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A Managerial Perspective on Risk and Return for Corporate Innovation Projects

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Virtually all companies today pursue innovation in order to remain competitive. The question facing corporate decision makers is not whether to innovate, but rather which projects to pursue. Conventional wisdom suggests high-risk projects provide the highest returns. We explore this notion with attention to the patent output from a cross-sectional sample of U.S. corporate innovation projects. Project risk is assessed upon project proposal using a managerial perspective. The manager viewpoint is an important one since managers are distinct in their approach to assessing risk, as we expound, and are often the initial filtering point for project proposals. Patent counts are measured 3 to 5 years later as an indicator of project returns. We find that a "swing-for-the-fences" strategy is effective, but not the sole best path to patent output. Findings inform research on managerial risk construal and provide a fundamental basis for evaluation of potential innovation projects. *Organization Management Journal*, 12: 200–207, 2015. doi: 10.1080/15416518.2015.1081553

Keywords corporate innovation; managerial decision making; patent output; risk and return

Investment in research and development within the United States has grown at a staggering and largely uninterrupted pace since 1953 (National Science Foundation National Center for Science and Engineering Statistics, 2012). This growth is largely attributable to the business sector, as virtually all companies today pursue innovation in order to remain competitive. At the same time, the days of initiating corporate research and development based on mere intellectual curiosity are long gone. Even Google has whittled away at its "20-percent-time" program that encouraged employee experimentation on projects of their own choosing. Return on investment is instead of utmost concern. Sophisticated portfolio approaches and analyses of strategic fit abound as industry and academia continuously explore ways to enhance investment decision making in this area. Yet the basic relation between singular project risk and return remains a fundamental and, we contend, underappreciated consideration.

Conventional wisdom suggests high-risk projects provide the greatest return. For instance, Rich Barton, the co-founder of Zillow and Expedia, gave the following advice in addressing technology developers:

> Look, you have an at bat, and it takes just as much energy to swing for the fences as it does to bunt. OK. So, why bunt? Why bunt? Why not swing for the fences? I would argue that it is just as likely that you will succeed if you swing for the fences as if you bunt, and the outcome will be much more magical. And, I have to say, being a part of something that you are swinging for the fences and you are trying to change the world, is an excitement that you just don't get from bunting. (Cook, 2011)

To abide by this strategy, companies and their managers, along with outside investors and government funding programs, would favor high-risk projects with potential for high returns when choosing among ways to support corporate innovation (Rothaermel, 2008, p. 220). We empirically explore the practical usefulness of this tenet in the pages that follow by modeling a "managerial" perspective of initial project risk as a predictor of subsequent patent output. We contend that the manager's view of project risk is a particularly important one since they are often the filtering point for employee proposals and the gateway for which ideas are considered at the organization's executive level (Reitzig, 2011). For instance, a cross-sector survey of large companies throughout the United States, United Kingdom, and France indicates that 87% of these firms use managers to facilitate corporate innovation (Koetzier & Alon, 2013). Further, patent count is considered a pertinent measure of project returns since it is recognized as an important innovation outcome and an indicator of corporate knowledge creation, invention, and firm innovativeness (Bertoni & Tykvovà, 2015; Wadhwa & Kotha, 2006; Wanga & Hagedoorn, 2014).

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In short, this study employs a cross-sectional sample of corporate innovation projects to examine a managerial and project-specific perspective on risk and return. Findings contribute to an understanding of the concepts of risk in managerial decision making, a perspective of analysis that researchers have argued is important but lacking in much of the organizational research on risk and return (Nickel & Rodriguez, 2002; Ruefli, Collins, & LaCugna, 1999). From a practical perspective, our guiding question in this investigation reduces Cook's baseball analogy to a fundamental empirical question: What is most predictive of scoring hits (i.e., producing patents) when it comes to choosing innovation projects—a low-probability swing-for-the-fences approach or a high-probability bunt approach? As such, findings will inform managerial decision making and contribute to an evidence-based management approach to corporate knowledge creation.

