population, containment of national healthcare expenses, and national prestige as an advanced nation. Pharmaceutical firms are rewarded by higher reimbursement prices to the extent that they fulfill their responsibilities to enhance the public welfare. Higher reimbursement price is also economically valuable for pharmaceutical firms, since it benefits them both directly (through higher revenue) and indirectly (through reputation as being more innovative).

The evaluation of medical valuableness is reliable and precise because the government delegates to independent specialists, including physicians, scientists, payers, and pharmaceutical firms the requirement to determine the improved

efficacy of the new pharmaceutical. This is a highly rigorous and comprehensive measurement process since these specialists make every possible effort to fairly and consistently evaluate each new pharmaceutical because the Japanese government is concerned about balancing two competing social welfare needs, i.e., containing pharmaceutical costs and promoting developments of effective pharmaceuticals. In other words, reimbursement for non-innovative pharmaceuticals should be tightly controlled, while truly innovative ones should be compensated for by a lucrative reimbursement price.

The third reason we selected new pharmaceutical development in the Japanese market, is that the independent specialists also determine which aspect of each new pharmaceutical is evaluated as new. More specifically, each newly developed pharmaceutical is categorized into 9 application classes, including NCE (new chemical entity), change in dosage, change in delivery, change (or addition of) indication, change in form, addition of form, mixture of existing NCE, modified mixture, and others. This classification is useful for our operationalization, since the NCE classification is traditionally thought to represent exploration in the context of new pharmaceutical development, while the other classifications are thought to represent exploitation (Bierly & Chakrabarti, 1996; Cardinal, 2001; Dunlap-Hinkler, Kotabe, & Mudambi, 2010). An NCE represents a totally new chemical entity that did not exist as an ethical pharmaceutical drug. So finding a NCE requires a search beyond known libraries of active ingredients, while a non-NCE reuses NCEs already approved for medical use. Consequently, the measure we are using is a more direct measure of the economic value of the innovation because it does not include the distortion of other value chain activities that exists in measures such as sales, sales growth and profits or profit growth.

We constructed a database on new pharmaceutical approvals from June 1999 to March 2009 (excerpts of database entries are shown in the appendix). During the 11 years, 259 new pharmaceuticals with new NCEs developed by 99 firms were approved for reimbursement, while 376 new pharmaceuticals reusing then-existing NCEs were approved. Our database includes additional information on these new pharmaceuticals, such as the therapeutic area of indication, drug type (internal, external, or injection), approved reimbursement price, firms who developed each pharmaceutical, and application class. As for data on firms, we also added information on whether each pharmaceutical was developed by a single firm or generated through some R&D alliances among multiple firms. We were also able to include in our database, cases where the pharmaceutical gained orphan drug status[1].

All this information was available from governmental public announcements on new approvals. The database on new pharmaceutical approval is paired with another database on each firm's pharmaceutical pipelines. Pipelines are pharmaceutical candidates under development. A professional medical magazine, called *New Current*, has been publishing exhaustive lists of pharmaceuticals under development since 1990. Leveraging their lists, we gathered data on pipelines at 1990, 1995, 2000, and 2005 for 98 firms listed on a new NCE pharmaceutical approvals list. Since new pharmaceutical development takes on average between 8-12 (Pisano & Rossi, 1994) or 7-11 (Powell, Koput, & Smith-Doerr, 1996) years, we expect our pipeline data covers most of those new pharmaceuticals listed on 1999-2009 approvals[2].

Variables and Analysis

In order to understand the optimal degree of organizational ambidexterity, we construct the measure of organizational ambidexterity and test its association with sample firms' exploratory innovation performance in terms of exploratory degree of valuableness. The unit of analysis is each new NCE pharmaceutical approved for reimbursement.

Dependent variable (exploratory degree of valuableness). Our dependent variable is each new NCE pharmaceutical's reimbursement price standardized for one-day usage. Since the official reimbursement price is set at the minimum units of packaging (i.e., per pill, or per vial), standardization for one-day usage is necessary for fair comparability[3].

