August 2013

# A Review and Analysis of the Effects of Financial Slack on Firm Innovation

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# A REVIEW AND ANALYSIS OF THE EFFECTS OF FINANCIAL SLACK ON FIRM INNOVATION

by

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A Dissertation Submitted in

Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

in Management Science

at

The University of Wisconsin–Milwaukee

August 2013

ABSTRACT
A REVIEW AND ANALYSIS OF THE EFFECTS OF FINANCIAL SLACK ON FIRM INNOVATION

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The University of Wisconsin–Milwaukee, 2013
Under the Supervision of Professor Edward Levitas

I analyze the effect of financial slack on firm innovation by reviewing prior research and conducting an empirical analysis. The goal of this paper is to describe, refine and expand research on the relationship between financial slack and innovation. I describe how past scholars' conceptualizations and operationalizations of financial slack vary across studies and are often inconsistent with theoretical definitions suggesting that financial slack is a resource that exists *in excess* of some foreseeable need. My theoretical analysis suggests that one solution to this problem may be to operationalize financial slack as a proportion of total R&D spending (what I refer to as the financial slack-R&D ratio). Research suggests that innovation outcomes may be more strongly affected by the ratio of financial slack relative to total R&D spending than by financial slack measured independent of R&D spending. However, few, if any scholars have operationalized financial slack as a proportion of total R&D spending. I assess the moderating role of project and department level variables that are easily observable (readily accessible to firm managers), universal (found across firms and across industries) and for which the management literature provides conflicting support regarding their likely influence on the financial slack-innovation relationship. Specifically, I explore the influence of portfolio

effects (the number and diversity of R&D projects) and maturity effects (nearness to completion) on the amount of financial slack-R&D ratio needed to optimize innovation outcomes. I test my hypotheses using data from a sample of U.S.-based biotechnology firms attempting to develop new pharmaceutical drugs.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

# ACKNOWLEDGEMENTS

I am grateful for the many insightful contributions of Dr. Edward Levitas, my dissertation committee chair. I also acknowledge the contributions of four other committee members who also provided useful feedback; Dr. Sali Li, Dr. Sarah Freeman, Dr. Jude Rathburn and Dr. Satish Nambisan.

# CHAPTER 1: INTRODUCTION

Over recent years, much scholarly attention has focused on the relationship between financial slack (defined here as cash possessed by the firm that is not committed to a specific foreseeable expense) and firm innovation (*e.g.,* Greve, 2003; Hall, 2002; Mishina *et al.,* 2004; Nohria & Gulati, 1996; Thompson, 1967; Vicente-Lorente, 2001; Voss *et al.,* 2008). This is because the degree to which firms are able to achieve high performance is strongly linked to both the successful management of innovation (O'Brien, 2003) and the successful management of financial slack (Chakravarthy, 1986). Moreover, financial slack and innovation are thought to have a strong effect on each other, particularly in technologically dynamic industries (Greve, 2003; Mishina *et al.,* 2004). For example, pursuing a strategy of innovation often makes firms more dependent on financial slack as a safeguard against the challenges and pitfalls associated with research and development (R&D) (Hall, 2002; Vicente-Lorente, 2001). Conversely, financial slack may insulate firms from their environment and result in agency effects, potentially leading to innovations that are less likely to be successfully commercialized or that are less profitable (Kraatz & Zajac, 2001).

Though debate exists as to which effects are stronger and when, financial slack is thought to have both positive (Hall, 2002; Vicente-Lorente, 2001) and negative (Jensen & Meckling, 1976; Williamson, 1964) effects on firm innovation. Research that attempts to reconcile divergent views converges on the idea that an inverse U-shaped relationship exists between financial slack and firm innovation (*e.g.,* Herold *et al.,* 2006; Nohria & Gulati, 1996). What I refer to throughout this manuscript as the *inverse U-shaped perspective* posits that financial slack allows firms to better manage the uncertainty associated with innovation, explaining the increase in firm innovation per dollar of financial slack that occurs as firms move from low to more average levels of financial slack (Herold *et al.*, 2006; Nohria & Gulati, 1996). On the other hand, it also creates a managerial safety net that results in agency costs (*e.g.*, putting forth less effort in deliberating managerial decisions) (Jensen & Meckling, 1976; Williamson, 1964) and opportunity costs (leaving cash idle rather than investing it) (Opler *et al.*, 1999). Agency and opportunity costs explain the decrease in firm innovation per dollar of financial slack that occurs as firms move from average to above average levels of financial slack (Herold *et al.*, 2006; Nohria & Gulati, 1996). This relationship is mirrored in research exploring the effect of financial slack on firm performance (*e.g.*, George, 2005; Tan & Peng, 2003) as may be expected given that that a strong link exists between firm innovation and firm performance (O'Brien, 2003).

Though the inverse U-shaped perspective has many interesting theoretical implications, few scholars have expanded on this work, leaving important practitioner concerns unanswered. For example, the inverse U-shaped perspective implies that firms will optimize innovation outcomes by holding stores of financial slack that are average relative to similar firms. This prescription is not sensitive to differences in project or firm level characteristics or to changes in firm strategy (*e.g.*, an increase in the scale of R&D activity). Moreover, managers often may not know how much financial slack their competitors are holding because the amount may fluctuate or be kept secret. Furthermore, debate exists as to whether the relationship between financial slack and firm innovation truly has an inverse U-shape. Research is unclear whether financial slack results in negative or just diminishing innovation at extreme high levels (Herold *et al.*, 2006).

Scholarship that supports a negative relationship relies on a small number of outlier observations (Herold *et al.*, 2006).

The goal of this paper is to better understand how firms are able to optimize the innovation benefits of financial slack while minimizing its significant agency and opportunity costs. I will depart from prior research on the financial slack-innovation relationship in two significant ways. First, research suggests that innovation outcomes may be more strongly affected by the ratio of financial slack relative to total R&D spending rather than by financial slack alone (e.g., O'Brien, 2003). However, few, if any scholars have operationalized financial slack as a proportion of total R&D spending (what I refer to as the financial slack-R&D ratio). Moreover, my research suggests that measuring financial slack as a proportion of total R&D spending (rather than independent of R&D) may have significant theoretical and practical benefits. A measure of financial slack that is proportional to R&D spending is sensitive to potential portfolio effects and it is easier for managers to utilize in a real innovation context). Hence, I operationalize financial slack as a proportion of total R&D spending.