DEFINING THE MANAGERIAL RISK PERSPECTIVE

Existing research sheds light on antecedents of patent output at the firm, industry, and country level (e.g., Ahuja & Katila, 2001; Hall & Ziedonis, 2001; Somaya, Williamson, & Zhang, 2007), but such findings do not speak directly to the project level of analysis where day-to-day managerial decision making takes place. Yet this is often where the fate of potential corporate innovation projects are determined, one project at a time as ideas and proposals vie for management support (Reitzig, 2011). Evaluation of project risk is at the crux of managerial assessment during this stage.

At the firm level of analysis and beyond, risk has been interpreted as variance in returns within most management literatures. However, construing risk as variance does not capture the concepts of risk employed by managers who must assess and oversee the risks of their decisions (Ruefli et al., 1999). This is because a variance measure of risk does not involve any specific event that invokes decision making (see Nickel & Rodriguez, 2002). Variance in returns is assessed based on the aggregation of investment performance, well after decisions are made. We are instead concerned here with the assessment of project risk prior to project commencement, subsequently matched to performance assessed at a future point in the project process.

March and Shapira (1987) reported the tendency of managers to look at the volume of risk rather than variation of performance. In operationalization of the managerial risk perspective, MacCrimmon and Wehrung deconstructed the definition of risk to the magnitude of the payoff at stake and the chance of the outcome occurring. These two dimensions of risk are evident in the way innovation is often labeled in dichotomous terms associated with high and low risk. For instance, the basic baseball terminology used by Cook to describe innovation—swing for the fences or bunt—clearly encompasses the concepts of payoff magnitude and probability of success. See Table 1 for other common labels associated with innovation that also inherently use the managerial definition of risk. In assessing these two risk characteristics within the present study, magnitude of the payoff at stake is represented by projected future earnings of proposed innovation projects, 10 years forward, and probability refers to the perceived likelihood of project success.

OPPOSING VIEWS ON THE RISK–RETURN RELATIONSHIP

Previous studies focusing on financial returns have yielded two conflicting views regarding how risk may influence returns (Miller & Bromiley, 1990). We first summarize these two views and then discuss how they might inform predictions for the context under study—a managerial perspective of risk in relation to patent output for innovation projects. The first broad view stems from the economic literature and suggests a positive relationship between risk and return (Fisher & Hall, 1969). Under this

TABLE 1
Managerial definition of risk inherent in innovation labels

Two dimensions of risk inherent in innovation labels: payoff magnitude and probability of success	
High magnitude, low probability	**Low magnitude, high probability**
Swinging for the fences	Bunting
Major breakthroughs	Gradual improvement
Disruptive innovations	Sustaining innovations
Exploration	Exploitation
Revolutionary	Evolutionary
Creativity	Practicality
Novelty	Familiarity
Radical change	Incremental change
Blue sky thinking	Grounded thinking
Basic research	Applied research
Innovative	Adaptive

view, high-risk projects are assumed to provide more returns because most organizations are risk averse and as such would not take a high-risk decision unless the expected reward can compensate the risk (Singh, 1986). Capital budgeting theory also requires that there should be risk-induced discounts for the future value of project returns. A high-risk project must provide higher future net cash flows to have the same net present value as a low-risk project (Bromiley, 1991).

Contradicting this broad view are Bowman's (1980) empirical findings of a negative relationship between risk and return using accounting data. Miller and Bromiley (1990) also found that there is a negative association between income stream risk and return. The explanations for these and similar findings are mainly drawn from the causal perspective that low-performance companies take more risk. However, the negative risk–return relationship has also been explained from the causal direction of risk preceding performance. The good management theory (Bowman, 1980) argues that managerial intervention to reduce risk is associated with lower cost and better performance (Andersen, Denrell, & Bettis, 2007). For example, having good management associated with acquisition and merger activities led to lack of surprise (risk) and increased profit (Bowman, 1980). In sum, extant literature presents conflicting accounts of risk's influence on financial performance as either positive or negative.