This is the economic value of the innovation or its exploratory degree of valuableness. Since

1) Orphan drugs are those pharmaceuticals for very rare and serious diseases. Governments grant several preferential treatment including expedited approval and a higher reimbursement price, so that pharmaceutical firms would be compensated for smaller market opportunities.

2) Since pipeline identifiers often change (usually from serial numbers to unique names) during development, it is extremely difficult to make sure an exact match between pipeline data and approval data.

3) For example, the reimbursement price for Takeda's diabetes drug, Actos (pioglitazone hydrochloride), was set at 119.2 yen per pill, and it's allowed for 3 pills pre day. It gives us 357.6 (119.2*3) yen as Actos's reimbursement price standardized for one-day usage.

the Japanese economy had been under deflation during most of our observation period, it was not necessary to make any inflation adjustment on the reimbursement prices. The distribution of this variable is highly skewed, so we took the natural logarithm of new NCE pharmaceutical's reimbursement price standardized for one-day usage.

Independent variables. Our independent variable measures each firm's degree of organizational ambidexterity in terms of their development resource allocation to non-NCE as well as NCE pipelines. Our measure of organizational ambidexterity is defined as one divided by |x - a|+0.001, where x is the total non-NCE pharmaceutical pipeline counts of 1990, 1995, 2000, and 2005, divided by the total number of pipelines (non-NCE as well as NCE) over the same period. In our study, "a" denotes a threshold balance between exploration and exploitation, which divides over (under) and under (over) exploitation (exploration). Consequently, |x - a| indicates the degree of deviation from that threshold for each firm. We take the reciprocal of this value so that a higher measure indicates a higher degree of organizational ambidexterity. Since x equals a for some firms, we add 0.001 to the denominator. Then, we vary the value of a to see which sets of our independent variables with differing threshold values show a significant association with our dependent variable. The threshold value with a significant positive association with our dependent variable is concluded to be an optimal degree of organizational ambidexterity.

Control variables. We included several control variables in order to control the effects of alternative explanatory factors. More specifically, we controlled for R&D spending, as well as whether each firm is a biotech company or not (dummy variable). In addition, several dummy variables on each new pharmaceutical's characteristics are also included.

Preceding studies have found that the size of an organization affects its innovative performance (Camisón-Zornoza, Lapiedra-Alcamí, Segarra-Ciprés, & Boronat-Navarro, 2004). When we analyze product development performance at pharmaceutical firms, R&D spending would be the best measure for operationalizing size, because it decides the number and the quality of researchers firms can hire (Dunlap-Hinkler, Kotabe, & Mudambi, 2010). We collected data on R&D spending from Iyakuhin-kigyo Soran (A Directly for Pharmaceutical Firms) and Datastream at 1995, 2000, and 2005, and averaged them for each firm. Since pharmaceutical firms are relatively consistent and do not drastically change the level of R&D spending due to the fact that pharmaceutical development is a multi-year endeavor with cumulative effects of R&D investment, we believe our measure reasonably captures the substance of size variances among the sampled firms. As is customary, the variable is put in the model in natural logarithm (Greene, 2000; Long, 1997).

We also feel it necessary to control for whether a firm is a biotech company, because biotechnology is a competence-destroying innovation (Nelson, 1994; Powell, Koput, & Smith-Doerr, 1996), in that it is a new technological regimen compared to the traditional chemical based method of developing new pharmaceuticals . Consequently, risk preference characteristics are quite different between biotech firms and traditional pharmaceutical firms, which should affect the relationship between exploitation and exploration.

In addition to these control variables, several dummy variables on each pharmaceutical's characteristics are included. First of all, whether those NCE pharmaceuticals are developed as a result of R&D alliances or not is included. An alliance between pharmaceutical companies is expected to positively affect innovative performance, since allied firms are able to deploy more resources, as well as to draw on diversified sources of knowledge. Therefore, we include a dummy variable that shows whether those NCE pharmaceuticals are developed as a result of R&D alliances or not.