Second, scholars have been reluctant to explore department and project-level factors because the inner workings of firms' innovative activities are fraught with complexity, secrecy, and context-specific peculiarities (Adams *et al.*, 2006). Because powerful influences on the relationship between financial slack and firm innovation may occur at the project and department level, I will focus my analysis on discrete innovation outcomes occurring throughout a sequential progression of R&D stages.

To minimize the problems of opacity and external validity described by Adams *et al.*, (2006), I assess the moderating role of project and department level variables that are easily observable (readily accessible to firm managers) and universal (found across firms and across industries). Conflicting support can be found in the management literature for each of the moderating variables included in this study regarding their likely effect on the financial slack-innovation relationship.

Hence, I present conflicting hypotheses regarding the potential moderating effect for three such variables. The first two variables I explore include the number of R&D projects and the degree of technological diversity between them. Research suggests that increasing the number and technological diversity of R&D projects may result in a portfolio effect (Lubatkin & Chatterjee, 1994), potentially decreasing the need for financial slack as a safeguard. Conversely, increasing the number and diversity of R&D projects may also result in increased planning and coordination challenges (Lubatkin & Chatterjee, 1994), or what I refer to as "complexity effects." As opposed to portfolio effects, complexity effects may result in an increased need for financial slack as the number and diversity of R&D projects increases.

The third potential moderating influence on the relationship between financial slack and firm innovation I test is project maturity (the nearness of an R&D project to completion). The management literature also provides conflicting evidence regarding the likely moderating influence of R&D project maturity. In the early stages of R&D, firms are more uncertain about their ability to overcome the technical challenges associated with developing the project (Miller & Folta, 2002; Nelson & Winter, 1977; Roberts & Weitzman, 1981), which can lead to greater dependence on financial slack as a safeguard. Alternatively, greater dependence on financial slack may occur in the later stages of R&D. In the later stages, design revisions and corrections become much more costly and unpredictable (Miller & Folta, 2002), which may lead to an increased need for financial slack to cover such expenses.

# CHAPTER 2: LITRATURE REVIEW

## BACKGROUND

Previous research has linked effective management of financial slack to the growth and survival of firms (Penrose, 1959), particularly in technologically dynamic industries (Greve, 2003; Mishina *et al.*, 2004). Scholars attribute this relationship to the fact that innovation results in firm assets that have high transaction costs (they are difficult to buy and sell) (Pisano, 1990) and high adjustment costs (it is costly to significantly scale up or scale down the ongoing rate of investment) (Himmelberg & Petersen, 1994). Moreover, overly optimistic or inattentive managers are likely to underestimate or ignore foreseeable costs (Lant, 1985; Schiff & Lewin, 1970), potentially leading to more R&D budget shortfalls and fewer surpluses. Internally-held cash that is not committed to a predefined purpose is the most efficient internal resource that firms can use to supplant R&D budget shortfalls because it is unabsorbed (not committed to an alternate use) and because it is generic (has a wide variety of potential uses) (Greve, 2003; Mishina *et al.*, 2004; Voss *et al.*, 2008). Furthermore, financial slack allows innovative firms to avoid soliciting external capital markets (which can be especially costly in the R&D context due to information asymmetries and high degrees of success uncertainty; Hall, 2002; Vicente-Lorente, 2001).

The goal of this chapter is to summarize scholarly work examining the relationship between financial slack and firm innovation. I begin by describing how researchers have used multiple and sometimes inconsistent conceptualizations of financial slack, potentially leading to significant concerns regarding construct validity. I then discuss the degree to which various popular measures of financial slack accurately measure the construct as it has been theoretically defined as a resource that exists *in excess* of some minimal level of foreseeable need (*e.g.*, Bromiley, 1991; Miller & Leiblein, 1996; Mishina *et al.*, 2004). Next, I review conflicting prior research that suggests that either a positive (*e.g.*, Bourgeois, 1981; Hall, 2002; O'Brien, 2003; Thompson, 1967; Vicente-Lorente, 2001) or negative (*e.g.*, Jensen & Meckling, 1976; Kraatz & Zajac, 2001; Williamson, 1964) relationship exists between financial slack and innovation. Following that, I discuss how scholars reconcile these views by proposing that financial slack has a positive effect on innovation at low levels and a diminished, or even negative effect at high levels (an inverse U-shaped relationship) (*e.g.*, Herold *et al.*, 2006; Nohria & Gulati, 1996). Ultimately, my research in this chapter suggests that measuring financial slack as a proportion of total R&D spending may provide important insights. I conclude by discussing the implications of the inverse U-shaped perspective, its limitations, as well as potential avenues for future research.

## SLACK AND FINANCIAL SLACK

Before I define financial slack, it is important to establish a clear understanding of the broader umbrella of 'slack' under which the term falls. Of the multitude of variations on the basic definition of slack presented in the management literature, most definitions converge on the idea that slack refers to a resource that exists *in excess* of some minimal level of foreseeable need (e.g., Bourgeois, 1981; Child, 1972; Cyert & March, 1963; March & Shapira, 1987; Nohria & Gulati, 1996). Accordingly, scholars suggest that financial slack is cash that exists *in excess* of some minimal level of predetermined operational use (e.g., Bromiley, 1991; Miller & Leiblein, 1996; Mishina *et al.*, 2004).