We conjecture that the risk–return findings and theory that pertain to financial returns translate in a less unitary way to predict patent output, in a way that distinctly recognizes both the probability and magnitude characteristics of project risk. The theory that good management can simultaneously reduce risk and increase returns and the fundamental notion that greater risk is undertaken only for higher returns both implicitly link returns to occurring within the divergence between probability of success and the financial amount at stake. This is where the potential for interfirm-performance differences and competitive advantage resides since it allows firms to differ in their strategic decisions regarding which probability and corresponding financial stake to pursue, and to exploit their competencies for influencing these components of risk (Rothaermel, 2008).

By extension, a lack of divergence between probability of success and financial amount at stake, on the other hand, is a constraint to interfirm-performance differences and potential competitive advantage. This reasoning is best understood when probability of success and financial amount at stake are both low. The combination of risk factors provides little opportunity for performance advantage for any firm, and thus, in terms of the present study context, little incentive to pursue patents with projects that fall within this domain. A similar neutralizing effect on interfirm performance can be envisioned when probability of success and amount at financial stake are both high. This combination of risk factors provides a clear performance choice for all firms, and thus a competitive advantage for none. Likewise, innovation outcomes from projects that fall within this domain arguably face a greater threat of imitation from competitors. A more efficient way than patents for firms to maximize the financial value of innovation outcomes in this context is to practice secrecy of inventions in order to gain market lead time, and avoid seeking patents altogether or at least defer patents until the commercialization stage (HanGyeol, Yanghon, Dongphil, & Chungwon, 2015; Laursen & Salter, 2005).

In order to empirically consider this interactive perspective of the two risk characteristics in predicting patent output, we propose a guiding set of hypotheses.

Hypothesis 1a (b): There will be an interactive association between an innovation project's risk characteristics and its subsequent patent output such that patent quantity will be greater for projects high (low) in probability and low (high) in magnitude relative to projects that are consistently high or low on both risk dimensions.

METHODS

Sample

Our study employs a wide cross-sectional sample of U.S. corporate innovation projects derived from proprietary information held by the National Institute of Standards and Technology Technology Innovation Program (NIST-TIP). NIST is a nonregulatory federal agency and its program's mission was to help for-profit organizations in their pursuit of development and commercialization of innovations, thereby potentially providing broad-based benefits for the national economy. Data were collected for 183 innovation projects that received a portion of seed funding from the Technology Innovation Program (TIP) from 2005 to 2007.

Under the terms and conditions of this agency's funding awards, decision makers from the firms proposing each project were required to respond to multiple surveys. We use data from two surveys: the Baseline Report that participants completed upon the initial project proposal, and the Closeout Report that was completed 3 to 5 years later. The timing of the two surveys is an important aspect of the study. The Baseline Report provided an assessment of project risk before project commencement, in keeping with the conceptualization of managerial risk in decision making as expounded herein. The Closeout Report provided a measure of patent output subsequent that of project risk assessment.

Measures

Managerial Risk

Following our managerial definition of risk, we measured project risk based on the firm's perceived probability of project success and projected project revenue 10 years forward (labeled potential "magnitude" of project payoff). Both items are from the company decision maker's perspective at the Baseline point of survey. Consistent with our conceptualization and hypotheses, we focus on the interactive relation between these two dimensions of risk rather than the main effect of either individual dimension. Therefore, the managerial risk scale is not interpretable in linear terms. Instead, our conceptual development points to the intersections of low probability/high magnitude and high probability/low magnitude to predict higher patent output for innovation projects within these areas of the risk quadrant.

Project Performance (Patents)

Patent output is measured by the number of patents reported at the Closeout period. This measure of performance is distinct from a financial measure of project performance (e.g., product revenue) in that it generally occurs within a shorter time frame, and is less influenced by an organization's preexisting market dominance and environmental conditions (Pisano, 2010). It is also notable that the measure is based on the Closeout survey, representing a 3- to 5-year time lag between the independent variable and dependent variable. While there is potential for patents to continue to unfold beyond the Closeout period, we suggest this 3- to 5-year window of time provides a reasonable reflection of project innovation since, as noted earlier, patents generally occur within a shorter time frame than financial returns. Finally, it should also be noted that the funding program held neither explicit nor implicit incentives for patent output since funding was fully committed prior to patent output and participants were permitted only one round of seed funding.

