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Michael Heeley
Colorado School of Mines

David R. King
Marquette University

Jeffrey Covin
Indiana University - Bloomington

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Effects of Firm R&D Investment and Environment on Acquisition Likelihood*

Michael B. Heeley, David R. King and Jeffrey G. Covin

Colorado School of Mines; US Air Force; Indiana University

ABSTRACT R&D investments contribute to the development of firm technology resources, and the possession of such resources often increases a firm's attractiveness as a potential acquisition target. However, the value ascribed to a firm's technology resources by would-be acquirers may be moderated by its industry's environmental characteristics. Using data from 2886 firms, we find that investments in R&D predict acquisition likelihood and that R&D investments are most strongly associated with acquisition of firms under conditions of high environmental munificence and dynamism. Theoretical and managerial implications are discussed.

INTRODUCTION

The acquisition wave of the 1990s was prompted in large part by firms trying to keep pace with unprecedented rates of technological and environmental change. Over one-fifth the number and two-fifths the value of United States acquisitions during this time period involved the acquisition of technology-based firms (Inkpen et al., 2000). Several researchers (e.g. Bower, 2001; Ranft and Lord, 2000, 2002) have suggested that high-technology acquisitions represent a distinct response to the innovation imperative that pervades many industries. In particular, it is commonly argued that the need for innovativeness will often drive firms to acquire technology-based targets in order to access those targets' innovation-enabling technological resources (e.g. Hitt et al., 2001; King et al., 2003). This possibility is consistent with Blonigen and Taylor's (2000) observation that acquisitions and R&D investments may substitute for one another as drivers of innovation, and it begs the following question: Does a target firm's R&D investment contribute to its likelihood of being acquired?

To answer this question, one should consider why firms engage in acquisition activity. The resource-based view recognizes that valuable resource stocks can be built through acquisitions (Carow et al., 2004). Some other acknowledged benefits of acquisitions include: (1) lower entry costs than internal development (Roberts and Berry, 1985); (2) the circumvention of entry barriers (Singh and Montgomery, 1987), such as patents

Address for reprints: Jeffrey G. Covin, Indiana University, Kelley School of Business, Department of Management, 1309 E. Tenth Street, Bloomington, IN 47405-1701, USA (covin@indiana.edu).

(Teece, 1986); and (3) faster access to (Capron, 1999; Lambe and Spekman, 1997) and greater control over resources than internal development often affords (King et al., 2003). Of course, the successful transfer of target firm resources to the acquirer is not assured when using acquisition as a technology-sourcing strategy (Capron and Pistre, 2002). Nonetheless, acquisitions represent a frequently effective means for appropriating value from others' technology (Hitt et al., 2001).

Given the possible benefits of acquisition activity as a technology-sourcing strategy, it is somewhat surprising that research has not extensively explored the extent to which a firm's investments in technology resources predict its likelihood of being acquired. Most acquisition research has been framed around understanding the motivations and performance of *acquiring* firms (e.g. King et al., 2004; Ravenscraft and Scherer, 1987; Sirower, 1997), with the resource profiles of these firms often examined as plausible predictors of acquisitions (Capron and Pistre, 2002; Chatterjee and Wernerfelt, 1991). By comparison, the resource profiles of attractive acquisition *targets* have received significantly less research attention. Only a handful of empirical studies specifically focus on the attributes of potential acquisition targets (e.g. Billet, 1996; Hasbrouck, 1985; Mitchell and Lehn, 1990; Palepu 1986), and this paucity of research represents an acknowledged gap in the strategic management literature (Bruno et al., 1992; Burgelman, 1994).

Consistent with resource-based theory (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984), the premise of the current research is that firms with resources or higher-order capabilities that are valued by would-be acquirers are often targeted for acquisition. R&D expenditures are a recognized path to the creation of valuable technology resources (e.g. Dierickx and Cool, 1989; Grabowski and Vernon, 1990), and the possession of such resources has been shown to invite a firm's acquisition (Bresman et al., 1999; Ranft and Lord, 2000, 2002). Significantly, the development of valuable firm resources often requires sustained firm investment (Ethiraj et al., 2005; Vassolo et al., 2004; Winter, 2000, 2003). Therefore, firms with sustained R&D investments may be the most attractive acquisition targets, other things being equal.

Of course, 'other things' are seldom equal. A factor that may influence the value ascribed to technology resources, and therefore the likelihood that such resources will invite a firm's acquisition, is the environment of the target firm where those resources exist. Priem and Butler (2001) argue that resources are differentially valuable across environments. Consistent with this point, Miller and Shamsie's (1996) research shows that property-based resources have stronger associations with firm performance in stable than dynamic environments, and that the opposite is true of knowledge-based resources. Likewise, R&D-induced technology resources may be more valuable in some environments than in others. Research has yet to explore how target industry environmental characteristics influence the acquisition likelihood of firms that invest in R&D.

The present study is motivated by the research opportunities suggested above. In particular, the goals of this study are: (1) to explore whether a firm's R&D investment impacts its acquisition likelihood; and (2) to assess whether the environment where a firm operates influences the relationship between its R&D investment and its likelihood of being acquired. We expect that certain commonly-recognized environmental factors – i.e. munificence, dynamism, and complexity (Dess and Beard, 1984) – will moderate the

relationship between R&D expenditures and acquisition likelihood. The theoretical background and hypotheses of this research are presented next.

THEORETICAL BACKGROUND AND HYPOTHESES

Resource-based theory (Barney, 1991; Wernerfelt, 1984) offers a powerful lens for viewing acquisitions. According to resource-based theory, organizations are collections of unique resources and higher-order capabilities that emerge as interacting sets of resources begin to facilitate the accomplishment of particular tasks. Resources and capabilities are developed or acquired over time and represent the primary source of firm profitability and the primary basis for competitive strategy. Differences in the resource profiles of firms and in the specific ways these resources are used within firms form the basis for competitive advantage. Resources and capabilities are regarded as valuable within an industry to the extent that they enable firms to efficiently and effectively exploit significant environmental opportunities. Thus, a principal task of a firm's managers is to develop (or acquire) and then deploy resources that are strategically relevant to conditions in the firm's environment.

