WHEN DO HIGH-TECHNOLOGY FIRMS CHANGE TECHNOLOGY SOURCING VEHICLES? THE ROLE OF POOR INNOVATIVE PERFORMANCE AND ORGANIZATIONAL SLACK

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ABSTRACT

We address the issue of when and how technology-intensive firms respond to poor innovative performance by changing the balance of their technology-sourcing portfolio (i.e., alliance, acquisition, or go-it-alone). We advance a behavioral perspective on the make/buy/ally question, suggesting that differences in organizational slack will generate different portfolio decisions. Specifically, we posit that firms with greater levels of slack resources are more likely to respond to poor performance by (1) opting for greater vehicle diversification and (2) adding new sourcing vehicles, while firms with fewer slack resources will respond by (1) downscoping their portfolio of sourcing vehicles and (2) reverting to more familiar vehicles. We find support for our predictions using extensive data from the population of U.S. public pharmaceutical firms from 1992 through 2006.

Given the considerable strategic and organizational consequences of firms' decision to "make, buy, or ally" or "build, borrow, or buy" (Capron and Mitchell, 2012), it is not surprising that a large volume of research has explored firms' choice of sourcing vehicles. Extant research on vehicle choice can be sorted into single versus comparative vehicle studies. The former examines the factors that influence firms' likelihood of using a certain vehicle, such as internal development, alliances, or acquisitions, independently of any other vehicle they have been using or may use. For example, Dushnitsky and Lenox (2005) examined firms' likelihood of pursuing their research and development (R&D) goals through acquisitions, while Ahuja (2000) and Shan, Walker and Kogut (1994) studied firms' likelihood of doing so by forming cooperative relationships. The latter group of studies examines factors that influence firms' choices between vehicles, such as between alliances and acquisitions (Wang and Zajac, 2007; Yin and Shanley, 2008), alliances and internal development (Robertson and Gatignon, 1998), acquisitions and internal development (Hennart and Park, 1993), or among all three vehicles (Capron and Mitchell, 2009).

These studies have considerably advanced our understanding of why a firm would choose one vehicle over another, but significant questions remain as to why firms choose multiple vehicles and what would lead to a change in the portfolio of vehicles they have chosen. Clearly, anecdotal evidence highlights that firms develop their technology using a combination of vehicles. In 2002, for example, Merck pursued its innovation goals by spending $75 million on R&D-related alliances, $762.5 million on R&D-related acquisitions, and $3,945.5 million on in-house R&D. While there has been comparatively little research attention devoted to the blended portfolio of vehicles that firms regularly employ, it is noteworthy that the potential significance of this issue was already noted three decades ago by Lamont and Anderson (1985). Their work addressed how firms employ a combination of internal and external entry modes, finding that 36% of their sample of industrial firms used a mixture of vehicles. Simmonds (1990) and Busija, O'Neill and Zeithaml (1997) have also called attention to potential performance implications associated with using a combination of vehicles. More recently, scholars emphasizing dynamic capabilities have argued that firms seeking to renew their capabilities need to develop skills in both internal development and external sourcing modes, such as acquisitions and different types of alliances, and an ability to appropriately choose among them (Capron and Mitchell, 2009, 2012; Helfat *et al.*, 2006). Most recently, Van De Vrande (2013) introduced the concept of a technology-sourcing portfolio. Focusing on the portfolio of external sourcing vehicles (i.e. alliances, joint ventures, minority holdings, and mergers and acquisitions), she found a positive relationship between its diversity and firm innovative performance.

In this study, we seek to extend research in this area in several ways. First, we believe that the useful concept of a technology-sourcing portfolio would benefit considerably from the inclusion of internal development as an option, particularly in light of the historical interest in the related questions of make/buy/ally. Second, and more important, while we understand the interest in the consequences of vehicle portfolio choice, we believe it is important to first establish the likely antecedents of such choices. The technology strategy literature suggests that technology-sourcing vehicle choices are not exogenous and tend to exhibit path dependency. A host of factors (e.g., resources, transaction costs, internalization, organizational learning, experience, social embeddedness, asymmetric information, ownership structure, board composition, existing routines, and real options) have been shown to influence a firm's innovative behavior and increase its likelihood of utilizing the same sourcing vehicles over and over again (Zahra, 1996; Kale, Dyer and Sing, 2002; Villalonga and McGahan, 2005; Haleblian, Kim and Rajagopalan, 2006; Chan, Nickerson, and Owan, 2007; Cuervo-Cazurra and Un, 2010). We seek to extend this literature by arguing that a firm's prior innovative performance is also a likely important antecedent of vehicle portfolio choice. More specifically, our study advances a behavioral framework for predicting these choices; we suggest that the level of a firm's prior innovative performance relative to aspiration level, together with its level of slack resources, will significantly influence whether and how it will deviate from its path-dependent quest for innovation and change its portfolio of vehicles in response to poor innovative performance.

Another important way in which this paper contributes to the literature on innovation management is our emphasis on firms' concurrent use of all three major technology sourcing vehicles (i.e. make/buy/ally). Our working assumption is that firms employ a mix of vehicles, and thus rather than examine a firm's choice of a particular vehicle, or between vehicles, we examine factors affecting the composition of its overall portfolio of vehicles. Our findings call attention to the interdependencies between vehicles, suggesting that a firm's choice of a particular vehicle, or between vehicles, is affected by the other vehicles it employs. More generally, we provide a behavioral explanation as to when and how technology-intensive firms change the balance of their technology-sourcing portfolio, which can be detrimental to their innovative capacity and overall performance.

This paper also contributes to the literature on performance-induced change. Performance comparison, or performance relative to social and historical aspirations, is central to the Behavioral Theory of the Firm (Cyert and March, 1963). Prior research in this tradition has mainly focused on financial goals (Audia, Locke, and Smith, 2000; Greve, 2003). We extend this line of inquiry by proposing that in science-based industries firms pay attention, and form aspirations, along innovation goals, underscoring the need to pay attention to assorted kinds of organizational goals.

Finally, this study contributes to the work on the effects of organizational slack. There is an ongoing debate as to how slack resources affect organizations' propensity to change and innovate (Kraatz and Zajac, 2001). Some have argued that slack may decrease organizations' likelihood of changing by buffering organizations from environmental threats (Singh, 1986), and by deterring or misdirecting search behaviors (Levinthal and March, 1993; Levitt and March, 1988). Others have viewed slack as a facilitator of change (Schumpeter, 1942), providing latitude for greater experimentation, and hence, greater degrees of innovation (Nohria and Gulati, 1996; Zajac, Golden, and Shortell, 1991). More recently, rather than focus on how slack affects organizations' propensity to change, scholars have begun examining how slack shapes the sort of change organizations undertake in response to threat (Audia and Greve, 2006; Voss, Sirdeshmukh, and Voss, 2008). We follow this more recent line of thinking and explore how slack financial resources interact with innovative performance to affect changes in portfolio diversification and similarity.