However, numerous conceptualizations of financial slack ignore this important condition. For example, some scholars suggest that the term financial slack can be used interchangeably with words like ‘cash’ (e.g., Sharfman *et al.*, 1988; Voss *et al.*, 2008), ‘liquidity’ (e.g., Daniel *et al.*, 2004; Levitas & McFadyen, 2009), or ‘low leverage’ (e.g., O’Brien, 2003). This potentially creates construct validity problems because it implies that financial slack is simply the product of firm managers’ preference for internal (equity) financing ahead of external (debt) financing. However, the total stock of cash (or liquidity) held by a firm cannot be accurately termed ‘financial slack.’ Only that portion which is not already reserved for a specific, planned use should be conceptualized as financial slack. Operationalizations of financial slack should also conform to this requirement (see Bromiley, 1991; Miller & Leiblein, 1996; Mishina *et al.*, 2004; Moses, 1992)

Scholars have suggested that those who are unsure about whether a particular cash resource may also be characterized as financial slack should describe the extent to which that resource is absorbed (committed to a specific use) or unabsorbed (uncommitted to any specific use) (*e.g.*, Greve, 2003; Singh, 1986; Voss *et al.*, 2008). Only resources that are highly unabsorbed should be characterized as financial slack (Voss *et al.*, 2008). Greve (2003) suggested that scholars should use the term ‘absorbed financial slack’ to describe liquid firm assets that are committed to a predetermined use. Mishina *et al.* (2004) suggested that scholars should use the term ‘negative financial slack.’ I argue that both of these terms increase existing confusion regarding the theoretical requirement that financial slack must be in excess of foreseeable need (absorbed or negative financial slack is, by definition, *not* in excess of foreseeable need). Hence, throughout this manuscript, I use the generic term 'financial slack' in reference to unabsorbed or uncommitted idle cash reserves. When referring to firm liquidity committed to a foreseeable use, I will specify by using the term 'absorbed liquidity.'

It is important to draw a clear distinction between financial slack and absorbed liquidity because they have dissimilar costs and benefits (Singh, 1986). Financial slack (an idle resource uncommitted to any other use) is more costly for firms to hold than absorbed liquidity, which can be at least partially committed to another use (e.g., cash reserved for a marketing campaign that could be abandoned or postponed) (Greve, 2003; Mishina *et al.*, 2004; Voss *et al.*, 2008). Furthermore, financial slack is cheaper and easier to access than absorbed liquidity, so it can be more effectively utilized as a resource to supplant R&D budget shortfalls or to pursue emergent opportunities. Scholars attempting to understand the firm-level strategic implications of holding liquid assets should be precise about the specific resource they are observing.

## MEASURING FINANCIAL SLACK

Past scholars offer some useful guidelines with regard to how researchers should operationalize financial slack despite the challenges of discerning between absorbed liquidity and financial slack. For example, Moses (1992) argued that the best way to operationalize financial slack as existing in excess of foreseeable need is by calculating the difference between current assets and current liabilities. However, Bourgeois (1981) argued that, from a research perspective, relative measures of slack are generally more useful.[1] Hence, using the current ratio (current assets divided by current liabilities) to operationalize financial slack (e.g., Greve, 2003; Kim *et al.*, 2008; Singh, 1986) may

[1] See Bourgeois (1981: 37) for a complete review of the theoretical, methodological and operational benefits of utilizing relative measures of organizational slack as opposed to absolute measures

result in more valid and generalizable empirical findings. Regardless if they are absolute or relative, operationalizations that attempt to measure the amount of cash held by the firm that is above and beyond some minimum level of operational need (e.g., current liabilities) are most consistent with theoretical definitions of financial slack existing in excess of foreseeable need.

Other scholars have used the difference between cash held by the focal firm and the average cash held by a sample of similar firms to calculate financial slack (e.g., Litschert & Bonham, 1978). This approach may be useful when the current ratio is not available (e.g., department-level analyses of diversified firms). However, it should be noted that the average cash held by a sample of firms is not a very good indicator of a firm's foreseeable need since that could vary significantly across firms. Controlling for some of the primary antecedents of financial slack (*e.g.,* firm size, sales revenue, liquidity) may help to mitigate this problem. Other scholars suggested measuring both absorbed and unabsorbed financial slack to detect differences caused by the level of absorption (*e.g.,* Greve, 2003; Singh, 1986).

Perceptual measures also can be utilized to capture managers' conceptualization of how much cash is held in excess of foreseeable need. However, firm managers generally underestimate costs and overestimate revenues (Lant, 1985), so the questionnaires that accompany such measures need to be carefully worded so as to capture cash that is truly in excess of projected demand. Research suggests that the best way to achieve this is to employ questions that require managers to describe the amount of organizational disruption (or cost) the organization would experience if an amount of cash were removed from the operating budget (*e.g.,* Lant, 1985).

# THE EFFECTS OF FINANCIAL SLACK ON FIRM INNOVATION

## The positive effects of financial slack on firm innovation

Three basic assumptions form the foundation for the view that financial slack has a positive effect on firm innovation. I use the term 'innovation' throughout this manuscript in reference to new products or ideas that have been successfully commercialized (Schumpeter, 1934). The first assumption is that R&D projects require assets that are sensitive to volatility in the ongoing rate of investment (Hall, 2002; O'Brien, 2003; Pisano, 1990). The second assumption is that R&D projects inherently cause problems of information asymmetry between firm managers and prospective investors, thereby restricting access to external sources of capital (Hall, 2002; Levitas & McFadyen, 2009; Vicente-Lorente, 2001). The third assumption is that uncommitted stores of cash represent the most efficient resource firms have available to cover unexpected R&D costs or to supplant shortfalls in the availability of investment capital (Greve, 2003; Mishina *et al.,* 2004; Voss *et al.,* 2008). The strategy of supplementing innovation budget shortfalls using a stockpile of uncommitted cash is known as 'technical buffering' (Bourgeois, 1981; Thompson, 1967) or 'R&D smoothing' (Brown & Petersen, 2011). Each of the assumptions associated with what I will refer to hereafter as the *technical buffering perspective* are described in greater detail below.

***Sensitivity to the ongoing rate of investment.*** The first assumption of the technical buffering perspective is that pursuing a strategy of innovation generally causes firms to make investments that increase their vulnerability to volatility in the availability of external sources of investment capital (Hall, 2002; O'Brien, 2003; Pisano, 1990). This is largely because R&D projects usually involve highly skilled labor and/or specialized equipment (Hall, 2002). Such assets have high transaction costs (they are difficult to buy and sell) (Pisano, 1990) and high adjustment costs (it is costly to significantly scale up or scale down the ongoing rate of investment) (Himmelberg & Petersen, 1994). R&D projects also tend to have uncertain costs that can fluctuate significantly (Greve, 2003). For example, human and mechanical failures can lead to major delays and wasted effort. Failing to increase project investment in the face of unexpected cost increases requires firms to incur high adjustment and/or transaction costs (O'Brien, 2003). Furthermore, managers' tendency to be overly optimistic about their ability to achieve innovation causes an increased likelihood that actual costs of R&D projects will exceed projected costs (Lant, 1985). Maintaining a store of financial slack may help managers to avoid the high adjustment costs and transaction costs associated with cash flow volatility, unexpected increases in the cost of development, and managerial failure to foresee significant costs.