Secondly, the NCE pharmaceutical's therapeutic area is expected to affect reimbursement price. Specifically, those NCE pharmaceuticals with indications of cancer or infectious diseases generally are granted a higher reimbursement price, because they have been Japan's and the World's most fatal diseases respectively. Types of NCE pharmaceuticals are also an important consideration for setting reimbursement price. Generally speaking, injection NCE pharmaceuticals are expected to be more expensive, since they are administered only by physicians, and thus could contain stronger active ingredients[5]. Finally, those NCE pharmaceuticals with orphan drug status are also granted higher reimbursement prices so that pharmaceutical firms are compensated for the smaller market size. Overall, the availability of data reduces our sample down to 231.

Self-injection is not allowed in Japan, except for limited indications including diabetes.

Statistical Method

The data includes repeated observations for the same firm. In order to account for autocorrelation that may arise because each firm is measured repeatedly across multiple times, we employed the GEE (generalized estimating equations) regression method (Liang & Zeger, 1986).

Descriptive statistics and correlations for all the key variables are reported in table 1 for the case of a equals 0.58 (which we found to be the most significant results as we report below). Overall, the independent and control variables show considerable variance, and most correlations among the variables range from small to moderate. We also checked VIF (variance inflation factors) for all variables in all models and none of them exceeds 2, which indicates a very limited threat of multicollinearity.

Results

Table 2 and 3 report the results of our analysis on organizational ambidexterity and exploration degree of valuableness. Specifically, Table 2 reports the results for a between 0.1 and 0.9 with 0.1 increments, while Table 3 reports the results for a between 0.52 and 0.64 with 0.02 increments. QIC (quasi-information criterion) are reported at the bottom of the table, indicating how each model with smaller QICs improves upon the base model, which includes only control variables (Pan, 2001).

Model 1a and model 2a show the results with the control variables only. Model 1b through 1j and 2b through 2h add the independent variables. Here, we discuss the results from models focused on our main effects, i.e., model 1b through 1j for Table 2, and model 2b through 2h for Table 3 respectively.

We first examine the coefficients for the degree of organizational ambidexterity in model 1b through 1j reported in Table 2. The significant ($p < .05$) and positive coefficient is identified for the case of a equals 0.1 (model 1b). Although marginally, the significant ($p < .10$) and positive coefficient is also found for the case of a equals 0.6 (model 1g). For other values of a, we fail to find significant coefficients.

As for the control variables, most of them show significant coefficients in the expected direction, except for R&D spending and alliance. R&D spending does not show significant coefficients. As for the alliance variable, the results show a negative and significant ($p < .001$) coefficient, indicating alliances are used more for covering each other's weakness, rather than

Table 1 Descriptive Statistics and Correlations: a = 0.58 a

Variable	Mean	s.d.	1		2		3		4		5		6		7		8
1. Reimbursement price [a]	8,19	2,51															
2. R&D spending [a]	11,07	1,44	,09														
3. Biotech	0,04	0,20	,39	**	-,14	*											
4. Alliances	0,17	0,38	-,38	**	-,29	**	-,10										
5. Cancer indication	0,16	0,36	,22	**	,15	*	-,03		-,07								
6. Infectious disease indication	0,25	0,43	,17	**	,02		-,02		-,18	**	-,25	**					
7. Injection	0,36	0,48	,67	**	-,01		,24	**	-,25	**	,08		,03				
8. Orphan drug	0,11	0,31	,33	**	-,01		,13	*	-,12		,08		,09		,18	**	
9. Ambidexterity (a = 0.58)	4,85	7,20	,09		-,05		,01		-,08		-,03		,11		,06		-,05
"a natural logarithm * p < .05 ** p < .01"																	

Table 2 Results of GEE regression analysis for the effects of ambidextrous resource allocation on exploration degree of valuableness [a]