Our paper also intends to offer an empirical contribution. Specifically, while prior studies have typically measured a firm's use of alliances and acquisitions by counting their numbers (Hagedoorn and Duysters, 2002; Haleblian, Kim, and Rajagopalan, 2006), there is no comparable count measure for a firm's use of internal development. We therefore measure a firm's R&D efforts by using the amounts invested across the three basic types of sourcing vehicles: internal development, cooperative agreements, and acquisitions (Pisano, 1990), and avoid cross-industry variances (e.g., product-market characteristics) by focusing on one industry. Specifically, we test our hypotheses using a large longitudinal dataset comprised of all U.S.

public pharmaceutical firms between 1992 and 2006, and we find strong support for our notion that relative performance and organizational slack strongly influence firms' choice of technology-sourcing portfolios.

THEORY AND HYPOTHESES

In science-based industries, the ability to rapidly discover, develop, and commercialize new technologies is a major source of competitive advantage (Cobbenhagen, 2000). Consequently, survival in such industries depends on a firm's ability to acquire and develop new technological knowledge and capabilities (Pisano, 1990). This is especially true in the pharmaceutical industry where most economic rents are created by charging premium prices for proprietary, patent-protected drugs (Comanor, 1986). Furthermore, the small cost of producing a drug, relative to the expenditure of time and money required to develop a new drug, makes a firm's R&D abilities the major factor determining its competitive stance (Scherer, 1993).

A major factor that has been shown to affect a firm's ability to innovate and compete is the composition of its portfolio of technology sourcing vehicles. Veugelers and Cassiman (1999), for example, showed that firms that employ only one vehicle, either internal R&D or external sourcing of technology, introduced fewer new or substantially improved products compared to firms which combined internal and external vehicles. Van De Vrande (2013) found significant relationships between the composition of a firm's portfolio of external sourcing vehicles and its innovative performance. It is therefore imperative to understand the factors that determine the composition of the whole portfolio of vehicles and when and how firms adjust its composition. We take a first step towards understanding such factors by examining how a firm is likely to change its portfolio of technology sourcing vehicles in response to its innovative performance, as indicated by its relative success in patenting.

While the use of patent data in social science research has been criticized for failing to account for cross-industry variation and firms' idiosyncratic propensity to patent (Levin *et al.*, 1987), this criticism is less pertinent to the pharmaceuticals industry. It has long been recognized that the pharmaceutical industry makes much more extensive use of patents than other industries (DiMasi *et al.*, 1991). Pharmaceutical firms are particularly prone to patenting because patents enable them to become a monopolist producer of an innovation and thus enjoy high profits (Comanor, 1986). The competition to become a monopolist producer, in turn, creates a patent race, in which only one in several firms that have undertaken investments in R&D will appropriate all the profits of innovation.

The high profits a monopolistic advantage provides, on one hand, and the monetary loss incurred by those who lose the patent race, on the other, generate tremendous pressures on pharmaceutical firms to modify their portfolio of technology sourcing vehicles when failing to position themselves at the forefront of the innovation race. Put differently, a pharmaceutical firm's strategic position is first and foremost determined by its stock of patents (Deeds and Decarolis, 1999; Markman, Espina, and Phan, 2004). A failure to maintain a continuous flow of new patens may therefore threaten the firm's future strategic position (Dierickx and Cool, 1989), and would thus propel managers to make changes to the portfolio of vehicles used to produce patents.

Our expectation that a firm's failure to achieve its innovation goals will lead it to make compositional changes in its portfolio of technology sourcing vehicles is consistent with the notion that firms need to address research gaps in a timely manner by supplementing internal

R&D with acquisitions (Chesbrough, 2003) and that declining patenting productivity may be a reason behind a pharmaceutical firm's change in its mix of vehicles (Higgins and Rodriguez, 2006). However, prior research has not yet posited or tested specifically how firms modify their portfolio of technology sourcing vehicles in response to poor innovative performance. We address this issue below.

Innovative performance goals and aspirations

We begin our analysis of how firms modify their portfolio of technology sourcing vehicles in response to poor innovative performance by invoking and extending concepts utilized in the behavioral theory of the firm (Cyert and March, 1963) , particularly “performance-induced change” (Ocasio, 1995). We propose that in science-based industries firms pay attention to innovation goals and form aspirations along those goals. We further propose that firms that fail to achieve their innovation goals will modify their portfolio of technology sourcing vehicles, and that the type of change they are likely to make will depend on the slack financial resources they possess.

Organizational learning theorists argue that aspirations are set against both internal and external referents (Argote and Greve, 2007). A great body of research has shown that firms learn from their past experience and build aspiration levels based on past performance (Cyert and March, 1963; Lant and Montgomery, 1987). The performance history of an organization is used to set the aspiration level while maintaining differences between organizations constant (Greve, 1998). Organizational decision-makers compare the organization’s performance against its historical aspiration levels to determine whether and how their organizations should adapt (Cyert and March, 1963; Lant, 1992). The motivation to change depends on how far their performance level is below or above their historical aspirations (Cyert and March, 1963; Greve, 1998).

Aspiration levels are built on observations of others (Cyert and March, 1963). At the individual level, research suggests that the performance of others affect the aspiration levels of individuals (Meyer and Gellatly, 1988). Similarly, at the organizational level, it has been shown that managers form reference groups of other organizations that are similar to theirs (Greve, 2008; Lant and Baum, 1995) and build aspiration levels by observing these organizations. However, research at the level of the firm has yielded surprisingly contradictory findings. Specifically, studies have found that discrepancies between the organization's current performance and its social aspirations leads to more organizational change (Ketchen and Palmer, 1999), to less change (Greve, 1998), to riskier or more radical change (Harris and Bromiley, 2007) and to less risky change (Iyer and Miller, 2008).