Significantly, research suggests that acquisitions represent an important tool for managing firm resource profiles (Capron and Mitchell, 1998; Capron and Pistre, 2002). The following discussion argues that technology resources have implications for a firm's possible acquisition. Given that technology resources contribute to a fundamental capability for innovation (e.g. Itami and Numagami, 1992) that is built through sustained investment (e.g. Miller and Shamsie, 1996; Winter, 2000, 2003), we believe that a firm's recent history of R&D expenditures will be a key factor in predicting acquisition. Moreover, different environments will place differential demands on the need for particular resources profiles, so the resources targeted through acquisition will likely be those that confer value in the environments where they are employed (i.e. in the target industry). Consistent with this point, a premise of the current paper is that a potential target firm's industry environment will likely influence the perceived value of its technology resources. We argue that the relationship between a potential target firm's investments in R&D and its acquisition likelihood is moderated by characteristics of that target firm's industry environment.

R&D Expenditures and Acquisition Attractiveness

Research has extensively examined R&D's impact on such factors as firm performance and innovative output (e.g. Ahuja and Katila, 2001; Pakes, 1985; Ravenscraft and Scherer, 1987). By contrast, very little research has examined the relationship between R&D investments and acquisition activity. The observation that overall R&D investment and acquisition activity are positively related (Jensen, 1988) implies little, if anything, about how these phenomena relate at the firm level. Moreover, the majority of R&D-acquisition research has focused on the R&D investments of the acquiring firms and not their targets. Of the past studies that have explored the R&D-acquisition linkage, the most common finding is that an acquiring firm's R&D investments positively affect the likelihood of external technology (vs. internal development) acquisition (e.g. Griliches and Mairesse, 1984; Veugelers 1997).

Some studies have shown that acquiring firms' R&D investments decrease as a function of those firms' acquisition activity (Blonigen and Taylor, 2000; Hitt et al., 1991). Explanations for this observed relationship vary, but typically relate to acquiring firms having less incentive to perform R&D. For example, R&D following an acquisition may decline as a result of an increased emphasis on financial controls, acquisitions acting as a substitute for R&D, or perceptions that technology maturity limits the perceived benefit of further R&D (King et al., 2003). These explanations for decreased R&D following an acquisition should not impact the value of a potential target firm's resources relating to R&D investments that have already been made. Moreover, to the extent that acquisitions substitute for acquiring firms' R&D investments (Blonigen and Taylor, 2000; Peteraf and Bergen, 2003), observations of decreased R&D spending following an acquisition support the premise of the current research that target firm R&D resources are recognized and valued by their acquirers.

Granstrand et al. (1992) report that the acquisition of innovative firms has been increasing in perceived importance over time as a technology-sourcing strategy; a sentiment reiterated by Ahuja and Katila (2001). Given the growing recognition that acquisitions can be an effective part of a firm's technological innovation strategy (Bettis and Hitt, 1995; King et al., 2003), the matter of whether R&D investments invite a firm's acquisition warrants careful examination. Of particular relevance for the current study is whether greater R&D expenditures increase a firm's attractiveness as an acquisition target or, more accurately, its likelihood of being acquired. There are credible reasons to believe it does. Nelson and Winter (1978), for example, argue that the capacity to recognize and exploit technological opportunities is a function of a firm's technology-targeted resource commitments, like R&D investments. Similarly, Zahra and Covin (1994) and Canals (2000) assert that R&D investments often directly contribute to a firm's innovative capability, and that such capability is a resource imperative among firms operating in many industries.

Firms with greater R&D investments should, over time, accumulate more valuable technology resources, creating a context conducive to the emergence of competitiveness-enhancing innovative capability. This is because knowledge-based resources tend to develop in a path dependent manner (Kogut and Zander, 1996), with sustained investments contributing to the depth of firm capabilities (Berry and Taggart, 1994; Helfat and Peteraf, 2003). Significantly, the desire for others' technology resources has been identified as a common motive for firm acquisitions (Bresman et al., 1999; Chakrabarti et al., 1994; Hitt et al., 1996). Therefore, we examine the following relationship:

Hypothesis 1: The size of a firm's R&D stock is positively related to the likelihood of that firm being acquired.

Moderating Impact of a Target Firm's Environment

A firm's external environment is a multidimensional construct, with the most commonly recognized environmental dimensions being munificence, dynamism, and complexity (e.g. Bluedorn, 1993; Dess and Beard, 1984; Keats and Hitt, 1988; Pfeffer and Salancik, 1978; Sharfman and Dean, 1991). In general, our argument is that the value

of a target firm's technology resources is a function of the environment where those resources are employed. Consistent with the expressed need for the examination of interactions in management research in general (Henderson and Mitchell, 1997) and acquisition research in particular (Hitt et al., 1998; King et al., 2004), we develop theory explaining why a target firm's industry environment moderates the relationship between that firm's investments in R&D and its acquisition likelihood. In some environments, the need for technology resources will be particularly great, and firms that possess technology resources in those environments will tend to be acquired.

Environmental munificence. Munificence is reflected in the degree to which environmental resources, broadly defined, are supportive of sustained growth for the overall set of firms within an industry (Dess and Beard, 1984; Sharfman and Dean, 1991). This environmental dimension has been discussed within the population ecology literature under the label of environmental carrying capacity (Aldrich, 1979). Munificence is characteristically assumed to have a positive net effect on firm performance (DeCarolis and Deeds, 1999). However, munificence is more appropriately regarded as an enabling rather than a causal variable in the realization of high firm performance (Keats and Hitt, 1988).

Assuming that R&D expenditures create valuable technology resources that invite acquisition, would-be acquirers may be particularly attracted to technologically capable targets operating in munificent environments. Such environments are growing and opportunity rich (Castrogiovanni, 1991), and these qualities often invite entrance. However, not all potential target firms operating in munificent environments will be equally attractive. Rather, firms entering an industry through acquisition will be attracted to targets perceived as capable of helping them exploit market opportunities. For example, in industries experiencing rapid growth, acquisitions are often used when acquiring and target firms possess complementary resources that must be combined to facilitate the exploitation of market opportunities (Anand, 2004; King et al., 2003). Moreover, research suggests that resources, which contribute to a firm's capacity to innovate, are particularly valuable in industries undergoing rapid growth (Utterback, 1994). Therefore, technology resources may be especially crucial to firm success in munificent environments, and firms that possess such resources will often be acquisition targets.