***Restricted external investment.*** R&D projects also cause problems of information asymmetry between firm managers and prospective investors that restrict firms' access to external sources of investment capital (Hall, 2002; Levitas & McFadyen, 2009; Vicente-Lorente, 2001). Prospective investors often find managers' claims about the future value of R&D projects difficult to verify because such projects tend to be risky, complex, and secretive in nature (Hall, 2002; O'Brien, 2003; Vicente-Lorente, 2001). Managers also may be motivated to artificially inflate the value of firm investments to attract investment capital (Peng *et al.*, 2010; Qian & Li, 2010) which may exacerbate the information asymmetry problem. As a result, Hall (2002: 5) argued, "the marketplace for financing the development of innovative ideas looks like the 'lemons' market modeled by Akerlof

(1970). The lemons' premium for R&D will be higher than that for ordinary investment because investors have more difficulty distinguishing good projects from bad.” Moreover, investments in innovation are highly specific and difficult to redeploy. Hence, they often serve as a poor source of debt collateral (Vicente-Lorente, 2001). Therefore, firms that are more R&D intensive generally experience more difficulty accessing external sources of capital (Hall, 2002; O’Brien, 2003; Vicente-Lorente, 2001).

***Financial slack as a resource for R&D.*** Because financial slack is the most unabsorbed (most accessible) and most generic (greatest variety of potential uses) type of slack, it is ideal for covering the unexpected resource shortfalls that characterize firm innovation efforts (Greve, 2003; Mishina *et al.,* 2004; Voss *et al.,* 2008). While more absorbed types of slack are theoretically accessible to firm managers, practicality concerns and political jockeying by influential internal stakeholder groups often make its actual recovery and utilization costly or problematic (Mishina *et al.,* 2004; Voss *et al.,* 2008). Firm managers may be more willing and able to risk discretionary cash resources in the search for new sources of competitive advantage than other forms of slack that are more difficult to repurpose or replenish (e.g., human resource slack) (Voss *et al.,* 2008). Accordingly, innovative firms tend to suffer decreased performance when they ignore the increased level of financial slack that pursuing a strategy of innovation demands (O’Brien, 2003).

**The negative effects of financial slack on firm innovation**

Financial slack may also have negative effects on firms’ ability to successfully innovate. First, by holding financial slack firms incur opportunity costs (costs associated with holding cash in reserve rather than investing it) (Opler *et al.*, 1999). Idle cash may or may not be used to cover the unexpected R&D costs and cannot be used to expand planned innovation efforts.

Second, agency theorists argue that financial slack degrades firms' innovative efficiency by making firm managers less diligent (not dedicating their full effort) and more opportunistic (accumulating personal benefits from firm resources) (Jensen & Meckling, 1976; Williamson, 1964). For example, less diligent managers may fail to give adequate administrative consideration to all available R&D alternatives. Opportunistic managers may pursue attention-grabbing new products when the firm really needs a more discrete overhaul of its distribution strategy.

Agency scholars suggest that the buffering concept described by Thompson (1967), initially used to illustrate the positive effects of financial slack, may result in negative long-term effects. Specifically, Kraatz & Zajac (2001) agreed that financial slack allows firms to engage in buffering. However, they argued that the long-term effect is that firms will make continually more elastic responses to environmental change. From this perspective, high levels of financial slack loosen the coupling between the firm and its environment, thereby desensitizing firm managers to changes in market conditions (Kraatz & Zajac, 2001). The assumption is that over time the separation between the firm's competitive advantage and the demands of the market will grow, thereby reducing firm performance.

The divergence between technical buffering and agency views of the effect of financial slack on firm innovation hinges on two basic discrepancies. The first major discrepancy is about the role of uncertainty. Agency theorists are in agreement with the technical buffering perspective that slack resources buffer firms against uncertainty, thereby simplifying the coordination challenges associated with managing an innovative firm (Kraatz & Zajac, 2001). However, the technical buffering view supposes that managers, freed from constantly reallocating resources to meet the day-to-day budgetary uncertainties associated with firm innovation, will instead focus their energy on achieving long-term competitive advantage (Bourgeois, 1981; Thompson, 1967). Conversely, the agency view assumes that the predominant effect of the reduced uncertainty is that managers become less diligent, failing to dedicate their full efforts toward planning and revising firm investments (e.g., Jensen & Meckling, 1976; Kraatz & Zajac, 2001; Williamson, 1964). Financial slack may give firm managers increased certainty that they will successfully complete the R&D projects that they choose to pursue (Mishina *et al.,* 2004). However, agency theorists argue that overall the effect will be negative because managers will choose inferior projects and will not dedicate their full effort to ensuring rapid and efficient completion (Greve, 2003).

The second major discrepancy between the technical buffering and agency perspectives concerns the perceived of importance of the degree to which a firm is able to achieve co-alignment with market demand. Agency theorists assume that to optimize performance, firms must at all times strive to achieve the maximum level of alignment possible with the demands of the external market (financial slack creates a buffer between the firm and the environment, decreasing environmental alignment and presumably, performance; Kraatz & Zajac, 2001). However, the technical buffering perspective gives more weight to the role of establishing long-term core firm competencies and continually developing them over time. It inherently places less importance on the degree to which firms successfully conform to shorter-term fluctuations in market demand.

**Reconciling positive and negative views of financial slack**

Scholars have empirically explored the influence that technical buffering and agency effects have on firm innovation and firm performance. Results on both dependent variables mirror one another, which is expected given the strong link that exists between innovation and firm performance (O'Brien, 2003). Broadly, researchers find that financial slack has an inverse U-shaped relationship with both firm innovation (*e.g.,* Herold *et al.,* 2006; Nohria & Gulati, 1996) and with firm performance (*e.g.,* George, 2005; Tan & Peng, 2003). The inverse U-shaped perspective posits that financial slack allows firms to better manage the uncertainty associated with innovation, explaining the marginal increase in firm innovation that occurs as firms move from low to more average levels of financial slack (Herold *et al.,* 2006; Nohria & Gulati, 1996). Conversely, it also results in agency costs, explaining the marginal decrease in firm innovation that occurs as firms move from average to above average levels of financial slack (Herold *et al.,* 2006; Nohria & Gulati, 1996).