One possible reason for these inconsistent findings may be that, while organizations have a wide range of goals, including profitability, sales, production and technology (Cyert and March, 1963), most research in the behavioral theory of the firm tradition has focused on financial goals (Audia *et al.*, 2000; Greve, 2003). However, experimental work has shown that behaviors are guided by a variety of aspirations (Locke and Latham, 1990), suggesting that we should expand our attention beyond organizational financial goals. This seems especially important in science-based industries, and particularly in the pharmaceutical industry, where the technologies being developed are so far removed from a commercial product and regulatory approval that a firm's current financial performance provides little indication of future performance. Thus, we expect firms in such industries to attend and modify their operations in response to more short-term, readily available performance outcomes, such as their relative innovative performance. Accordingly, we seek to extend prior research within the tradition of the behavioral theory of the firm by examining how firms behave when failing to meet their historical and social innovative aspirations. In the next section we identify two specific types of changes that firms may make to their portfolio of technology sourcing vehicles.

Two Types of Change

In response to poor innovative performance, a technology intensive firm can either focus its efforts and further apply and exploit the technology sourcing vehicles with which it is most familiar, or shift its emphasize and explore new or less familiar vehicles (March, 1991). To determine which kind of change firms undertake we measure two aspects of change: diversification and dissimilarity.

Change in diversification measures changes in the way a firm distributes its R&D resources across different technology sourcing vehicles. A firm's portfolio may contain different types of vehicles — i.e. cooperative arrangements, acquisitions, and internal development. The more vehicles a firm employs and the more equally it distributes its R&D budget across them, the more diversified its portfolio. For example, a firm may spend its entire R&D budget solely on internal development one year (i.e. no diversification), and distribute it equally across the three sourcing vehicles the following year (i.e. maximum diversification). Thus, the first aspect of change we examine is the difference in the level of diversification of the portfolio across consecutive years.

The second aspect of change we examine is *dissimilarity*, which indicates whether a firm responds to poor innovative performance by investing in new vehicles or by reverting to tried and tested vehicles. A firm that spends its entire R&D budget on alliances one year, for example, and exclusively on acquisitions the following year, may not have changed the level diversification of its portfolio (i.e. it still conducts all of its R&D through a single vehicle), but it obviously pursues R&D in a very different way than before. Hence, the second aspect of change we examine is the difference in the particular types of vehicles that comprise the portfolio across consecutive years.

In summary, we analyze how firms change both the diversification level and the composition of their portfolios in response to poor innovative performance. The next section addresses the role of slack financial resources as a key contingency that would likely moderate the effect of poor innovative performance on these two types of changes in technology sourcing vehicles.

Slack financial resources and portfolio changes

Our theory suggests that a key factor that will determine whether a firm will place its emphasis on existing vehicles, or shift it to novel vehicles, is its stock of excess financial resources. This premise is based on several studies which have shown that slack resources influence the amount and type of changes that executives chose to make in response to low performance and environmental threat. For example, in a study examining strategic investments made when organizations perform below aspiration, Audia and Greve (2006) found that performance below the aspiration level led executives of firms with large stocks of resources to expand their resource base but led executives of firms with small stocks of resources to contract it. Voss, Sirdeshmukh, and Voss (2008) examined how slack resources interact with environmental threats to influence the type of product development that organizations undertake. Their analysis of nonprofit professional theaters showed that theaters with low levels of financial slack were more likely to respond to environmental threats by focusing on established plays that have been previously produced, while theaters with high levels of slack were more likely to create new-to-the-world plays.

The authors of these papers explain their results by arguing that slack resources influence managerial tendency towards risk taking in the face of low performance and threat. Managers, they argue, become risk seeking when slack resources are abundant and risk averse when resources are scarce. By buffering organizations from the threat of failure, slack resources permit managers to counter threats to the organization's strategic position by increasing investments in innovative competencies. In contrast, when scarce resources are limited, decreases in performance are regarded as a threat to the organization's survival, leading managers 'to reduce investments in innovative ventures and revert to tried and tested competencies with more predictable outcomes that limit potential losses' (Voss *et al.*, 2008: 152). As Audia and Greve (2006) explain: 'managers of firms with a limited stock of resources perceive the low performance as a step closer to firm failure. Threatened by the prospect of additional losses that can jeopardize the survival of the firm, these decision makers become risk averse. Their risk behavior presumably stems from a combination of their inability to generate risky courses of action (Staw, Sandelands, and Dutton, 1981) and their choice of low-risk options that do not require investing the firm's few remaining resources (March and Shapira, 1992). In contrast, managers of firms with large stocks of resources are less concerned about the risk of incurring additional losses, because additional losses would not threaten the firm's survival. They look more at the upside of decisions that require substantial allocations of resources, and are more prone to make risky decisions' (page 84).

Based on this line of argument, we expect that a firm's slack of financial resources will affect the type of change that the firm will make to its portfolio of technology sourcing vehicles in response to poor innovative performance. With relatively little concern about the firm's survival and greater opportunities for experimentation, we expect mangers of firms with plenty of slack resources to respond to poor innovative performance by increasing investments in new innovative vehicles. On the other hand, we expect managers of firms with limited stocks of slack to reduce investments in innovative ventures and revert to tried and tested vehicles with more predictable outcomes. Accordingly we make the following hypotheses:

H1: Firms with greater slack resources will respond to poor innovative performance by increasing the diversification of their portfolio of technology sourcing vehicles.

H1a: Firms with greater slack resources will respond to poor innovative performance by adding new technology sourcing vehicles.

H2: Firms with fewer slack resources will respond to poor innovative performance by decreasing the diversification of their portfolio of technology sourcing vehicles.

H2a: Firms with fewer slack resources will respond to poor innovative performance by reverting to familiar technology sourcing vehicles.

DATA AND METHODS

Sample and Data

We test our hypotheses on a sample consisting of all U.S. public pharmaceutical firms between 1992 and 2006, which we compiled by cross-checking the annual lists published by Forbes 500 and Hoovers. This process resulted in 30 firms and a total of 392 firm-year observations.

The amounts invested in each sourcing vehicle, financial data, diversification measures, and CEO and board demographics have been manually collected using the *10K files* and *Annual reports* submitted by firms to the SEC[1]. We measured innovative performance using patent data from the *Hall Patent Database* and the *United States Patent and Trademark Office (USPTO)*. Consistent with previous studies (Wiseman and Bromiley, 1991), firms with less than 3 years of data within a 5-year period, and the first year in each data series for the independent variable, are eliminated. Missing data in the case of some of our control variables further reduced the final panel to 327 firm-year observations when examining Diversification and to 312 firm-year observations when examining Dissimilarity.