Control Variables

Finally, we included control variables to rule out alternative explanations for the focal risk–return relationship. To control for firms' performance before they apply for project seed funding, we included return on assets (ROA) 1 year prior to the application. Industry effects were controlled by dummy variables. We considered five industry categories: electronics, manufacturing, biotechnology, materials/chemicals, and information technology. To address the liability of company newness (Freeman & Hannan, 1983), we control for whether a firm considers itself a young, startup firm or not. We also control for research and development (R&D) intensity (R&D expense divided by revenue) and firm size (number of employees) because different technological and human resources may influence a firm's performance. Given that status as a publicly listed company requires fairly successful operations and certification of finances by the U.S. Securities and Exchange Commission, we control for whether a firm is publicly or privately held. In order to take into account the potential lessening of risk burden through the sharing of innovation project risk with other firm partners, we control for whether the innovation project is a joint venture. Lastly, we control for whether there was any significant company change during the innovation project funding period, defined as a change in company top management team, strategic direction, or ownership, or a company restructuring, merger/acquisition, financial difficulty/downsizing, or any other significant events.

Analytic Strategy

Our dependent variable is a count measure. Because our dependent variable is a nonnegative integer with limited range, we cannot use simple ordinary least squares (OLS). The assumption of homoscedasticity and normally distributed errors does not hold for our model. We therefore use a negative binomial model. While Poisson models are also possible, we use the negative binomial model because it does not assume mean–variance equality.

RESULTS

Means, standard deviations, and correlation coefficients are reported in Table 2. The descriptive statistics showed that there is no systematic bias in the direction or magnitude of the variables. To test for the presence of multicollinearity, we examined the variance inflation factors (VIFs) and none of them are more than 10, which is the commonly accepted threshold (Neter, Wasserman, & Kutner, 1985). We therefore retain all variables.

Table 3 summarizes the results of the negative binomial model analysis. Model 1 introduces the control variables and model 2 tests the relationship between risk and project performance. Overall, the models are robust. The log-likelihood of the fitted model shows that all predictors included show clear difference from the nested model. In particular, the likelihood-ratio test of alpha shows that the dispersion of parameter alpha is 183.58 with an associated p value of .001. The large test statistic suggests that our dependent variable of patents is overdispersed and is not sufficiently described by the simple Poisson distribution. We also additionally ran a Poisson regression and found that the results are substantively the same.

We had speculated there would be an interactive association between an innovation project's risk characteristics and its subsequent patent output such that patent count would be greater for projects high (low) in probability and low (high) in magnitude relative to projects that are consistently high or low on each risk dimension. We found the coefficient for the interaction of the two risk characteristics of interest to be negative and significant ($\beta = -.003$; $p < .05$), a first step in confirming our proposed relationships.

To evaluate the direction of the relationship and better understand the complex nature of disaggregated dimensions of risk, we graphed a three-dimensional perspective of the interaction (see Figure 1). Figure 1 Our results are consistent with the posited relationships, indicating that the highest patent output is associated with innovation projects at the intersections of low probability/high magnitude and high probability/low magnitude within the risk quadrant. Consistent with our earlier conceptual reasoning, it seems a low/high and high/low divergence between probability of success and projected magnitude of financial returns allows firms to exploit their competencies in strategic pursuit of patent output, whereas a lack of divergence between probability of success and projected magnitude of financial returns constrains these strategic benefits.

TABLE 2
Descriptive statistics and correlations

Variable		Mean	*SD*	1	2	3	4	5	6	7	8	9
1.	Performance	1.77	5.03									
2.	Probability	63.25	23.75	−.08								
3.	Magnitude	2.33	11.57	.12	−.05							
4.	Return of asset	−2.25	42.72	.01	−.09	.01						
5.	R&D intensity	1.19	2.32	.00	.02	.17*	−.01					
6.	Firm size (logarithm)	3.74	2.37	.16*	−.04	.27*	.07	−.20*				
7.	Public company	.01	.11	.02	−.12	−.05	.01	−.12	.68*			
8.	Significant changes	.74	.44	.10	−.11	.05	−.03	−.01	.09	.16*		
9.	Joint venture	.25	.44	..09	.09	−.48*	.02	−.28*	.48*	.21*	−.13	
10.	Startup	.50	.50	−.08	.07	−.07	−.04	.28*	−.52*	−..36*	.07	−.52*