Of course, not all firms in munificent environments that possess valuable technology resources will want to be acquired. For example, firms in such environments may not want to be acquired if they control or possess resources that are complementary to their technology resources and that collectively facilitate the exploitation of market opportunities. Such 'complete' resource profiles tend to be the exception rather than the rule in munificent environments where the dynamics of technological change are present. More commonly, a diversity of resource profiles will exist, with many smaller firms possessing technology resources but not the complementary resources needed to leverage them in the pursuit of market opportunities (King et al., 2003; Teece, 1986). Given the bilateral transference of resources between acquiring and target firms (Capron and Mitchell, 1998), technologically capable target firms operating in munificent environments will often want to be acquired in order to access complementary resources that facilitate

the exploitation of market opportunities (Graebner and Eisenhardt, 2004; Hill and Rotharmel, 2003).

Importantly, high munificence environments, relative to low munificence environments, may enable firms to realize greater returns from a given stock of technology resources. Firms in more munificent environments target a greater percentage of their resource base toward the pursuit of growth, enabling a more productive use of firm resources (Covin et al., 2000). R&D investment, for example, will more likely be targeted toward the exploitation of opportunity in emerging domains where rivalry is not harsh and product acceptance is more assured. High munificence, in effect, amplifies the rent-generating potential of firm technology resources. Under conditions of low munificence, by contrast, internal resources are regularly expended on purely defensive moves or in the competition for scarce external domain space (Sharfman and Dean, 1991). R&D expenditures in low munificence environments, as such, may not produce firm gains comparable to those achievable through the same level of investment in more munificent environments.

The preceding observations imply not only that munificence may invite R&D expenditures, but also that munificence moderates the value of a given stock of R&D resources. This is because R&D investments should be of greater value in industry environments where the returns to such investments are better assured. Positive returns to R&D investments are more likely assured in relatively munificent environments because such environments afford more and better opportunities for growth (Castrogiovanni, 1991). When R&D investments are made in the context of more attractive opportunity domains, the overall returns to those investments will be less speculative. In short, acquirers will more likely be accessing valuable technology resources through acquiring targets operating in environments where those resources constitute strategic assets (Amit and Schoemaker, 1993) of predictable value. Therefore, we hypothesize the following relationship:

Hypothesis 2: The relationship between the size of a firm's R&D stock and its acquisition likelihood is more positive among firms in high munificence environments than among firms in low munificence environments.

Environmental dynamism. Dynamism represents the level of environmental volatility or the unpredictability of change within an industry (Dess and Beard, 1984; Sharfman and Dean, 1991). Environmental change *per se* does not imply the presence of dynamism. Rather, dynamism is manifest when there is no readily discernable pattern to environmental change (Mintzberg, 1979). External events and trends, such as those related to competitor actions or market growth, may not be truly random – that is, perfectly uncertain – under conditions of dynamism. Still, uncertainty induced by volatility is a defining aspect of environmental dynamism (Bergh, 1998).

Hoskisson and Hitt (1990) have argued that environmental uncertainty can reduce acquisition activity by placing the value of new resource combinations in doubt. However, the contributions of sustained R&D investment to a firm's competitiveness may be particularly great in dynamic environments, and such competitiveness may amplify a firm's attractiveness as an acquisition target. R&D represents an investment in

knowledge-based resources, and such resources have been shown to have *greater* utility in dynamic versus stable environments (Miller and Shamsie, 1996). Moreover, R&D investment is a well-recognized path to innovation (e.g. Ahuja and Katila, 2001; Pakes, 1985), and may be considered a strategic imperative for firms facing dynamic environments (D'Aveni, 1994). Finally, through investments in R&D, firms build absorptive capacity (Cohen and Levinthal, 1989, 1990) that enables them to assimilate new technological knowledge quickly, even if their historic technology resources prove to be less than optimal in the evolving technological context. As such, R&D investments can enable firms to cope with the rapid pace of technological change (King et al., 2003).

In short, investments in R&D are likely to facilitate innovation and, thereby, enable firms to act in accordance with the demands of a dynamic environment. Consistent with the arguments offered in support of the role of munificence as a moderator of the relationship between a target firm's R&D stock and its acquisition likelihood, dynamism should operate in a similar moderating role. Specifically, as suggested above, the technology resources created through sustained investment in R&D constitute potential strategic assets in dynamic environments. The strategic asset value of technology resources in dynamic environments is based on their ability to enable the firms holding those resources to renew themselves or achieve competitive advantage through innovation. Innovativeness is particularly valuable in dynamic environments because such contexts require sporadic or even continuous adjustments to firms' competency profiles and/or product-market offerings (Rindova and Kotha, 2001) in order for competitiveness to be sustained. Firms that make such adjustments can circumvent the adverse effects of dynamism-induced strategic dissonance (Burgelman and Grove, 1996) and achieve favourable competitive positioning. It follows that firms operating in dynamic environments that have invested heavily in R&D may be particularly attractive acquisition targets. We offer the following hypothesis:

Hypothesis 3: The relationship between the size of a firm's R&D stock and its acquisition likelihood is more positive among firms in high dynamism environments than among firms in low dynamism environments.

Environmental complexity. Complexity is a function of the number, diversity, and distribution of external factors and parties with which a firm must interact (Dess and Beard, 1984). Complexity is reflected in such factors as the breadth and variety of a firm's geographic markets, customers, suppliers, and competitors. Complexity, also referred to as environmental heterogeneity, increases the information processing demands of firms operating in a given environment (Miller and Friesen, 1982, 1983). The aspect of complexity of particular concern in the current research is the industry's exhibition of what Grossack (1965) referred to as dynamic concentration, which is an indicator of changes in the level of monopoly power within an industry.

In general, monopoly power within an industry increases as industries consolidate, becoming more concentrated, and decreases as industries fragment, becoming less concentrated (Keats and Hitt, 1988). Fragmented industries are regarded as more complex than concentrated industries because in the former market power and associated resources are relatively widely and evenly distributed among numerous firms. Such

conditions create the potential for intense rivalry and the need for firms to monitor and potentially respond to a broad set of rivals that may be playing diverse, unclear, or irrational competitive games. By contrast, in more concentrated industries a smaller number of rivals serve as the focal point for the competitive action. These rivals will often play a coordinating role, imposing competitive discipline on the industry through the clarification of viable industry strategic recipes (Keats and Hitt, 1988; Spender, 1989).