Variable Description

Diversification and Dissimilarity in Technology Sourcing Vehicles

Prior studies have typically measured a firm's use of technology sourcing vehicles by counting the number of alliances and acquisitions it made each year. This method, however, does not capture in-house R&D activities. To overcome this limitation, we record the amounts invested in each of the three vehicles each year (and use their natural logs in the models). We record the amounts invested in alliances and acquisitions only when they were completed for the purpose of developing or improving a new technology. To determine that, we conduct a keyword search of all firms' 10K reports, proxy statements, and Annual Reports, for words such as 'research', 'R&D', 'alliance', 'JV', 'collaboration', and 'acquisition'. Then, we carefully read the chapters in which these keywords appeared. We verify the accuracy of our data by crosschecking the information provided in the 10K and Annual reports with information

[1] To insure thoroughness, we compared our data on top executives with the *Dunn and Bradstreet's Reference Book of Corporate Management, Hoovers,* and *Thomson One Banker's Officers and Directors* databases.

provided in the firms' proxy statements, media reports recorded in Factiva, and the Recombinant Capital (ReCap) Alliance Database.

Diversification. We measured a portfolio's diversification using the entropy measure (Palepu, 1985) that equaled:

$$\sum\left(P_i * ln\left(\frac{1}{P_i}\right)\right)$$

where P_i is the percentage of R&D investment in a particular strategic vehicle. This measure accounts for two elements of diversification: (1) the number of vehicles used, and (2) the relative importance of each (Palepu, 1985) given by the investment amount.

Dissimilarity. The extent to which a firm changes the composition of its portfolio of technology sourcing vehicles across years is measured as the sum of the absolute differences between the weights of each sourcing vehicle in the portfolio at year *t* versus year *t-1*. A change in weights shows that the firm changes the emphasis places on the different vehicle:

$$\sum\left(ABS\left[W_{ID_t} - W_{ID_{t-1}}\right] + ABS\left[W_{MA_t} - W_{MA_{t-1}}\right] + ABS\left[W_{A_t} - W_{A_{t-1}}\right]\right)$$

A change in the resources allocated to one vehicle may affect the resources available for other vehicles. An important advantage of using weights in the computation of the dissimilarity measure is that it accounts for such interdependencies. The higher the sum of the absolute differences in weights, the greater the dissimilarity of the composition of a firm's portfolio between two consecutive years. A simplified example of a dissimilar change in the portfolio of sourcing vehicles is presented in Figure 1.

-- Insert Figure 1 about here –

Innovative Performance Aspirations and interactions with Slack

We measure *Innovative Performance* as the number of patents granted to a firm or its subsidiaries in a given year. Empirical studies have shown that the number of patents held by a corporation is highly related to sales growth (Scherer, 1965) and has economic significance (Scherer and Ross, 1990). Patents are an externally validated measure of technological novelty (Griliches, 1998) and firms that patent more than their peers are considered to be on the technological and innovation frontier of their field (Achilladelis, Schwarzkopf, and Cines, 1990; Rothaermel and Boeker, 2008).

Innovative performance is evaluated against aspiration levels which may be determined by a firm's past innovative performance (historical aspirations) or the performance of similar firms in the industry (social aspirations). We calculate a firm's *historical aspiration level* using a simple equation in which the input is its historical performance and the output is its aspiration level which is then used to evaluate future performance. The rule used to generate historical aspiration levels is:

$$A_t = a * A_{t-1} + (1 - a) * P_{t-1}$$

where *A* is the aspiration level, *P* is the technological performance and *a* is the weight of the most recent aspiration level. The value of *a* results from estimating models with different values of *a* and retaining the value that best fits the data (see Audia and Greve, 2006). The model predicting *Diversification* retained a value of *a* equal to .6, and the model predicting *Dissimilarity* retained a value of *a* equal to .9. *Social aspiration levels* uses information on the technological performance of peer organizations, and is thus defined as a firm's patent counts averaged across all firms in the panel in a given year. For both types of aspirations, *performance below the aspiration level* equals 0 when performance is above the aspiration level, and equals performance minus aspiration level when performance is below the aspiration level (Greve, 1998).

Our hypotheses examine the effect of technological performance below historical and social aspiration levels for slack rich and slack poor firms, thus requiring an interaction between a firm's technological performance and its level of slack. For *Firm Slack*, we use the category of *potential slack* calculated as the ratio of income before taxes and interest charges to interest charges (Bourgeois and Singh, 1983; Bromiley, 1991). This measure reflects the ability of the firm to take on further debt (a higher ratio reflects a higher ability) and is particularly suitable to predict acquisitions, alliances, and internal development investments that often times require external financing. The raw measure takes negative values and is highly skewed. Therefore, we normalize this variable by adding a constant value to the data prior to applying the log transform. The transformation thus equals: $log(Y+a)$ such that $min(Y+a) = 1$, where Y is the raw measure and a is the constant.

Control variables

We control for several firm-level factors that may explain changes in technology sourcing vehicles. All control variables are lagged by one year. We account for *Prior Diversification* and for *Prior Dissimilarity* in technology sourcing vehicles using the same measures as for our dependent variables, calculated at time $t-1$. The choice of vehicles may be affected by the level of product diversification, so we control for *Business Line Diversification*. A firm's operating budget may influence the decision to invest in a particular technology sourcing vehicle (i.e. in-house R&D is usually less expensive than an acquisition), so we control for firms' prior

Operating Budget (natural logarithm). Larger firms are in better position to pursue acquisitions or alliances (Rothaermel, 2001) so we measure *Firm Size* using the natural logarithm of the value of total assets.

TMT size has been shown to increase acquisition activity (Lei and Hitt, 1995), so it is controlled for by the total number of managers on a firm's TMT. Newer members in the TMT are more prone to change a firm’s way of doing business than older members who are more entrenched. To capture this possibility, we control for both *TMT average tenure* (in a managerial position) and *TMT variance in tenure*.

Top executives that are involved in R&D activities have a direct impact on the choice of technology sourcing vehicles. Therefore, we control for the average age of a firm’s vice-presidents top executives directly involved in research and development activities using the variable *VP Research age* and for *VP change* as a dummy variable that equals 1 if a new VP was hired in the previous year and 0 otherwise.

The CEO is the ultimate decision-maker in the firm. Since older CEOs may avoid risky actions such as undertaking new acquisitions (e.g., Hambrick and Mason, 1984), we control for both the *CEO age* and *CEO Tenure* (in position). In all models we control for firm-level and year fixed effects.