	Model 1a (Base model)			Model 1b (a = 0.1)			Model 1c (a = 0.2)			Model 1d (a = 0.3)			Model 1e (a = 0.4)		
R&D spending [b]	0,10		(,08)	0,10		(,09)	0,10		(,08)	0,10		(,08)	0,10		(,08)
Biotech	2,98	**	(,92)	1,81		(1,15)	2,98	**	(,92)	2,98	**	(,92)	3,02	**	(,93)
Alliances	-0,96	***	(,23)	-0,96	***	(,23)	-0,96	***	(,23)	-0,96	***	(,23)	-0,97	***	(,23)
Cancer indication	1,34	***	(,34)	1,37	***	(,33)	1,33	***	(,34)	1,34	***	(,33)	1,34	***	(,33)
Infectious disease indication	0,96	***	(,23)	0,96	***	(,22)	0,95	***	(,23)	0,96	***	(,23)	0,96	***	(,23)
Injection	2,76	***	(,23)	2,73	***	(,23)	2,76	***	(,23)	2,76	***	(,23)	2,76	***	(,23)
Orphan drug	1,26	**	(,42)	1,32	***	(,39)	1,26	**	(,42)	1,26	**	(,42)	1,27	**	(,41)
Ambidexterity				0,00	*	(,00)	0,00		(,00)	0,00		(,00)	0,00		(,00)
Constant	5,55	***	(,93)	5,54	***	(,94)	5,54	***	(,93)	5,55	***	(,92)	5,50	***	(,91)
QIC	155,152			539,939			555,444			555,769			555,201		

	Model 1f (a = 0.5)			Model 1g (a = 0.6)			Model 1h (a = 0.7)			Model 1i (a = 0.8)			Model 1j (a = 0.9)		
R&D spending [b]	0,11		(,08)	0,11		(,08)	0,11		(,08)	0,11		(,08)	0,11		(,08)
Biotech	2,88	**	(1,00)	2,95	**	(,96)	2,89	**	(,97)	2,92	**	(,98)	2,95	**	(,98)
Alliances	-0,94	***	(,23)	-0,91	***	(,23)	-0,92	***	(,24)	-0,91	***	(,24)	-0,91	***	(,24)
Cancer indication	1,35	***	(,34)	1,34	***	(,34)	1,35	***	(,34)	1,35	***	(,34)	1,35	***	(,34)
Infectious disease indication	0,97	***	(,23)	0,94	***	(,23)	0,98	***	(,23)	0,98	***	(,23)	0,98	***	(,23)
Injection	2,77	***	(,23)	2,77	***	(,23)	2,78	***	(,23)	2,78	***	(,23)	2,78	***	(,23)
Orphan drug	1,28	**	(,42)	1,31	**	(,41)	1,29	**	(,41)	1,30	**	(,41)	1,30	**	(,41)
Ambidexterity	0,00		(,00)	0,05	†	(,03)	0,04		(,04)	0,18		(,15)	0,32		(,28)
Constant	5,46	***	(,93)	5,22	***	(,93)	5,30	***	(,93)	5,04	***	(,98)	4,89	***	(1,06
QIC	554,271			553,013			554,710			554,699			555,012		

"a n = 231 observations. Numbers in parentheses are standard errors. Tow-tailed tests for all effects.b natural logarithm

† p < .1

* p < .05

** p < .01

*** p < .001

Table 3 Results of GEE regression analysis for the effects of ambidextrous resource allocation on exploration degree of valuableness [a]

	Model 2a (Base model)			Model 2b (a = 0.52)			Model 2c (a = 0.54)			Model 2d (a = 0.56)		
R&D spending [b]	0,10		(,08)	0,11		(,09)	0,11		(,09)	0,11		(,08)
Biotech	2,98	**	(,92)	2,96	**	(,95)	2,98	**	(,92)	2,98	**	(,94)
Alliances	-0,96	***	(,23)	-0,94	***	(,24)	-0,95	***	(,24)	-0,93	***	(,23)
Cancer indication	1,34	***	(,34)	1,33	***	(,34)	1,34	***	(,34)	1,33	***	(,34)
Infectious disease indication	0,96	***	(,23)	0,96	***	(,23)	0,95	***	(,23)	0,93	***	(,23)
Injection	2,76	***	(,23)	2,77	***	(,23)	2,77	***	(,23)	2,77	***	(,23)
Orphan drug	1,26	**	(,42)	1,28	**	(,42)	1,27	**	(,42)	1,29	**	(,42)
Ambidexterity				0,01		(,01)	0,00		(,00)	0,02	*	(,01)
Constant	5,55	***	(,93)	5,44	***	(,96)	5,47	***	(,95)	5,53	***	(,93)
QIC	155,152			556,329			555,078			553,399		