Theory suggests that technologically capable firms operating in concentrated industries may be of particular interest to would-be acquirers (Chatterjee, 1990). The internal dynamics common to industry consolidation give rise to this expectation. In particular, as industries consolidate the number of potential targets decreases and the value of the remaining targets' resources increases (Barney, 1988). If firms in consolidating industries possess superior technology resources, those resources should increase in value as a function of their relative scarcity. Consistent with this point, Doukas and Switzer (1992) found that R&D expenditures in concentrated industries are significantly associated with superior stock returns. Additionally, early acquirers in consolidating industries often 'select' the best targets and leave later acquirers with a decreased and less desirable pool of targets from which to select (Anand and Singh, 1997; Carow et al., 2004). Thus, industry consolidation can create a 'numbers game' where attractive acquisition candidates become increasingly rare. If a firm, in relation to other firms in an industry, has superior technology resources it will more likely stand out as a potential acquisition target.

Additionally, the consolidation of an industry in which R&D-active firms operate may signal the coalescence of the industry around a dominant design or technological standard. Such an occurrence reflects industry technological progress, and such progress is likely to be led by firms with superior technology resources. As the pace setters of technological change, technologically superior firms, in general, will be the most attractive acquisition targets. The dynamics of industry consolidation may amplify the value of their technology resources to would-be acquirers, increasing the use of acquisitions in concentrated industries (Anand, 2004). As a result, superior technology resources enabled through R&D investment will most likely invite the attention of would-be acquirers when the direction of technological progress has been established and the dynamics of consolidation are present – conditions consistent with the exhibition of increasing monopoly power within an industry. Given that increasing monopoly power signifies a decreasing level of environmental complexity, the following relationship is hypothesized:

Hypothesis 4: The relationship between the size of a firm's R&D stock and its acquisition likelihood is more positive among firms in low complexity environments than among firms in high complexity environments.

METHODS

Sample

We test our hypotheses with data obtained from two databases. The needed data came from the *Securities Data Corporation (SDC)* database, and the *Standard and Poors COM-*

PUSTAT data tapes. The *SDC* database was used to identify firms that were acquired between 1 January 1990 and 31 December 2000. The resulting list of firms was then matched to *COMPUSTAT* to obtain the needed accounting data. From this population, we used three screening criteria to select the sample for testing the hypotheses.

First, since the research is intended to test whether the level of a firm's R&D investment impacts its acquisition likelihood, we only sampled firms that reported R&D expenditures in *COMPUSTAT*. Specifically, we limited our sample to firms that reported R&D within the five-year period prior to their acquisition. (Note: This excludes firms with missing values for R&D, but does include firms that report zero R&D.)

Second, the sample only includes firms that were identified by *COMPUSTAT* as operating primarily in industries represented by four-digit SIC codes. We excluded firms that were identified as operating primarily in industries represented by two- or three-digit SIC codes because such firms' industries represent broad categories that can mask the environmental effects we were trying to capture through our measures.

We performed a sensitivity analysis and discovered that our results were sensitive to the presence of outliers in the data. Specifically, our sensitivity analysis indicated that the results for Hypothesis 4 are sensitive to the presence of outliers. While our other results did not change, Hypothesis 4 was only statistically supported when the outliers were included in the analysis. As a result, we added a third screen that deleted firms from the final sample if their scores on any of the research variables differed from the sample means by more than five standard deviations. By eliminating outliers beyond five standard deviations, we were able to retain relevant observations (over 96 per cent of a sample from any distribution) and ensure that a few firms are not driving our results with extreme scores on the research variables. As our results are more significant before these outliers were deleted from our sample, their removal has a conservative impact on our overall findings.

A total of 1443 acquired firms met the selection criteria identified in the aforementioned screens. To form our final sample, we matched these firms with 1443 non-acquired firms, which were also screened for extreme outliers (greater than five standard deviations) on the research variables. Three matching criteria were employed. First, like the acquired firms, the non-acquired firms must have reported a separate R&D expenditure figure in the five-year period prior to the matched acquired firm's acquisition. Second, the acquired and non-acquired firms must have used the same fiscal year-end month to insure temporal correspondence between the accounting measures. Third, non-acquired firms were selected for the matching control sample if they were: (1) the *COMPUSTAT* database's closest size match to the acquired firms; and, following the precedent of Barber and Lyon (1996), (2) within 30 per cent of the size of the acquired firms with which they were paired for the year prior to the acquired firm's acquisition. We defined firm size in terms of market capitalization, which is consistent with existing research (e.g. Ravenscraft and Scherer, 1987). Moreover, the target firm's shareholders often view market capitalization as the necessary minimum price that must be obtained for the acquisition to be favourably evaluated. Because it would have controlled for the variation needed to test our environmental contingency hypotheses (Hypotheses 2–4), we did not match on industry.

Measures

Dependent variable. The dependent variable is the acquisition status of the firm. This measure is a dichotomous variable, with a value of 0 assigned to non-acquired firms and 1 to acquired firms.

Independent variable. The independent variable in our research is an industry-adjusted R&D stock measure (i.e. Σ (Firm R&D – Average Industry R&D)). Adjusting firm R&D investment by industry enabled us to control for possible differential returns to R&D across industries. A stock measure of R&D was employed because technology resources are generally built over time through sustained R&D investment, and the duration and magnitude of R&D investment affects the value of the technology resources a firm can build. The number of years over which one should examine investments in R&D in order to best capture their value is not clear from prior research. Pakes and Schankerman (1984) observed lags between R&D project inception and commercial application ranging from 1.2 to 2.5 years. However, Pakes and Griliches (1984) suggested that R&D's effects on patenting sometimes occur after lags of six years and higher. Taking a compromise between these extremes, we employed a five-year cumulative R&D stock measure. We also depreciated our measure of R&D stock by 15 per cent per year, following Griliches and Mairesse's (1984) argument that more recent investments in R&D tend to be more valuable.

Moderator variables. The moderator variables in our research are the three environmental dimensions of munificence, dynamism, and complexity. All data for computing the environmental variables were obtained from *COMPUSTAT*. These variables were assessed for each industry using its four-digit SIC code and operationalized using the procedure initially proposed by Keats and Hitt (1988) and subsequently adopted by others (e.g. Bergh and Lawless, 1998; Boyd, 1990, 1995; Dollinger and Golden, 1992). In brief, munificence was measured by averaging the regression coefficients of a given industry's net sales and operating income over a five-year period. Dynamism was measured by averaging the standard errors of the regression slopes for the two munificence regression equations. Significantly, although the munificence and dynamism scores were derived from the same data, there is no reason to question their independence. The relationship between munificence and dynamism, as operationalized here, is analogous to the relationship between a distribution's mean and standard deviation – that is, one does not predict the other.