RESULTS

Descriptive statistics and bivariate correlations are shown in Table 1. As a reminder, we hypothesized that firms with performance below their technological aspirations level will pursue two types of changes in their technology sourcing vehicles, and that the direction of these changes will be different for slack poor and slack rich firms. The results provide strong support for this prediction. Specifically, Tables 2 and 3 show the estimates of the GLM regression with firm-level and year fixed effects predicting *Diversification* (Table 2 Models 1 through 3) and *Dissimilarity* (Table 3 Model 1 through 3). Model 1 in each table presents the baseline model, while Model 2 and 3 present the predicted relations when technological performance is below the historical and social aspiration levels, respectively.

-- Insert Table 1 about here –

Consistent with Hypotheses 1a and 1b, a decrease in innovative performance induces slack-rich organizations to diversify their technology-sourcing portfolio and utilize new vehicles. In contrast, and in accordance with Hypotheses 2a and 2b, slack- poor organizations respond to a decrease in innovative performance by decreasing their portfolio's diversification and reverting to familiar vehicles. The Hypotheses are equally supported when comparing technological performance to either historical or social aspirations levels, with the sole exception of social aspiration levels when predicting *Dissimilarity*.

-- Insert Tables 2 and 3 about here –

To illustrate our findings, we graph the interactive effects of *Innovative Performance* and *Slack* on *Diversification* and *Dissimilarity* in Figures 1-3 (as Model 2 in Table 3 indicates, the interactive effects of *Innovative Performance* relative to historical aspiration levels and *Slack* on *Dissimilarity* are not significant and thus were not graphed). As indicated by the top lines in all three graphs, as performance decreased below aspirations, slack-rich firms increased their portfolio's diversification and dissimilarity (i.e. making the portfolio more diversified and using new vehicles). In contrast, as indicated by the bottom lines, as performance decreased below aspirations, slack-poor firms decreased their portfolio's diversification and dissimilarity. These outcomes were driven by the negative and significant effect of the interactions of *Innovative performance below aspirations* and *Slack*.

-- Insert Graphs 1 through 3 about here --

A number of results for the control variables are noteworthy. Business line diversification negatively affects the diversification and dissimilarity of technology sourcing portfolios. The reason may be that business line diversification diverts financial and human resources from investments in technology sourcing vehicles. We note that the size of the top management team is also negatively related to both *diversification* and *dissimilarity* (although not significant for the latter). Finally, the age of the VP specializing in R&D activities is positively associated with diversification and dissimilarity (not significant for the former). One possible reason for this effect is that age reflects experience in a variety of technology sourcing vehicles rather than simply being an indicator of inertia in decision-making.

DISCUSSION

Strategy scholars have long been interested in how firms source their technology. We contribute to this work by extending the technology-sourcing portfolio concept to include internal development, and examine when and how technology-intensive firms change their portfolio of vehicles in response to poor innovative performance. Overall, the results provide strong support for our theory: greater levels of slack resources lead poor-performing firms to experiment with greater vehicle diversification and the addition of new sourcing vehicles, while firms with fewer slack resources respond to poor innovative performance by downscoping their portfolio and reverting to more familiar sourcing vehicles.

These finding are particularly important considering that a firm's ability to successfully innovate and deliver superior long term financial performance rests on its ability to renew its innovation processes (Teece, 2007). Identifying the behavioral antecedents of a firm's portfolio composition is therefore an essential step towards better understanding its ability to obtain and sustain competitive advantage in an open economy with rapid innovation and globally dispersed sources of knowledge. More generally, it is a necessary prerequisite to explain how and why firms differ in their innovative behavior and performance. In this study we take an important step towards answering these questions by showing when and how firms divert from their path-dependent quest for innovation and change their portfolios of technology-sourcing vehicles.

This study contributes to two additional bodies of research: studies on performance-induced change and the literature on organizational slack. A growing number of scholars within the tradition of the behavioral theory of the firm have shown that performance below aspirations causes search for alternative actions and risk taking in the form of new practices' adoption (e.g., Baum and Dahlin, 2007; Greve, 1998; Greve, 2003; Iyer and Miller, 2008; Park, 2007). Our work complements and extends these studies in two ways.

First, by and large, these studies have examined financial performance and financial aspirations, typically operationalized as profitability. Our findings suggest that in science-based industries firms pay attention to, and form aspirations along, innovation goals. By highlighting the important effects of innovation goals, our findings stress the need to extend research beyond financial performance to a variety of organizational goals and aspirations. Although the importance of examining a variety of organizational goals has long been called for (Cyert and

March, 1963), only recently scholars have begun to consider goal aspirations other than financial (e.g. Greve, 2008). Our theory and results underscore the significance of this new line of inquiry.

Second, while our results corroborate the generally observed tendency of firms to change their practices in response to poor performance, they also demonstrate that firms search for alternative actions and adopt new practices when benefiting from high levels of slack resources but resort to more familiar actions and practices when suffering from a shortage of slack resources. These results inform the ongoing debate about the impact of slack resources on organizations' propensity to change and innovate (Kraatz and Zajac, 2001; Nohria and Gulati, 1996; Singh, 1986) by showing that slack does not only affect the likelihood of change but also the sort of change undertaken.

With respect to study limitations, data constraints and the need to control for potential confounds impelled us to restrict our study to an examination of vehicles used for the sourcing of technological capabilities, focus on innovative performance goals, and test our hypotheses using a single-industry sample. Nevertheless, the types of vehicles examined (i.e., alliance, acquisition, or go-it-alone) are used for a multitude of strategic and business development purposes (e.g., market entry, geographical entry, or sales and marketing) and across numerous industries. Firms' responses may be different in degree and kind depending on the organizational goals and aspirations examined, and the characteristics of the industry under study. Future research could extend this study by investigating other types of organizational goals across a wider variety of industries. Likewise, while this paper is one of the firsts to examine all three major technology sourcing vehicles (i.e. make, buy, ally) concurrently, we acknowledge that there are many other ways through which firms may source their technology, such as hiring talent from competitors or licensing patented technology. Although no single study is likely to be exhaustive in including all vehicles, we believe that our consideration of a more comprehensive set of vehicles has allowed us to shed new light on firms' choice of vehicles and on the performance consequences of their choices.