Note. $N = 183$. $^{*}p < .05$. Industry dummies omitted. Performance = patent quantity; magnitude = projected project revenue 10 years forward, reported in millions. Dummy coding: public company 0 = no, 1 = yes; significant changes 0 = yes, 1 = no; joint venture 0 = no, 1 = yes; startup 0 = no, 1 = yes.

TABLE 3
Results of negative binomial model

Variables	Model 1	Model 2
Return on asset	0.001 (0.009)	0.001 (0.008)
R&D intensity	0.107 (0.111)	0.137 (0.120)
Firm size	0.325 (0.109)**	.0.303 (0.107)**
Public company	−18.42 (2187.2)	−17.73 (1986.1)
Significant changes	−0.490 (0.457)	−0.451 (0.455)
Joint venture	0.603 (0.558)	0.577 (0.537)
Startup	0.624 (0.492)	0.669 (0.479)
Industry M	0.777 (0.700)	0.474 (0.700)
Industry I	−0.286 (0.582)	−0.329 (0.574)
Industry A	−0.546 (0.725)	−0.831 (0.725)
Industry E	−0.078 (0.577)	−0.255 (0.574)
Probability	−0.009 (0.008)	−0.002 (0.008)
Magnitude	−0.015 (0.341)	0.001 (0.331)
Risk		−0.003 (0.669)*
Alpha	2.244***	0.724***
Log-likelihood	−161.35575	−159.24529
Wald	24.31*	28.05*
Pseudo R^2	0.0701	0.0822

Note. Unstandardized coefficients reported. Standard errors are in parentheses. ***$p < .001$, **$p < .01$, *$p < .05$. Industry dummies: M = manufacturing, I = information technology, A = materials/chemicals, E = electronics, B = biotechnology (reference category).

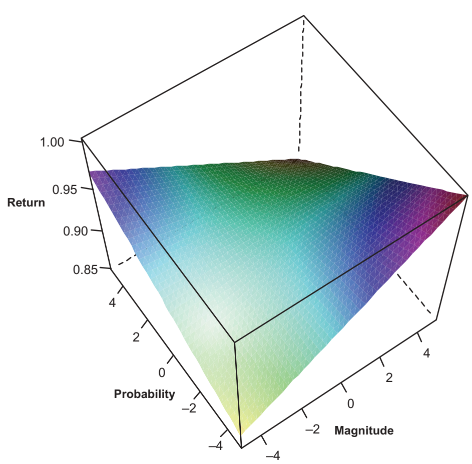

FIG. 1. Patent returns in relation to risk magnitude and probability.

DISCUSSION AND IMPLICATIONS

Risk is an essential element of strategic management practice and research. However, much of this research—particularly in the area of corporate innovation and patent output—has relied on measures borrowed from other disciplines. Strategy scholars have argued that our continued reliance on adopted measures is a key factor in delaying the pragmatic maturation of strategy research (see Bettis, 1991; Daft & Buenger, 1990; Ruefli et al., 1999). It has been strongly suggested that "strategy researchers now confront a fundamental methodological change rooted in this early borrowing of methods" (Ruefli et al., 1999: 167). Accordingly, we applied a measure of risk derived from a managerial perspective—a two-dimensional measure of risk that encompasses both probability and potential magnitude of project success. We emphasize this as an informative approach for analysis at the project level, as compared to the typical measure of risk as variance that is applied at the firm level and beyond. Using this measure, innovation projects were analyzed based on their initial risk ratings and subsequent patent output.

Our empirical results demonstrated a significant interactive relationship between the risk characteristics of probability of success and magnitude of potential payout, as perceived at project start, in predicting patent output upon project completion 3 to 5 years later. As Figure 1 shows, patent output was highest for projects in which high probability was combined with the potential for a low-magnitude payout and when low probability was combined with the potential for a high-magnitude payout. Thus, it would seem that a swing-for-the-fences approach is indeed one way to succeed in knowledge creation, but not the sole best way.