Complexity was measured by regressing the terminal-year (i.e. year five) market shares of the firms in a given industry on these firms' initial-year (i.e. year one) market shares. This measure is, essentially, an index of a trend toward or away from large-firm market dominance within the industry. Under the original specification (Keats and Hitt, 1988), complexity is reverse-scored, so smaller numbers indicate more complex environments. To aid interpretation, we multiplied the computed measure by negative one, so that larger numbers indicate more complex environments.

Control variables. As mentioned above, the acquired firms were chosen if: (1) the acquisition took place between 1 January 1990 and 31 December 2000; (2) the firm reported

R&D in any year within the five-year period prior to its acquisition; and (3) the firm's primary industry was identified by *COMPUSTAT* with a four-digit SIC code. These firms were then matched with a sample of similar-sized, non-acquired firms that were paired with the acquired firms during the year prior to their acquisition. Thus, through the matching process, we controlled for the effect of year of acquisition and the effect of firm size. Because we could not identify a precise size match for all firms in the acquired sample when creating the non-acquired control sample (rather, the control firm must have been within 30 per cent of the paired acquired firm's market capitalization value), we also include the log of market capitalization as a control variable in our analysis.

In addition to the items accounted for in the matching process, we used a measure of firm financial performance as a control variable. A firm's financial performance may be systematically related to its R&D spending (e.g. DeCarolis and Deeds, 1999; Grabowski and Vernon, 1990) as well as to its likelihood of acquisition (e.g. Bruton et al., 1994; Vermeulen and Barkema, 2001). Additionally, would-be acquirers may evaluate the attractiveness of a target firm's resources, including its technological capabilities, in light of the firm's financial performance. As such, we controlled for the target firm's financial performance in the current research, using industry-adjusted return-on-assets (i.e. Firm ROA – Industry Average ROA) in the year prior to acquisition as our control measure.

Analysis

To test our hypotheses involving the likelihood of a binary outcome, we used hierarchical logistic regression for matched-case samples (Hosmer and Lemeshow, 2000). This form of regression analysis is commonly employed in acquisition research (e.g. Brush, 1996; Chatterjee et al., 2003; Vermeulen and Barkema, 2001). In our application, logistic regression computes coefficients using maximum likelihood calculations that are based on the log odds (logit) that a firm was acquired. Before calculating our two models, all predictor variables were standardized in order to facilitate interpretation of the results (Aiken and West, 1991). In the first model, acquisition likelihood was predicted using industry-adjusted ROA, the log of market capitalization, the firm's industry-adjusted R&D stock measure, and the three environmental measures. In the second model, we added interaction terms created by multiplying the R&D measure by the environmental measures (Sharma et al., 1981). Hypothesis 1 is supported if the coefficient for depreciated R&D stock is positive and significant in Model 1. Hypotheses 2, 3, and 4 are supported if the coefficients in Model 2 for the R&D \times munificence, R&D \times dynamism, and R&D \times complexity interaction terms are significantly positive, positive, and negative, respectively.

RESULTS

The means, standard deviations, and correlations for the research variables are shown in Table I for the combined sample (Panel A), the acquired firms (Panel B), and the non-acquired firms (Panel C). As can be seen, the acquired and non-acquired firms are, on average, of similar size and operate in environments that score similarly (again, on average) in terms of the three environmental measures. Relative to the non-acquired

Table I. Means, standard deviations, and correlations among study variables

<i>Variable</i>	<i>Mean</i>	<i>s.d.</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>
<i>Panel A: Combined sample</i>								
1. Acquisition status ^a	0.500	0.500						
2. R&D stock ^b	-55.045	233.902	0.03†					
3. Market capitalization ^c	4.662	1.663	0.00	0.18***				
4. Return on assets ^b	0.306	1.870	0.06***	0.01	0.02			
5. Munificence	1.150	0.145	0.01	0.04*	0.01	0.09***		
6. Dynamism	1.041	0.039	-0.04*	0.06†	-0.10***	-0.04*	0.06***	
7. Complexity	-0.867	0.372	0.04*	-0.01	0.02	-0.03	0.21***	0.09***
<i>Panel B: Acquired firms</i>								
1. Acquisition status ^a	1.000	0.000						
2. R&D stock ^b	-48.049	230.188						
3. Market capitalization ^c	4.664	1.664		0.19***				
4. Return on assets ^b	0.427	1.947		-0.01	0.01			
5. Munificence	1.151	0.147		0.06*	-0.00	0.09***		
6. Dynamism	1.039	0.0.7		0.08**	-0.09***	-0.05*	0.13***	
7. Complexity	-0.853	0.360		-0.01	-0.00	-0.04	0.21***	0.08***
<i>Panel C: Non-acquired firms</i>								
1. Acquisition status ^a	0.000	0.000						
2. R&D stock ^b	-62.041	237.432						
3. Market capitalization ^c	4.661	1.662		0.17***				
4. Return on assets ^b	0.184	1.783		0.03	0.04			
5. Munificence	1.149	0.142		0.02	0.01	0.08***		
6. Dynamism	1.042	0.042		0.06*	-0.12***	-0.02	-0.00	
7. Complexity	-0.881	0.382		-0.02	0.04	-0.02	0.22***	0.10***

Note: ^a 1 = acquired; 0 = not acquired; ^b industry-adjusted; ^c log; † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

firms, the acquired firms have, as expected, somewhat larger industry-adjusted ROA averages and less negative R&D stock averages. The fact that the R&D stock figures are negative for all panels is consistent with the finding that acquired firms (to which the non-acquired firms were size-matched) tend to be smaller than the average-size firms in their industries (Hitt et al., 2001; King et al., 2004), and smaller firms will generally have fewer financial resources to potentially invest in R&D. Notably, the correlations in all panels are well under the 0.80 threshold Gujarati (1995, p. 355) identified as suggestive of multicollinearity problems.