	Model 2e (a = 0.58)			Model 2f (a = 0.60)			Model 2g (a = 0.62)			Model 2h (a = 0.64)		
R&D spending [b]	0,11		(,08)	0,11		(,08)	0,11		(,08)	0,11		(,08)
Biotech	2,99	**	(,94)	2,95	**	(,96)	2,91	**	(,98)	2,89	**	(,97)
Alliances	-0,94	***	(,23)	-0,91	***	(,23)	-0,90	***	(,24)	-0,91	***	(,24)
Cancer indication	1,33	***	(,34)	1,34	***	(,34)	1,34	***	(,34)	1,35	***	(,34)
Infectious disease indication	0,93	***	(,23)	0,94	***	(,23)	0,96	***	(,23)	0,98	***	(,23)
Injection	2,75	***	(,23)	2,77	***	(,23)	2,78	***	(,23)	2,78	***	(,23)
Orphan drug	1,30	**	(,41)	1,31	**	(,41)	1,31	**	(,41)	1,30	**	(,41)
Ambidexterity	0,02	***	(,01)	0,05	†	(,03)	0,05		(,04)	0,03		(,03)
Constant	5,39	***	(,92)	5,22	***	(,93)	5,18	***	(,94)	5,28	***	(,93)
QIC	552,319			553,013			553,579			554,409		

"a n = 231 observations. Numbers in parentheses are standard errors. Tow-tailed tests for all effects.b natural logarithm
† p < .1
* p < .05
** p < .01
*** p < .001

complementing each other's strength. Other control variables including biotech ($p < .001$), cancer indication ($p < .001$), and infectious disease indication ($p < .001$), injection ($p < .001$), and orphan drug ($p < .01$) show significant and positive coefficients as expected.

Model 2b through 2h in Table 3 report our tests with a varying with smaller increments around the value we found statistically significant. More specifically, we vary a with 0.02 increments between 0.52 and 0.64 to identify the optimal degree of organizational ambidexterity in more detail. The examination of coefficients for organizational ambidexterity variables show that significant and positive associations are identified when a equals 0.56 ($p < .05$, model 2d), 0.58 ($p < .001$, model 2e), as well as 0.60 ($p < .10$, model 2f). For other values of a, we fail to find significant coefficients. We also ran a similar analysis varying a between 0.02 and 0.14, with 0.02 increments, but found no significant and positive coefficients except for the case of a equals 0.1 as reported above (results are available from authors upon request).

Discussion

We examined in this paper the important research question, what is the optimal degree of organizational ambidexterity. Our conclusion from our analysis of new pharmaceutical products development is that the optimal degree of organizational ambidexterity is not necessarily the even allocation of resources between exploitation and exploration. The finding also shows organizational ambidexterity is beneficial, not only in terms of organizational growth as measured by sales and other indirect measures, but also more directly in terms of new value creation represented in new product development.

We found that the optimal allocation in terms of exploration degree of valuableness is achieved when either 10 percent or 58-60 percent of pipelines are exploitative or when they are either 90 percent or approximately 40 percent exploratory. Interestingly enough, we find that there are two distinct approaches to realize higher exploration degree of valuableness through organizational ambidexterity. The former approach may be consistent with our conventional image of the high technology organization and in particular high technology start ups. Most resources are dedicated to exploratory search, so that radically novel innovation will be generated. It is interesting to note that some exploitative resource allocation is worthwhile even in this type of organizational contexts. On the other hand, the latter approach is more aligned with our notion of an ambidextrous organization, often an incumbent firm in an industry. The balance is subtle in that it indicates the importance of the simultaneous pursuit of both exploitation and exploration, while emphasizing that roughly 1.5 times more allocation to exploitative pipelines than to exploratory ones is optimal. Whereas the former approach of allocating 90 percent to exploration is found to be beneficial in terms of exploratory degree of valuableness, we doubt it provides sufficient benefits in terms of efficient short-term product developments with exploitative nature and consequently could effect an organizations short-term survival. This is often the case with high technology start ups that must rely on regular infusions of capital from venture capitalists in order to survive until their exploratory breakthrough product is developed and marketed. Therefore, we focus on the latter approach and discuss some implications for practitioners involved in pharmaceutical products development in incumbent pharmaceutical companies.