However, the question of whether or not financial slack results in diminishing positive returns on innovation or whether it may actually have a negative effect on innovation at very high levels remains an important and unanswered question in the managerial literature (Herold *et al.,* 2006). Prior studies indicating that high levels of financial slack have a negative effect on innovation rely on a few outlier observations (e.g., Herold *et al.,* 2006; Nohria & Gulati, 1996). These studies indicate that at very high levels of financial slack firms may actually experience worse innovation outcomes, but relying on outlier observations leaves significant questions about validity (Herold *et al.*, 2006). More studies are needed to triangulate the findings of prior researchers regarding whether the relationship between financial slack and innovation is truly inverse U-shaped (actually results in a decrease in total firm innovation at very high levels), or just curvilinear (only results in a lower increase in total firm innovation at very high levels) (Herold *et al.*, 2006).

Prior scholarly works have attempted to refine the inverse U-shaped perspective by considering how the financial slack-innovation relationship may be altered by variance in the conditions of the external market (*e.g.*, Martinez & Artz, 2006); by variance in the type of firm pursuing the innovation (*e.g.*, Geiger & Makri, 2006); by variance in the type of innovation being pursued (*e.g.*, Voss *et al.*, 2006); and by variance in the type of managers who pursue innovation (e.g., Greve, 2003). Martinez & Artz (2006) found that industry regulation can suppress firms' propensity to utilize financial slack in the pursuit of risky investments like innovation. The analysis of Geiger & Makri (2006) assessed how changes in the type of innovation firms pursue may affect the financial slack- innovation relationship. Their analysis suggested that highly R&D intensive firms are significantly more likely to successfully use financial slack in developing a great number of technologically diverse innovations.

Additionally, Voss *et al.* (2006) hypothesized that high levels of financial slack will cause firm managers to engage in more risky exploratory innovation and that low levels of financial slack will cause managers to pursue innovation projects that exploit previous firm knowledge. Despite being firmly rooted in prior research (e.g., Mishina *et al.*, 2004; Nohria & Gulati, 1996; Tan & Peng, 2003), Voss *et al.* (2006) found no support for either of these hypotheses. Greve's (2003) analysis may offer some explanation. He suggested that the financial slack- innovation relationship may be moderated by managerial propensity to engage in problemistic search (increased investment in innovation caused by managerial aspirations exceeding actual firm performance). Specifically, he found that when managerial aspirations exceed actual performance, firms are more likely to use financial resources to fuel innovation (Greve, 2003). From this perspective, the key to maximizing the positive effects of financial slack on firm innovation is to keep managerial aspirations high, despite the fact that a common antecedent of financial slack is firm performance exceeding normal expectations (Cyert & March, 1963).

## PROPORTIONAL MEASURES OF FINANCIAL SLACK

The inverse U-shaped perspective has added considerable insight to scholars' understanding of the relationship between financial slack and firm innovation. However, by considering the level of total R&D spending relative to financial slack (what I refer to as the financial slack-R&D ratio) scholars may gain important insights. For example, O'Brien (2003) found that firms that ignore the increased need for financial slack that occurs as R&D efforts expand suffer significantly depressed performance. O'Brien's (2003) findings raise some internal validity questions regarding the inverse U-shaped perspective. He suggests that some of the decline in innovation output that occurs as firms hold higher levels of financial slack may be due to a lack of proportionality between financial slack and innovation resources.

# DISCUSSION AND CONCLUSION

In this chapter, I highlight some of the central ideas presented in scholarly work that explores the relationship between financial slack and firm innovation. The intent is to underscore theoretical and empirical research concerns that may affect study in this field. I also identify some gaps in the innovation literature. For example, scholars have expanded knowledge of the factors that affect the relationship between financial slack and innovation at the market level (e.g., Martinez & Artz, 2006), the firm level (e.g., Geiger & Makri, 2006), and the individual level (e.g., Greve, 2003). However, few have explored innovation at the department or project level. Because important influence on the success of innovation projects may occur at the project level (Benner & Tushman, 2002, 2003; Christensen & Raynor, 2003), it is important that researchers explore department and project level factors that may affect the financial slack-innovation relationship.

Adams *et al.* (2006) suggested that scholars' reluctance to empirically assess the inner workings of firms' innovative activities results from the secretive and complex nature of R&D and difficulty in generalizing findings across firms and across industries. To mitigate these problems, innovation research should assess variables that are easily observable (readily accessible to firm managers) and universal (found across firms and across industries) so that theoretical findings can be easily understood and utilized by practitioners. However, researchers should also be careful to account for differences across contexts (e.g., different countries and industries). By replicating innovation research in varying business environments, scholars may more accurately estimate the amount of financial slack firms require to optimize innovation outcomes.

Exploring the relationship between financial slack and firm innovation requires theoretical perspectives that are inclusive enough to be broadly understood, while being specific enough to be applicable to individual firms trying to achieve innovation. In the following chapters I utilize the ideas described above to guide my empirical research. My goal is to identify novel and important relationships that are potentially more theoretically useful and practically relevant than those described in prior research.

# CHAPTER 3: HYPOTHESIS DEVELOPMENT

Research on the relationship between financial slack and firm innovation has resulted in some significant findings that have shaped conventional understanding. Specifically, research suggests that financial slack has an inverse U-shaped relationship with firm innovation (e.g., Herold *et al.*, 2006; Nohria & Gulati, 1996). While identifying that an inverse U-shaped relationship exists is useful on a theoretical level, many questions remain regarding the practitioner application of this knowledge. As described above, this approach is not sensitive to basic changes in firms' innovation strategies (e.g., an expansion of innovation efforts). Also, managers may not know how much financial slack competitor firms hold since this amount may vary or be kept secret. I argue that measuring financial slack as a proportion of total R&D spending may result in significant theoretical benefits (more sensitivity to portfolio effects) and practitioner advantages (more easily utilized to determine the optimal level of financial slack).