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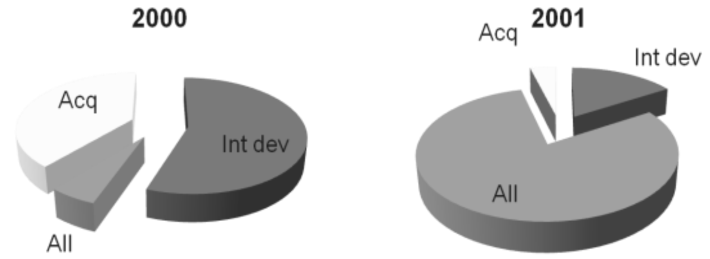
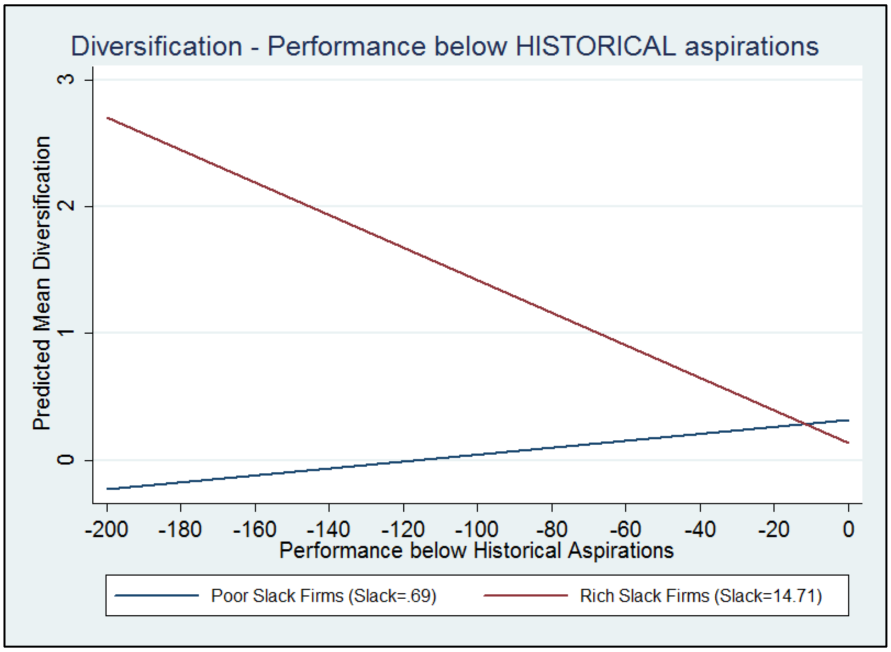
FIGURES AND GRAPHS

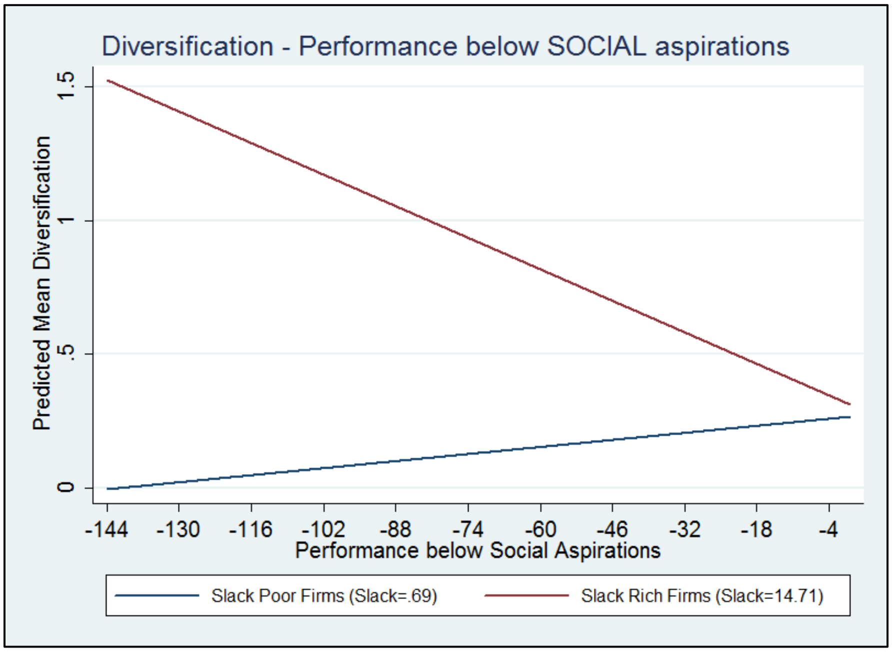
FIGURE 1. Example of dissimilar changes in the portfolio of sourcing vehicles - Pfizer



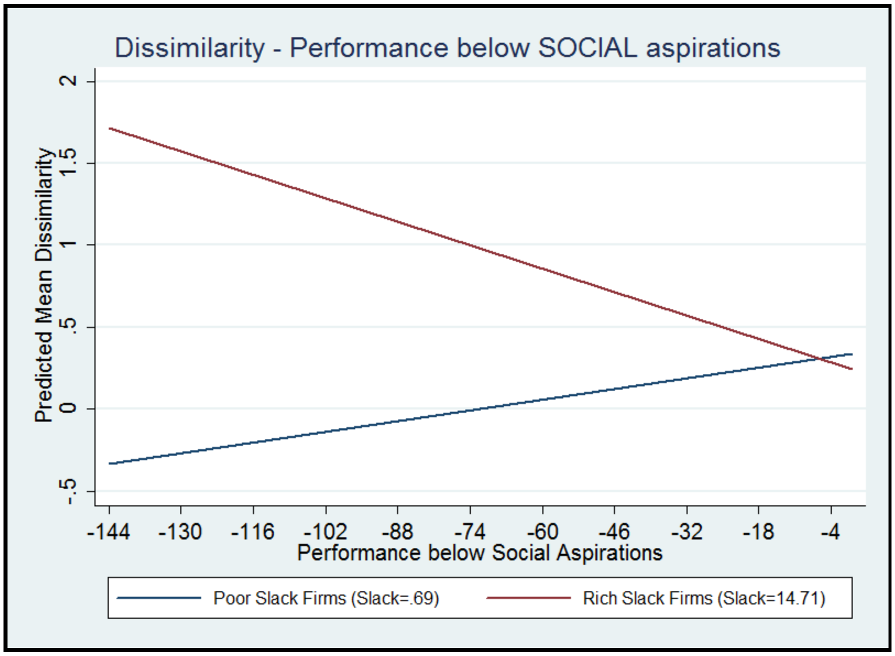
GRAPH 1. Innovative performance below historical aspirations – Slack interactions: effects on Diversification



GRAPH 2. Innovative performance below social aspirations – Slack interactions: effects on Diversification



GRAPH 3. Innovative performance below social aspirations – Slack interactions: effects on Dissimilarity