Table II shows the results of our logistic regression analysis. To aid interpretation, the exponent of the intercept's coefficient is the predicted odds of being acquired when other variables in the regression are at their means. An exponent value of 1.00 suggests there is no difference in the predicted odds of being acquired or not being acquired. Model 1 reveals that the direct effect of a firm's industry-adjusted, depreciated R&D stock is a modest predictor ($p < 0.10$) of the likelihood of acquisition, providing only marginal support for Hypothesis 1. (See the 'notes' for a discussion of the effect of firm patents on acquisition likelihood.) Our results indicate that a one standard deviation increase in R&D stock increases the predicted odds of being acquired by a multiplicative factor of 1.05.

The effects of ROA ($p < 0.001$), environmental dynamism ($p < 0.01$), and environmental complexity ($p < 0.01$) are also significant in Model 1. The positive coefficient for the control variable ROA is consistent with research, suggesting that acquirers generally target more profitable firms for acquisition (e.g. Mahoney and Pandian, 1992). The negative coefficient for environmental dynamism suggests that firms operating in less dynamic environments are more likely to be acquired, and the positive coefficient for environmental complexity suggests that firms operating in more complex (i.e. less concentrated) environments are more likely to be acquired. The lack of a direct effect for munificence in Model 1 supports the argument that the attractiveness of an industry suggests little, if anything, about the attractiveness as acquisition candidates of individual firms within those industries.

The result pertaining to complexity appears to conflict with Barney's (1988) and Chatterjee's (1990) suggestions that a firm's attractiveness as an acquisition target increases as the firm's industry consolidates. However, the apparent discrepancy between this study and prior research can be accounted for by considering the specific theoretical and empirical contexts in which these prior arguments were made. Barney's (1988) argument that industry concentration invites acquisition was offered under the assumption that the acquiring and target firms are strategically related, as defined by these firms having synergistic cash flows. Thus, Barney's suggestion that concentration increases acquisition likelihood is presented as a conditional effect, not a main effect like that revealed in Model 1. Likewise, Chatterjee's (1990) suggestion that industry concentration is positively associated with acquisition likelihood was not explored as a main effect, but as a comparison of the effects of an industry's concentration ratio on two industry entry modes (direct entry versus acquire) that both take entry as a given. By contrast, the current research does not explore the relative effects of an industry's concentration on acquisition versus direct entry events. Rather, the current research compares industry consolidation trends across firms that are acquired versus not acquired.

Notably, the current finding that acquisition likelihood is greater among firms whose industries are becoming less concentrated is consistent with Grossack's (1965) observation that decreases in the monopoly power of an industry, as would be characteristic of industries moving toward fragmentation (Porter, 1980), often occur when the smaller firms in an industry are experiencing the highest growth rates. Given that small firms with high growth rates are often targeted for acquisition (e.g. Granstrand and Sjolander, 1990; Williamson, 1975), industry dynamics that increase the proportions of such firms may spur overall industry acquisition rates.

Finally, the absence of a significant main effect for munificence indicates that acquirers are no more likely to target firms in more munificent than less munificent environments. This finding suggests that the value of operating in a munificent environment may not be embedded in that context *per se* but in the goodness of a firm's fit within that context. Thus, environmental munificence may only be relevant as a basis for evaluating the attractiveness of potential acquisition targets to the extent that those targets possess the resources needed to exploit opportunities inherent to their industries.

Model 2 indicates that a firm's environment moderates the relationship between R&D investments and the odds of being acquired. From the incremental chi-square test statistic of 8.59 ($p < 0.05$), we can safely reject the null hypothesis that no interaction effects exist.

Table II. Results of hierarchical logistic regression^a

<i>Variables</i>	<i>Model 1</i>		<i>Model 2</i>	
	<i>Logistic coefficient</i>	<i>Exponent of coefficient</i>	<i>Logistic coefficient</i>	<i>Exponent of coefficient</i>
Constant	−0.37***	0.69	−0.38***	0.68
Return on assets	0.09***	1.09	0.08***	1.08
Market capitalization	−0.02	0.98	−0.03	0.97
R&D stock	0.05†	1.05	0.10***	1.11
Munificence	−0.01	0.99	−0.02	0.98
Dynamism	−0.07**	0.93	−0.08***	0.92
Complexity	0.07**	1.07	0.08**	1.08
Munificence × R&D stock			0.10*	1.11
Dynamism × R&D stock			0.08*	1.08
Complexity × R&D stock			−0.01	0.99
χ^2	25.53***		34.12***	
$\Delta\chi^2$			8.59*	
−2 log likelihood	3975.31		3966.73	

Note: ^a n = 2886; † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.

The significant interaction effects indicate that the levels of munificence and dynamism moderate the effect of R&D investment on acquisition likelihood. Consistent with Hypothesis 2, R&D investments have a significantly ($p < 0.05$) more positive impact on the likelihood of acquisition under conditions of high environmental munificence. Consistent with Hypothesis 3, R&D investments have a significantly ($p < 0.05$) more positive impact on the likelihood of acquisition under conditions of high environmental dynamism. No support is found for Hypothesis 4 involving the proposed effect on acquisition likelihood of the interaction between R&D stock and environmental complexity.

To further interpret the interaction effects (see Jaccard, 2001), we consider how the effect of R&D stock on the predicted odds of being acquired changes given a one standard deviation increase in the environment scores. The exponent of the R&D × munificence coefficient equals 1.11, indicating that a one standard deviation increase in environmental munificence causes the impact of industry-adjusted R&D stock on the odds of being acquired to increase by a factor of 1.11. Likewise, a one standard deviation increase in dynamism increases the impact of R&D stock on the likelihood of acquisition by a factor of 1.08.

To illustrate these relationships, we follow Aiken and West (1991) and plot the effect of changes in R&D stock on the probability of being acquired: (1) at the mean level of the relevant environmental variable; (2) at one standard deviation above this mean level (represented by the ‘high’ line); and (3) at one standard deviation below this mean level (represented by the ‘low’ line). Figure 1 shows that an increase in the value of firm R&D stock increases the probability of being acquired in high munificence environments, while in low munificence environments increases in R&D stock have little impact on the probability of being acquired. In Figure 2 we can see that a similar relationship holds for