First of all, managers must pay close attention to how many resources are allocated to non-NCE pipelines when they try to develop more valuable NCE pharmaceutical products. This is because developing more valuable NCE pharmaceutical products benefits from maintaining substantial amount of non-NCE pipelines. This might sound counter-intuitive, but there are some examples that show this is in fact the case. For example, the useful experience of later phase developments is more frequently learned by being involved in non-NCE pharmaceutical products development, since NCE pipelines are more likely to fail in early stages than are non-NCE pipelines. Thus the late stage experience gained through having non-NCEs can be applied to the NCEs that make it into the latter stages of development. In addition, non-NCE products are more likely to generate financial resources with a shorter lead-time, and be more sustaining over time providing a more munificent organizational milieu for NCE product development. Off-course, excessive resource allocation to exploitative pipelines will erode a firms' capability to generate blockbuster products. Our finding on the critical threshold value of 0.56-0.60 should help managers to discern whether they should increase or decrease exploitative resource allocation in order to remain on-course.

By providing this guideline we are making explicit the rough rules of thump that managers may have been tacitly making. However, given the limits of our data we realize that these numbers should be used with care. Since the

product development cycle of the pharmaceutical industry is long, ranging from 7-12 years, and takes into account many steps, such as discovery, preclinical and clinical testing and such, we are not implying that the optimal ambidexterity level should be maintained at 1.5 throughout the entire process of development of a pharmaceutical drug. Our results indicate that firms that have a resultant mix of approximately 1.5 times exploitative activities will have an optimal mix of ambidexterity, which in turn will provide greater resources for conducting their exploratory product development activities.

Secondly, managers need to address the trade-off relationship between exploration frequency and exploration valuableness. One of the most obvious ways to increase the probability that pharmaceutical firms could successfully develop more NCE pharmaceutical products is to increase the resources dedicated to the development of NCE pipelines. However, increasing NCE pipelines inevitably reduces non-NCE pipelines unless the overall development budget is increased. Therefore, given our finding that a predominantly exploitative pipeline portfolio is positively associated with more valuable NCE products, there is a trade-off relationship between exploration frequency and exploration valuableness. By pursuing organizational ambidexterity, managers are able to circumvent the traditional trade-off relationship between exploitation and exploration. However, even ambidextrous organizations require sound managerial decision-making on how to balance exploration frequency and exploration valuableness. Managers will need to consider the idiosyncratic elements that are unique to each of their individual firms, in order to make the adjustment necessary to enhance their own successful conversion rate between those chemical entities beginning a pipeline and those resulting in a new pharmaceutical drug.

In addition to these implications for practitioners, our finding provides some theoretical implications for future academic research.

First of all, we show organizational ambidexterity is beneficial for organizational performance in terms of new value creation at the level of the pharmaceutical drug. Prior works on organizational ambidexterity predominantly focused on less direct growth-oriented measures like sales growth or profitability, mainly due to the difficulty in operationalizing the degree of valuableness of innovation in terms of each product developed. By using a unique measure of the more substantive aspects of the degree of valuableness, we are able to observe the beneficial effects of organizational ambidexterity in product development. Product innovation activities are only one sub-system, albeit an important sub-system in the firm's set of sub-systems that comprise the overall value chain. Thus, we show the value of innovation activities at the level of the product, we do not address how well the firms do in converting the higher value of each innovation into higher firm value. Consequently, we leave open the question of how well the ambidextrous company does at generating value at the overall level of the firm. This would be one promising area for future research.