TABLES

TABLE 1. Descriptive Statistics

	Variable	N	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1	Vehicle Diversification	327	0.26	0.27	0.00	1.04											
2	Vehicle Dissimilarity	327	0.26	0.37	0.00	1.72	0.50										
3	Innovative performance above Aspirations (Social)	327	34.23	72.80	0.00	403.17	-0.05	-0.13									
4	Innovative performance above Aspirations-Slack Interaction (Social)	327	125.46	265.84	0.00	1503.82	-0.03	-0.12	0.98								
5	Innovative performance below Aspirations (Social)	327	-24.56	36.26	-144.22	0.00	-0.03	-0.07	0.32	0.32							
6	Innovative performance below Aspirations - Slack Interaction (Social)	327	-119.59	186.60	-982.14	0.00	-0.05	-0.06	0.30	0.30	0.94						
7	Innovative performance above Aspirations (Historical .6)	327	13.70	32.61	0.00	208.26	-0.02	-0.05	0.60	0.58	0.12	0.10					
8	Innovative performance above Aspirations-Slack Interaction (Historical .6)	327	58.72	149.46	0.00	1838.48	0.02	-0.03	0.44	0.50	0.07	0.02	0.87				
9	Innovative performance below Aspirations (Historical .6)	327	-12.13	30.28	-208.96	0.00	0.04	0.09	-0.12	-0.12	-0.03	-0.05	0.17	0.16			
10	Innovative performance below Aspirations - Slack Interaction (Historical .6)	327	-46.94	112.27	-889.28	0.00	0.03	0.08	-0.10	-0.11	0.01	0.00	0.18	0.16	0.97		
11	Innovative performance above Aspirations (Historical .9)	327	24.17	49.40	0.00	293.06	-0.05	-0.05	0.75	0.73	0.13	0.11	0.89	0.76	0.17	0.17	
12	Innovative performance above Aspirations-Slack Interaction (Historical .9)	327	101.52	215.81	0.00	2104.79	-0.01	-0.03	0.58	0.64	0.07	0.02	0.80	0.90	0.16	0.15	0.89
13	Innovative performance below Aspirations (Historical .9)	327	-8.09	25.03	-256.43	0.00	0.01	0.05	-0.03	-0.03	-0.03	-0.05	0.14	0.13	0.83	0.79	0.16
14	Innovative performance below Aspirations - Slack Interaction (Historical .9)	327	-30.39	88.04	-838.53	0.00	0.00	0.04	-0.03	-0.03	-0.01	-0.03	0.14	0.14	0.83	0.82	0.17
15	Slack (LN)	327	5.74	3.21	0.69	14.71	0.10	0.00	-0.31	-0.26	0.18	0.05	-0.19	-0.06	0.23	0.19	-0.24
16	Prior Vehicle Diversification	327	0.25	0.26	0.00	1.04	0.43	0.47	-0.06	-0.04	-0.09	-0.09	-0.06	0.00	0.07	0.07	-0.08
17	Prior Vehicle Dissimilarity	312	0.25	0.36	0.00	1.56	0.13	0.43	-0.12	-0.12	-0.10	-0.07	-0.04	-0.01	0.08	0.09	-0.04
18	Business line Diversification	327	0.27	0.40	0.00	1.33	-0.19	-0.18	0.31	0.29	0.19	0.24	0.16	0.07	-0.19	-0.16	0.26
19	Operating Budget (LN)	327	6.82	2.24	2.14	10.61	-0.13	-0.11	0.54	0.50	0.11	0.21	0.26	0.11	-0.32	-0.27	0.34
20	Firm Age	327	63.14	55.10	2.00	156.00	-0.17	-0.19	0.46	0.41	0.21	0.29	0.25	0.10	-0.27	-0.20	0.30
21	Firm Size (LN)	327	21.38	2.27	14.38	25.54	-0.11	-0.04	0.51	0.47	0.06	0.16	0.25	0.10	-0.34	-0.29	0.33
22	TMT Size	327	10.22	5.61	2.00	31.00	-0.17	-0.11	0.12	0.09	0.08	0.15	0.07	-0.03	-0.04	0.01	0.00
23	TMT Tenure - average (position)	327	3.95	2.08	0.63	12.71	-0.20	-0.16	-0.03	-0.03	0.10	0.12	-0.04	-0.06	0.03	0.03	-0.01
24	TMT Tenure - variance (position)	327	11.54	12.41	0.00	80.87	-0.14	-0.11	-0.11	-0.11	0.12	0.13	-0.14	-0.14	0.06	0.07	-0.13
25	CEO Age	327	54.43	6.94	35.00	73.00	-0.07	-0.11	0.21	0.18	-0.01	0.04	0.09	0.00	-0.12	-0.09	0.13
26	CEO Tenure (position)	327	6.13	5.27	0.00	26.00	-0.14	0.00	-0.07	-0.08	-0.03	0.00	-0.02	-0.03	0.10	0.10	-0.01
27	VP Age - R&D	327	50.78	5.76	36.00	64.00	-0.05	-0.02	0.29	0.25	0.23	0.31	0.07	-0.08	-0.09	-0.06	0.11
28	VP Change - R&D	327	0.22	0.42	0.00	1.00	0.00	0.12	0.00	-0.01	-0.10	-0.06	-0.03	-0.05	-0.05	-0.04	-0.03

Variable	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
13 Innovative performance below Aspirations (Historical .9)	0.15															
14 Innovative performance below Aspirations - Slack Interaction (Historical .9)	0.16	0.98														
15 Slack (LN)	-0.10	0.20	0.17													
16 Prior Vehicle Diversification	-0.03	0.07	0.07	0.09												
17 Prior Vehicle Dissimilarity	-0.02	0.08	0.09	-0.04	0.49											
18 Business line Diversification	0.15	-0.13	-0.12	-0.32	-0.20	-0.15										
19 Operating Budget (LN)	0.18	-0.28	-0.25	-0.72	-0.15	-0.06	0.60									
20 Firm Age	0.14	-0.23	-0.19	-0.57	-0.18	-0.16	0.61	0.84								
21 Firm Size (LN)	0.18	-0.29	-0.26	-0.76	-0.12	0.01	0.53	0.96	0.76							
22 TMT Size	-0.09	-0.07	-0.05	-0.44	-0.15	-0.08	0.29	0.57	0.65	0.54						
23 TMT Tenure - average (position)	-0.03	0.04	0.04	0.03	-0.15	-0.15	0.05	-0.01	0.06	-0.05	-0.06					
24 TMT Tenure - variance (position)	-0.14	0.06	0.06	0.03	-0.10	-0.11	0.00	-0.06	0.02	-0.09	-0.02	0.79				
25 CEO Age	0.03	-0.10	-0.10	-0.22	-0.10	-0.10	0.18	0.37	0.44	0.31	0.32	0.41	0.39			
26 CEO Tenure (position)	-0.03	0.12	0.12	-0.12	-0.11	-0.01	-0.08	-0.07	-0.06	-0.05	0.04	0.55	0.55	0.28		
27 VP Age - R&D	-0.05	-0.02	-0.03	-0.23	-0.02	-0.02	0.34	0.43	0.48	0.38	0.33	0.19	0.20	0.47	0.04	
28 VP Change - R&D	-0.05	-0.05	-0.06	-0.20	0.02	0.12	0.06	0.15	0.10	0.17	0.09	-0.12	-0.10	-0.07	-0.06	-0.10