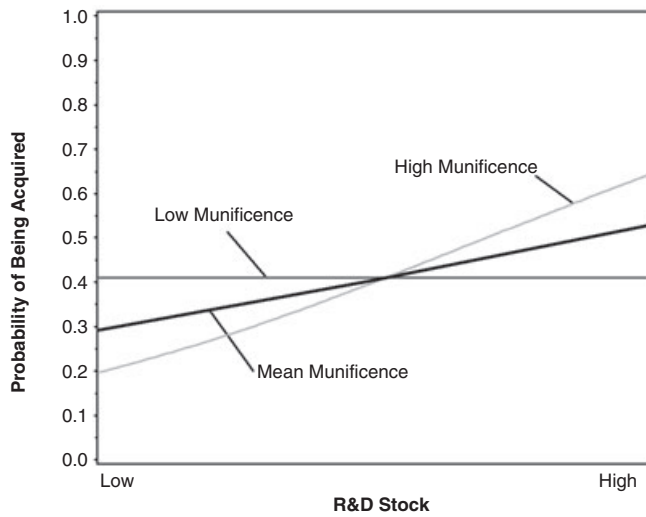


Figure 1. Plot of the probability of being acquired as a function of the interaction of firm R&D stock and environmental munificence

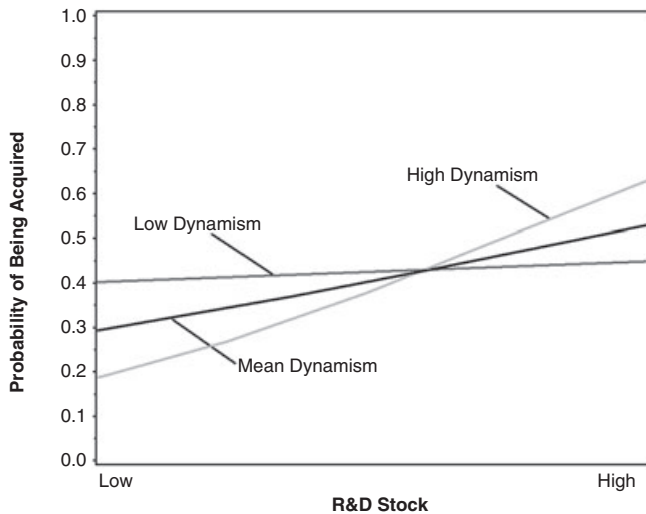


Figure 2. Plot of the probability of being acquired as a function of the interaction of firm R&D stock and environmental dynamism

the interaction effect of environmental dynamism and firm R&D stock on the probability of being acquired. Firms with the highest probabilities of being acquired have high R&D stock expenditures and also operate in very dynamic industries.

DISCUSSION AND CONCLUSION

The acquisition of target firms with technology resources is a logical response of acquiring firms to the innovation imperative imposed by the new competitive landscape (Bettis

and Hitt, 1995; Ranft and Lord, 2002). However, firms considering acquisitions cannot directly measure the technology resources of potential target firms. Rather, the existence of valuable technology resources must be inferred from observable information, such as target firms' investments in R&D.

The current research asked, 'Does R&D investment increase a firm's attractiveness as an acquisition target?'. Our results suggest that sustained investment in R&D alone is a modest predictor of acquisition likelihood. Firms that heavily invested in R&D were only slightly more likely to be acquired than firms with minimal investments in R&D. However, the power of R&D stock as a predictor of acquisition likelihood increased to statistically significant levels when conditions in the target firms' environments were considered. The identification of strong environmental moderating effects is consistent with Priem and Butler's (2001) argument that particular firm resources can be differentially valuable across environments. A primary implication of these moderating effects is that internal and external factors should be jointly considered as predictors of firm acquisition, and that neither firm resources (e.g. Barney, 1991) nor environmental constraints (e.g. Aldrich, 1979) necessarily have primacy in predicting a firm's acquisition likelihood. Additional implications for management theory and practice are discussed below.

Theoretical Implications

Our research has several theoretical implications. First, our findings support the expressed need to examine interacting variables in acquisition research (Hitt et al., 1998; King et al., 2004). Specifically, we find that multiple dimensions of a firm's environment moderate the relationship between a firm's R&D expenditures and its acquisition likelihood. Recognizing the interaction of firm resources and environmental attributes as predictors of firm acquisition could lead to new theory development. For example, it may be useful to conceive of R&D expenditures as helping firms to induce and adapt to environmental change. Firms that perform R&D above industry averages may develop and commercialize disruptive technologies that threaten other incumbent firms. Threatened incumbents, in turn, may target firms that performed relevant R&D in an attempt to shore up their technology resources and facilitate their adoption of disruptive technology. Alternatively, threatened incumbents may, on occasion, acquire targets that have developed disruptive technologies in an effort to keep those technologies from being commercialized. In short, observed patterns of industry and technological change might be appropriately modelled using more complex acquisition theories that incorporate interacting firm resource and environment predictors.

Second, acquiring firms appear to recognize either the *value creation potential* of R&D expenditures for the target firm or the *actual value created* when target firms invest in R&D. It is not clear from the study data whether the acquiring firms focused on their targets' R&D expenditures as a known input to technological resources or were simply focused on what those R&D expenditures helped to create for the target firms – that is, technological resource outputs, such as patents or new products. It is quite plausible that acquirers may not be able to directly examine technology resources as a basis for assessing the attractiveness of acquisition targets. However, they can look for evidence of

the presence of such resources using reported R&D spending. Importantly, this research suggests that even if acquirers do not attach value to a target firm's R&D expenditures *per se*, they do attach value to target firm attributes or outputs that are systematically associated with the presence of sustained R&D expenditures above industry averages. Efforts to explore the 'black box' of resource development, in general, and the development of technology resources, in particular, represent needed areas for theory building and empirical testing.

Third, consistent with Priem and Butler's (2001) comments on the resource-based view (RBV), the current findings suggest that the value of firm resources is exogenously determined. Priem and Butler (2001, p. 32) identify a need for empirical research supporting 'contingency theories of resource value'. Their concern is that 'the elemental strategy concept of value remains outside the RBV' (p. 36). The current finding that firm R&D stocks are more predictive of acquisition likelihood – an arguable indicator of resource value – in some environments than others supports Priem and Butler's (2001) contention that resources are exogenously valued and differentially valuable across environments. This finding also supports the aforementioned need to explore interactions in management research.