Secondly, our study shows there is another promising research direction to uncover the determinants of optimal degree of organizational ambidexterity. Our finding clarifies that there is a distinction between beneficial and non-beneficial ambidexterity, depending on the mix of exploitation and exploration. The finding is interesting in itself, but we were not able to provide an explanation of how this optimal mix is determined. We speculate that the degree of environmental stability is one of the key determinants, but an empirical verification is beyond the scope of the current paper. One future approach we could follow is to conduct a cross-industry analysis. Considering the fact that the pharmaceutical industry is one of the most quickly changing industries due to its technology intensive nature, we expect that the optimal mix of exploitation and exploration should be more skewed toward exploitation in the case of most other industries classified as middle to low technology industries.

Thirdly, another interesting research direction indicated by our results is to consider why a balance slightly skewed toward exploitation is beneficial for new value creation. In other words, it is necessary to understand how exploitation could increase subsequent exploration's degree of valuableness. One plausible explanation is the knowledge accumulated through incremental refinements associated with non-NCE pharmaceuticals development help in the absorption of the new knowledge required for NCE development (Suzuki & Methé, 2010). Alternatively, it also might be possible to emphasize the underlying organizational dynamism, designed in the exploitative innovation process, i.e., such disciplines as formalization or milestone management that an organization exercises when they allocate very limited resources to exploratory initiatives. Specifically, the use of rigorous milestone or deadline management is reported to discipline the

otherwise haphazard process of exploration (Brown & Eisenhardt, 1997; Gersick & Hackman, 1990). Further, the distinct definition of roles and responsibilities also makes rather chaotic intra-organizational interactions accompanying exploration more manageable (Sine, Mitsuhashi & Kirsch, 2006). Even bureaucracy, so often infamously portrayed as antagonist towards innovative spirits, has been shown to be instrumental in facilitating employees in the learning process, thus facilitating exploration under certain conditions (Adler & Borys, 1996).

Irrespective of all these contributions, our paper is not free from limitations, which open up further opportunities for future research. First of all, our results might have been strongly affected by the pharmaceutical industry's knowledge-intensive nature. If other more capital-intensive and less knowledge-intensive or moderate to low technology intensive industries are studied, the association between exploitative resource allocation patterns and subsequent exploratory innovation performance could be weaker. Thus, a cross industrial study would be an interesting avenue for future research. In addition, our research focuses on only one aspect of exploratory innovation. Although we feel it important to clarify hitherto neglected performance benefits in terms of exploration degree of valuableness, whether organizations should pursue ambidexterity or not depends on overall performance benefits in terms of both value creation and growth. Future research should take these two distinct aspects into consideration when performance benefits earned from organizational ambidexterity are examined. This could be accomplished by mixing the traditional measures of sales and profit with more direct measures of an innovations economic value. Thirdly, our independent variable on the degree of organizational ambidexterity measures a firm's resource allocation only indirectly. Ideally speaking, the amount of resources allocated to non-NCE and NCE products development could be measured in terms of monetary amounts. Such an analysis with more precise data tying the financial resources directly to NCE and non-NCE development, would most likely show a more substantial skew toward exploitative resource allocation, since non-NCE developments are more likely to survive until the later and more costly development stages. Finally, our research has examined how firms conduct product development activities in markets in a developed economy characterized with centralized pricing authorities. It would be valuable to conduct this type of study in markets where the pricing authority is less centralized. And in an economy which is still in the process of developing its institutional infrastructure, such as intellectual property rights (IPR).

Research on organizational ambidexterity generates the opportunity to reinterpret the long-established dichotomous relationship between exploitation and exploration. Yet, its potential is barely appreciated by practitioners due to the obvious lack of clear guidelines for applying the findings' implications to actual managerial practices. It also is unfortunate that the lack of appropriate measures on the consequential benefits of ambidexterity hinders its appreciation by managers involved in new product developments. We hope our study will stimulate practical, as well as scholarly discussions on how to leverage the findings on organizational ambidexterity for the creation of novel value.

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