TABLE 2 GLM piece-wise regression with firm and year fixed effects predicting Diversification in technology sourcing vehicles – Innovative performance and Slack interactions

	Vehicle Diversification		
	(1) -baseline-	(2) -historical-	(3) -social-
Innovative Performance below Aspirations		0.0035*	0.0024+
		(0.0017)	(0.0016)
Innovative Performance below Aspirations - Slack Interaction		-0.0011**	-0.0007**
		(0.0004)	(0.0002)
Innovative Performance above Aspirations		-0.0012+	-0.0025*
		(0.0009)	(0.0012)
Innovative Performance above Aspirations-Slack Interaction		0.0005***	0.0008**
		(0.0002)	(0.0003)
Slack (LN)	-0.0123	-0.0202*	-0.0251**
	(0.0095)	(0.0100)	(0.0103)
Prior Vehicle Diversification	0.2322***	0.2195***	0.1749**
	(0.0582)	(0.0579)	(0.0587)
Business line Diversification	-0.1243+	-0.1411*	-0.1744*
	(0.0690)	(0.0715)	(0.0734)
Operating Budget (LN)	0.0426	0.0230	0.0315
	(0.0474)	(0.0466)	(0.0461)
Firm Age	0.0020	0.0034	0.0062
	(0.0073)	(0.0078)	(0.0071)
Firm Size (LN)	0.0103	0.0101	0.0185
	(0.0387)	(0.0381)	(0.0378)
TMT Size	-0.0153***	-0.0140***	-0.0136***
	(0.0038)	(0.0039)	(0.0037)
TMT Tenure - average (position)	-0.0217*	-0.0228*	-0.0176+
	(0.0107)	(0.0107)	(0.0106)
TMT Tenure - variance (position)	-0.0013	-0.0020	-0.0024
	(0.0014)	(0.0014)	(0.0015)
CEO Age	0.0037	0.0052	0.0044
	(0.0034)	(0.0033)	(0.0033)
CEO Tenure (position)	-0.0015	-0.0024	-0.0006
	(0.0040)	(0.0039)	(0.0038)
VP Age - R&D	-0.0010	0.0006	-0.0013
	(0.0037)	(0.0038)	(0.0036)
VP Change - R&D	-0.0328	-0.0289	-0.0351
	(0.0325)	(0.0320)	(0.0315)
Firm fixed effects – YES			
Year fixed effects – YES			
Constant	*-0.3860*	*-0.4939*	*-0.9171*
	(0.7804)	(0.8090)	(0.7491)
Observations	327	327	327
AIC	34.1685	33.3753	27.4433
BIC	242.6163	256.9829	251.0510

One-tail for IV effects. Two-tail for controls. Standardized beta coefficients. Robust standard errors in parentheses
+ p<0.10 * p<0.05 ** p<0.01 *** p<0.001

TABLE 3 GLM piece-wise regression with firm and year fixed effects predicting Dissimilarity in technology sourcing vehicles – Innovative performance and Slack interactions

	Vehicle Dissimilarity		
	(1) -baseline-	(2) -historical-	(3) -social-
Innovative Performance below Aspirations		0.0036	0.0054**
		(0.0047)	(0.0022)
Innovative Performance below Aspirations - Slack Interaction		-0.0009	-0.0011***
		(0.0013)	(0.0003)
Innovative Performance above Aspirations		-0.0006	-0.0012
		(0.0009)	(0.0013)
Innovative Performance above Aspirations-Slack Interaction		0.0004*	0.0004+
		(0.0002)	(0.0003)
Slack (LN)	-0.0095	-0.0173	-0.0213+
	(0.0151)	(0.0148)	(0.0160)
Prior Vehicle Dissimilarity	0.2258**	0.2132**	0.2094**
	(0.0777)	(0.0775)	(0.0773)
Business line Diversification	-0.2816***	-0.2887***	-0.3056***
	(0.0818)	(0.0819)	(0.0866)
Operating Budget (LN)	-0.2010*	-0.2436**	-0.2169**
	(0.0795)	(0.0845)	(0.0805)
Firm Age	0.0240*	0.0319*	0.0262*
	(0.0109)	(0.0133)	(0.0111)
Firm Size (LN)	0.1562**	0.1576**	0.1688**
	(0.0590)	(0.0597)	(0.0592)
TMT Size	-0.0028	-0.0010	-0.0012
	(0.0049)	(0.0048)	(0.0051)
TMT Tenure - average (position)	-0.0167	-0.0173	-0.0096
	(0.0143)	(0.0144)	(0.0143)
TMT Tenure - variance (position)	-0.0021	-0.0025	-0.0034+
	(0.0019)	(0.0020)	(0.0020)
CEO Age	0.0016	0.0041	0.0026
	(0.0052)	(0.0054)	(0.0050)
CEO Tenure (position)	0.0058	0.0041	0.0062
	(0.0055)	(0.0054)	(0.0054)
VP Age - R&D	0.0118*	0.0128*	0.0118*
	(0.0050)	(0.0054)	(0.0049)
VP Change - R&D	0.0551	0.0606	0.0590
	(0.0438)	(0.0438)	(0.0438)
Firm fixed effects – YES			
Year fixed effects – YES			
Constant	*-4.5789***	*-5.2229***	*-4.9947****
	(1.4223)	(1.5996)	(1.4459)
Observations	312	312	312
AIC	234.3040	235.4683	234.4363
BIC	436.4261	452.5624	451.5305

One-tail for IV effects. Two-tail for controls. Standardized beta coefficients. Robust standard errors in parentheses
+ p<0.10 * p<0.05 ** p<0.01 *** p<0.001