In keeping with the opening baseball analogy, a more nuanced comparison between baseball and R&D risk is fitting (Hamel & Prahalad, 1994). A player can contribute to his team with either a big hit (e.g., home-run) or small but safe hits (e.g., bunts). Hamel and Prahalad conjectured that successful hits tend to come from someone who specializes in one or the other. In innovation terms, there are firms that pursue a breakthrough innovation that can change the landscape of current competitive dynamics. On the other hand, there are firms that make safe bets with an increased probability of success but small impact. Our findings support the efficacy of both strategies for quantity of patent output in relation to innovation projects.

Of equal interest are the project risk characteristics that resulted in lower patent output. Projects that are comparably low or high in both probability of success and magnitude of projected financial return had a relatively lower quantity of patent output than the projects already described. We reason that a lack of divergence between probability and magnitude of payout constrains the potential to gain competitive advantage through pursuit of patents. Conceptually, projects with a low probability and low magnitude of payout offer little incentive to pursue patents. Projects with a high probability and high magnitude of payout hold obvious potential for attractive financial returns, yet it is for this very reason that innovation outcomes from projects within this domain may face a greater threat of imitation from competitors. Disclosure of inventions through patents may exacerbate the threat of imitation. Therefore, strategic management of innovation outcomes in this context would call for keeping inventions secret as long as possible in order to gain market lead time (HanGyeol et al., 2015; Laursen & Salter, 2005). Our findings are consistent with this notion of manager or firm behavior, and would suggest projects with these risk characteristics are poor choices for government funding programs aimed at generating external knowledge spillover.

The preceding point, that firms may choose secrecy over patents as a way to maximize the financial return of innovation outcomes, highlights that our outcome measure, patent count, is only one outcome of interest when examining innovation projects. Patent count captures the quantity of patent output and has been used to represent invention and innovation across a variety of studies (e.g., Acs, Anselin, & Varga, 2002; Bertoni & Tykvová, 2015; Wadhwa & Kotha, 2006). However, it does not speak to the quality of patent output. In baseball terminology, we have simply captured the number of hits, not the value of each hit. However, our risk dimensions, probability and magnitude of payout, do indicate which projects have the characteristics of a home run (low probability, high magnitude potential) or bunt (high probability, low magnitude potential) at project commencement. Intuitively, it seems that these initial project characteristics should also influence the quality of patent output. Future research can extend the predictive value of the present framework by empirically examining this intuition, that is, by considering whether the managerial perspective on project risk also predicts actual patent quality (e.g., citation rates) in addition to patent quantity.

Although this study has many advantages, its limitations must also be noted. First, though the sample represented a wide cross section of industries and project type, we cannot necessarily generalize our findings to all corporate innovation contexts. Second, as discussed more fully in the preceding, due to the confidentiality of our sample and the longer realization period for quality-related returns, we were not able to consider patent quality as a potential additional outcome of interest. Thus, our results speak only to patent quantity. Third, our measure of project risk could be subject to respondent bias toward exaggeration of risk, though systematic exaggeration of risk across the projects would not unduly influence findings for interaction effects on relative outcomes, as investigated herein, as opposed to main effects and absolute relationships. Notwithstanding these points, we believe that the richness of the data in managerial insight, ex ante risk assessment, and situation-specific results contributes much value.

In sum, using a unique data set, we were able to directly assess risk perceptions for innovation projects at the project proposal stage and relate them to subsequent performance in the important area of project patent output. The study's focal risk characteristics represent a managerial and project-specific perspective on innovation risk, as opposed to the accounting and finance measure typically applied by researchers and analysts, in which risk is expressed as the variance of some broad measure of financial returns. This managerial risk perspective reflects how project risk is assessed in day-to-day practice when choosing to support certain innovation projects over others. As such, the findings more closely inform actual decision making and contribute to an evidence-based management approach to strategic filtering of research and development projects.

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