Finally, our results reveal that acquiring firms are likely to select profitable firms as acquisition targets. Thus, the current research is relevant to an ongoing debate in the literature. There are at least three possible relationships between target firm performance and acquisition likelihood, and each of these possibilities has its own body of supporting literature. Some research suggests that acquirers are attracted to profitable firms (e.g. Mahoney and Pandian, 1992). Other research suggests that acquirers are attracted to distressed firms believed to be under-performing (e.g. Bruton et al., 1994). There are also reasons to suspect that acquirers commonly evaluate target firms independent of their prior performance (e.g. Anand and Singh, 1997). We find that acquisition likelihood is related to target firm profitability, suggesting that acquiring firms may view target firm profitability as market validation of the value of the target's resources. Exploring the relationship between acquisition likelihood and firm profitability in contexts beyond those involving R&D resources represents a path to resolving divergent positions in extant management research.

Managerial Implications

Our research also offers implications for managers. Perhaps the acquisition of R&D intensive firms should play a more significant role in organizational strategies designed to enable firms to effectively respond to technological change. The acquisition of another firm's technology resources may substitute or, perhaps, complement a firm's own R&D investments. R&D can help firms induce and adapt to technological change, and the external sourcing of technology resources that flow from R&D investments can be a rational choice for managers whose firms operate in technologically dynamic and malleable environments. Although not directly implied by current findings, the external sourcing of technological capabilities may be particularly advisable under conditions of disruptive technological change (Bower and Christensen, 1995). Assuming that firms

can obtain needed technology resources through acquisition, real options theory (e.g. McGrath, 1999) would suggest it is rational to cede risky market experiments to others as a means of coping with uncertainty.

Second, it may be useful for the managers of would-be acquirers to examine target firms' relative R&D expenditures as a possible acquisition-screening criterion. It would be unwarranted to suggest that potential acquisition targets with no or low R&D investments will necessarily be unattractive targets. Nonetheless, this study's findings suggest that targets are generally creating something of value through their investments in R&D. By treating a target firm's R&D expenditures as a possible objective indicator of deeper capabilities, acquiring firms may be able to identify potentially attractive acquisition targets more quickly and efficiently. This is a significant consideration because knowledge-based resources like technology can be difficult to objectively identify (Zahra and George, 2002), so factors that suggest their presence, like R&D expenditures, may serve as useful criteria for acquisition decision purposes.

Third, the observed interaction effects of R&D and environment on acquisition likelihood suggest that managers value resources in consideration of the environments where those resources are deployed. Acquiring firms' interests may be well served if their managers consciously consider why and how a target firm's environmental contexts have relevance to their valuations of target firm resources. Theory concerning this issue was developed as the basis for the current research. However, managers will have their own (and quite possibly different) theories of why a target firm's environment, and not just the targets' resources, matter. An explicit and accurate articulation of an acquired firm's industry's logic (Spender, 1989) should facilitate the acquirer's successful integration of the target and ability to appropriate rents with the target firm's resources.

Finally, as stewards of shareholders, managers should be interested in how this research relates to investors. Shareholders of target firms typically realize stock premiums during acquisitions. Research indicates that such premiums are commonly over 40 per cent of the target firm's per share value (Jensen, 1993). Investors are, therefore, often interested in acquiring shares of firms that are probable acquisition targets. Firms that invest in R&D above industry averages qualify as acquisition candidates, particularly if they operate in environments characterized by high munificence and dynamism. As such, investors may want to consider using screening criteria that enable the identification of R&D-intensive firms operating in munificent or dynamic industries. Moreover, recent evidence indicates that leading technology firms are increasing R&D expenditures as a means of staying ahead of the competition in terms of innovation, and that heavy R&D spending positively contributes to a firm's growth prospects (Pringle, 2004). These results suggest that higher R&D expenditures may lead to better investor performance even if a firm is not acquired.

Limitations and Opportunities for Future Research

The preceding implications should be viewed in light of several important considerations and research limitations. First, for data availability reasons, the study was limited to publicly owned firms. The extent to which the results are generalizable to private firms is open to question. Perhaps the current effects would be less strong or not found among

private firms because their R&D funding is not a matter of public record. When resource allocations are not readily visible to firm outsiders, they potentially lose their symbolic value.

Second, while it may be reasonable to conclude from the current research that R&D expenditures are systematically related to a target firm's acquisition likelihood, particularly under conditions of high environmental munificence and dynamism, the precise link between R&D and acquisition remains something of a mystery. The current theory proposed that cumulative R&D expenditures create technology resources that have value to many would-be acquirers. However, the possibility cannot be ruled out that R&D expenditures result *from* or *in* some other factor that has attractiveness to a target firm's potential acquirers. This possibility does not diminish the significance of the current findings, but it does suggest that the linkage between a firm's R&D investment and its probability of being acquired could have alternative explanations.

Third, the results of the current study are probably more applicable to R&D investments involving applied rather than basic research. Relative to basic research, applied research tends to create more immediate, usable knowledge, which would be particularly valued by firms hoping to augment their technology resources. Additionally, the average size of the acquired firms is more characteristic of organizations engaged in applied research. Basic research, by contrast, tends to be the province of larger firms, universities, and government organizations.

In closing, resource-based theory has clarified the importance of having superior resources and capabilities to the achievement of competitive advantage (Barney, 1991). Superior technology resources are desirable in many industries, and managers regard financial investments in R&D as a principal means for developing such resources (Granstrand and Sjolander, 1990). A recognized alternative to the internal development of technology resources is the acquisition of technologically capable firms (Peteraf and Bergen, 2003). Still, the creation of strong technology resources, through either internal development or acquisition, remains challenging. This challenge is partially a reflection of the fact that a firm's overall technology resource profile has many potential 'input' variables, and R&D investment is only one of these variables. Therefore, future research might productively focus on better modelling how R&D investments operate in conjunction with other technology-related and non-technology related resources to create valuable technological capabilities. Future research might also explore how less visible or intangible inputs to technology resources – like tacit technological knowledge – affect a firm's likelihood of being acquired. Finally, researchers are encouraged to further investigate the means used by acquiring firms to successfully integrate the technology resources of target firms into the combined firms' operations.

NOTES

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Patents: In supplementary analysis, we examined whether the number of patents a firm holds affects its likelihood of being acquired. A significant main effect was found ($p < 0.01$), with number of patents having a positive impact on acquisition likelihood. We found no significant moderating effects of the environmental

variables on the patents-acquisition likelihood relationship. However, only a small number of the acquired firms in our sample ($n = 160$), and even fewer of the matched control firms ($n = 119$), produced any patents in the five years prior to acquisition. As such, we chose to not include patents as a second technology-related predictor variable (i.e. along with R&D expenditures) in our research.

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