I identify three variables that are easily observable, universal, and for which conflicting theoretical support exists regarding their likely effect on the relationship between financial slack and firm innovation. I explore how the number of innovation projects, the degree of diversity between them, and their nearness to completion affect the need for financial slack to optimize innovation outcomes.

The need for financial slack is not driven by just the total amount of innovation a firm wants to achieve, but also by the number and the diversity of innovation projects that a firm is simultaneously pursuing (Lubatkin & Chatterjee, 1994). Benefits associated with increasing the number of investments in a portfolio may occur as risk is shared across multiple R&D projects. As the number of R&D projects increase, portfolio effects may reduce the amount of financial slack needed as a safeguard against the challenges associated with pursuing a strategy of innovation. In addition to sharing risk, spillover effects (advances achieved in one technology as a result of exploring a related technology) also may allow firms to share benefits across a number of R&D projects (Garcia-Vega, 2006), potentially reducing the need for financial slack as a safeguard.

Conversely, challenges tied to increasing the number of investments in a portfolio may have the opposite influence on the risk associated with pursuing multiple R&D projects. As firms increase the number of R&D projects they pursue, they may experience costly internal planning and coordination challenges that increase the likelihood of setbacks and cost overruns (Breschi *et al.,* 2003; Garcia-Vega, 2006), possibly increasing the need for financial slack as a safeguard.

Consistent with portfolio theory, the diversity of innovation projects that a firm is pursuing may also influence the amount of financial slack needed as safeguard against the challenges of pursuing a strategy of innovation. Technological diversity describes the degree to which projects in a firm's R&D portfolio draw on technologies that are dissimilar from one another. On one hand, having an R&D portfolio with high technological diversity could result in firm-level synergies (sharing of risks and benefits) that may decrease the need for financial slack (Hall, 2002; O'Brien, 2003; Vicente-Lorente, 2001). On the other hand, heightened complexity could result in an increased likelihood of unexpected setbacks and cost overruns (Benner & Tushman, 2002, 2003; Breschi *et al.,* 2003; Garcia-Vega, 2006; Tushman & O'Reilly, 1996; March, 1991) that may increase the need for financial slack. Moreover, debate exists as to whether technological diversity enhances or diminishes spillover effects (Breschi *et al.,* 2003; Garcia-Vega, 2006).

The management literature is similarly conflicted about the role of project maturity (the nearness of an R&D project to completion). Research indicates that a shift in the type of uncertainty associated with an R&D project occurs as it nears completion (e.g., Miller & Folta, 2002; Nelson & Winter, 1977; Roberts & Weitzman, 1981). In the early stages of innovation, R&D projects are mainly dominated by uncertainty as to whether the firm will be able to overcome the technical demands associated with the project. In the later stages of innovation, R&D projects become more exposed to changes in market conditions. Specifically, as R&D projects near completion the cost of design changes in response to fluctuations in market conditions increases (Miller & Folta, 2002; Roberts & Weitzman, 1981). The management literature is unclear whether financial slack may be more useful in helping firms to overcome the uncertainty that characterizes the early versus the late stages of R&D (or if any difference exists at all).

To test conflicting theoretical implications on the need for financial slack to optimize innovation outcomes, I explore data from a sample of U.S.-based biotechnology firms attempting to develop new pharmaceutical drugs. I consider how changes in portfolio influences and project maturity may affect how biotech firms are able to successfully move individual drugs in development through successive stages of U.S. Food and Drug Administration (FDA) approval. Scholars indicate that understanding the relationship between financial slack and firm innovation is critical to firms' ability to achieve high performance (e.g., O'Brien, 2003). By exploring the distinct role that the financial slack-R&D ratio may have on firm innovation, I hope to expand theoretical understanding of this important field of research.

**THE FINANCIAL SLACK-R&D RATIO**

Prior research that explored the relationship between financial slack and firm innovation operationalized financial slack in several ways. For example, Nohria and Gulati (1996) used a conceptual measure, asking managers to estimate the reduction in output if the department's annual operating budget was reduced by 10%. Other scholars suggested using the current ratio (e.g., Greve, 2003; Kim *et al.*, 2008; Singh, 1986), or an absolute measure of current assets less current liabilities (e.g., Moses, 1992). Though they conform well to the theoretical requirement that financial slack be a resource that exists *in excess* of foreseeable need, these measures may not be ideal for determining the optimal level of financial slack that innovative firms should retain.

O'Brien (2003) suggested that the proportion of financial slack relative to total R&D spending may drive performance outcomes more significantly than financial slack alone. His research findings indicated that firms that ignore the increased demand for financial slack that occurs as innovation efforts expand suffer significantly depressed performance. Measuring financial slack as a proportion of total R&D spending (the financial slack-R&D ratio) may have other theoretical and practitioner research benefits.

For example, the financial slack– R&D ratio may be sensitive to potential portfolio effects that may occur as the number and diversity of a firm's R&D projects increase. Firms pursuing numerous technologically diverse R&D projects may experience a portfolio effect whereby innovation projects can share risks and benefits between them (Lubatkin & Chatterjee, 1994). Consider how insurance companies diversify risk among a portfolio of policies, enabling them to retain an ever lower proportion of emergency cash relative to the total value of the insured property (while at the same time the absolute level of emergency cash needed tends to increase).

As investments in a portfolio accumulate and diversify, only the proportion of the total investment that is at risk needs to be reduced for a portfolio effect to occur; the absolute amount that is at risk may increase (Lubatkin & Chatterjee, 1994). Similar to the portfolio effect insurance companies experience, an R&D portfolio effect could result in a lower proportion of emergency financial slack relative to total R&D spending needed to optimize innovation outcomes (discussed in detail in the next section). A measure of financial slack independent of R&D spending may not be sensitive to this type of effect. As the insurance company example demonstrates, the absolute need for cash can increase even as the proportional need diminishes.

In addition to its sensitivity to portfolio effects, the financial slack-R&D ratio gives managers an easily observable, internal marker that is sensitive to major changes in the scale of R&D activity to help determine the optimal level of financial slack. The inverse U-shaped perspective suggests that managers should hold financial slack that is average relative to that of competitor firms to optimize innovation outcomes. This prescription is not sensitive to changes in the focal firm's strategy (e.g., expanding innovation efforts) and relies on information that may not be readily available to firm managers (the financial slack holdings of competitors). Hence, when assessing the role of financial slack on firm innovation I will measure financial slack as a proportion of total R&D spending.

**PORTFOLIO EFFECTS**

Previous scholars have suggested that management practitioners employ financial slack as a safeguard against the risk and uncertainty associated with R&D projects (e.g., Hall, 2002; O'Brien, 2003; Vicente-Lorente, 2001). However, much like a stock portfolio, firms may be able to diversify their innovation risk across a range of varied R&D investments (Breschi *et al.,* 2003; Garcia-Vega, 2006). Portfolio theory is based on the "three legged stool" concept (Lubatkin & Chatterjee, 1994). When applied to strategic management, the central idea is that a firm will be less likely to "tip over" (become insolvent) as it adds "legs" (divergent sources of competitive advantage). Of course, the degree to which a stool will avoid tipping over depends on both the number of legs it has and the degree to which the legs are pointing in different directions.

Portfolio theory works in the same way. The degree to which a portfolio of investments can be considered diversified depends on two factors: the number of investments and the divergence in the type of risk or uncertainty that exists between them (Lubatkin & Chatterjee, 1994). The logic of portfolio theory is appealing. As Lubatkin and Chatterjee (1994: 114) put it, "reduce your firm's dependence on a single product, market, or technology, reduce your exposure to the hardships and cyclicalities of any single business environment, and you'll reduce your firm's corporate risk." However, increasing the number and diversification of innovation projects also can cause serious planning and coordination challenges (what I refer to as 'complexity effects') that may have the opposite influence on firms' need for financial slack.

**The number of R&D projects**

Portfolio and spillover effects could decrease the proportion of idle cash needed to serve as a safeguard against R&D setbacks. Conversely, pursuing multiple innovation projects may add complexity and uncertainty (Breschi *et al.*, 2003; Garcia-Vega, 2006), possibly increasing the likelihood of R&D setbacks and cost overruns. Moreover, prior research indicates that portfolio theory has limited application in explaining the performance effect of corporate diversification at the subsidiary firm level (*e.g.,* Lubatkin & Chatterjee, 1994).

The management literature provides divergent perspectives regarding the likely effect of increasing the number of R&D projects on firms' need for financial slack. Hence, I propose competing hypotheses about how complexity and portfolio effects associated with the number of R&D projects may influence this relationship. If increasing the number of R&D projects results in portfolio and spillover effects having the greatest influence on innovation outcomes then firms with many R&D projects should require less financial slack per dollar of R&D investment than firms with few R&D projects in order to achieve optimal innovation outcomes.

*H1a: Firms that pursue many innovation projects require less financial slack per dollar of R&D invested to achieve the same probability of successful innovation as firms that pursue few innovation projects.*

Conversely, if increasing the number of R&D projects results in complexity effects having the greatest influence on innovation outcomes then firms should require more financial slack per dollar spent on R&D as the number of projects increases in order to achieve optimal innovation outcomes.

> *H1b: Firms that pursue many innovation projects require more financial slack per dollar of R&D investment to achieve the same probability of successful innovation as firms that pursue few innovation projects.*

**The technological diversity of R&D projects**

As discussed above, the degree to which risk can be diversified in a portfolio depends not only on the number of investments, but also on the degree of divergence in the type of risk or uncertainty associated with each investment (Lubatkin & Chatterjee, 1994). Moreover, the type of risk firms experience from innovation is not consistent across R&D projects. Rather, it can be affected by variation in the type of innovation projects that firms choose to pursue (Benner & Tushman, 2002, 2003; Christensen & Raynor, 2003). Prior scholars exploring the effects of technological differences between projects in firms' R&D portfolio use the term *technological diversity* to describe the degree to which firms have a diversified portfolio of R&D investments (*e.g.,* Breschi *et al.,* 2003; Garcia-Vega, 2006).

Abernathy (1978) was one of the earliest scholars to note that a trade-off exists between firms' ability to achieve strategic flexibility in the face of environmental change and firms' ability to maintain operational efficiency in the existing environment. Firms that are more technologically diverse tend to pursue innovations that rely heavily on disparate sources of knowledge (Breschi *et al.,* 2003; Garcia-Vega, 2006). Such firms are more flexible and able to rapidly develop new sources of competitive advantage in the face of environmental change (Tushman & O'Reilly, 1996; March, 1991). Similar to firms with product diversification, technologically diverse firms experience risk reduction because they can shift between capabilities if market conditions threaten one or more firm competencies (Garcia-Vega, 2006). However, firms with a portfolio of R&D projects that are technologically diverse may miss opportunities to exploit established knowledge and capabilities obtained through past innovation experiences (Benner & Tushman, 2002, 2003; Breschi *et al.*, 2003; Garcia-Vega, 2006; Tushman & O'Reilly, 1996; March, 1991).

Conversely, firms that are less technologically diverse tend to pursue innovations that repeatedly draw on the same sources of knowledge (Breschi *et al.*, 2003; Garcia-Vega, 2006). Such firms are more certain of the success of their projects and are able to more rapidly innovate due to the decreased complexity caused by focusing on a narrower scope of technological know-how (Tushman & O'Reilly, 1996; March, 1991). However, firms that continuously pursue R&D projects that are technologically similar to previous innovations become increasingly monolithic, rigid, and unable to respond to changes in the external environment (Benner & Tushman, 2002, 2003; Breschi *et al.*, 2003; Garcia-Vega, 2006; Tushman & O'Reilly, 1996; March, 1991).

Thus, the effect of technological diversity on innovative firms' need for financial slack is unclear. Research exploring the effect of technological diversification of firm performance suggests that moderate levels of related diversification optimize performance, while very high or low levels of firm diversification tend to depress performance (e.g., Lubatkin & Chatterjee, 1994). Debate exists as to whether spillover effects are greater for firms that pursue more related or more unrelated technologies (Breschi *et al.*, 2003; Garcia-Vega, 2006). However, Nelson (1959) argued that firms that pursue more technologically diverse R&D projects will benefit more from *unexpected* spillover effects than will firms that pursue less technologically diverse R&D projects. Because financial slack is used to cover unexpected setbacks, it is reasonable to assume that expected spillover effects would have relatively little effect on the need for financial slack. The unexpected nature of spillover effects in technologically diversified firms may more significantly reduce the need for financial slack.

Other scholars argue that relying on established resources and competencies enables firms to innovate more rapidly and efficiently, and to more effectively align with market demand than firms that seek new and uncertain resources and capabilities (*e.g.*, Teece, 2007). Moreover, prospective investors may tend to perceive R&D projects that depart from a firm's established resources and capabilities as significantly more risky than R&D projects that do not (Levitas & McFadyen, 2009). Such investor perceptions are likely to cause firms to rely more heavily on financial slack as a resource to fuel innovation (Levitas & McFadyen, 2009). Furthermore, pursuing technologically diverse innovation projects can result in many of the same complexity effects as pursuing multiple innovation projects (decreased focus and efficiency) (Benner & Tushman, 2002, 2003; Breschi *et al.*, 2003; Garcia-Vega, 2006; Tushman & O'Reilly, 1996; March, 1991).

In recent years, some empirical research gives support to the notion that technological diversity results in better innovation outcomes (*e.g.*, Garcia-Vega, 2006). While this research helps to clarify this ambiguous relationship, it is based on a single sample of 544 European firms and relies partially on a potentially problematic measure of firm innovation (R&D intensity). Overall, the management literature provides unclear and/or divergent perspectives regarding the role of technological diversity on firms' need for financial slack. Therefore, I propose competing hypotheses about how technological diversity may influence this relationship. If increasing the degree of technological diversity in a firm's R&D portfolio results in spillover and portfolio effects having the greatest influence on innovation outcomes, then firms should require less financial slack per dollar of R&D investment as technological diversity increases to achieve optimal innovation outcomes.

*H2a: Firms that pursue innovation projects that are technologically diverse require less financial slack per dollar of R&D invested to achieve the same probability of successful innovation as firms that pursue innovation projects that are not technologically diverse.*

Conversely, if increasing the number of R&D projects results in complexity effects having the greatest influence on innovation outcomes, then firms should require more financial slack per dollar of R&D expense as technological diversity increases to achieve optimal innovation outcomes.

*H2b: Firms that pursue innovation projects that are technologically diverse require more financial slack per dollar of R&D invested to achieve the same probability of successful innovation as firms that pursue innovation projects that are not technologically diverse.*

## PROJECT MATURITY EFFECTS

Past scholars offer significant insights on the relationship between the maturity (nearness to completion) of innovation projects and the importance of financial slack as a resource to fund innovation. For instance, Nelson & Winter (1977) argued that the uncertainty about whether a firm will successfully complete an R&D project declines as the project nears completion. Roberts & Weitzman (1981) introduced the concept of the "sequential development project" (SDP). The SDP describes investments in which costs are additive, benefits accrue only upon completion and development can be halted or abandoned at any time (Roberts & Weitzman, 1981). As an SDP moves through successive stages, uncertainty about the realization of future benefits is reduced (Roberts & Weitzman, 1981). Miller and Folta (2002) introduced a construct that they termed the "compound real option." Compound real options are "complex series of nested investments [where] initial foothold investments confer privileged access to information and opportunities for future investments" (Miller & Folta, 2002: 659). The value of exercising each nested option lies in the reduction of uncertainty about benefits to be realized upon completing the project (Miller & Folta, 2002).

In addition to those mentioned above, numerous other scholars have commented on the general tendency for uncertainty about the future costs and benefits associated with an R&D project to decline over time (e.g., Dixit & Pindyck, 1994; McGrath, 1997). Since financial slack serves as a safeguard against the uncertainty associated with pursuing a strategy of innovation (Hall, 2002; O'Brien, 2003; Vicente-Lorente, 2001), we may expect the need for financial slack to decline as a project becomes nears completion. Moreover, research suggests that project maturity sends a signal of managerial competence (Nelson & Winter, 1977), potentially increasing access to capital markets (Olson, 1997).

However, scholars also conceive of R&D projects as a "search heuristic," or a complex, interrelated series of decisions broken down into smaller parts (*e.g.*, Miller & Folta, 2002; Nelson & Winter, 1977; Roberts & Weitzman, 1981). From this perspective, R&D can be thought of as a process whereby the range of potential action becomes narrower and narrower as consecutive decisions are made (Roberts & Weitzman, 1981; Miller & Folta, 2002). Theoretical support for this view can be found in the compound real options approach prescribing that managers should delay commitment to any particular innovation related decision to preserve a wide range of potential action for as long as possible (Miller & Folta, 2002). For example, once an auto manufacturer decides to develop a new pick-up truck, it becomes very costly to decide to instead produce a new luxury sedan midway through the design process. Hence, in the later stages of development, firms become more certain that they will be able to overcome the technological hurdles required to successfully complete the project (Miller & Folta, 2002; Nelson & Winter, 1977; Roberts & Weitzman, 1981). However, as R&D projects mature, the firm also becomes more exposed to uncertainty or volatility in market conditions. This is because the cost and complexities associated with making significant changes and revisions grow as R&D projects near completion (Miller & Folta, 2002). An unexpected shift in market demand or in the underlying technology could result in immediate, unexpected re-design and development costs - the type of costs for which financial slack is ideal for covering (Greve, 2003; Mishina *et al.*, 2004; Voss *et al.*, 2008).

Hence, the management literature is unclear regarding whether financial slack is more useful at the early or later stages of an R&D project's progression. On one hand, it could help firms overcome to the technological challenges that characterize early stages of R&D by providing funds needed to manage unexpected setbacks and budget shortfalls.

*H3a: Innovation projects that are more mature require less financial slack per dollar of R&D invested to achieve the same probability of successful innovation as innovation projects that are less mature.*

On the other hand, financial slack could be more useful in the later stages of innovation as a safeguard against the increased exposure to changes in market conditions that occurs as R&D projects near completion. Specifically, financial slack may provide the funds needed to respond to changes in consumer demand or technological development that are more costly to respond to during the late stages of R&D.

*H3b: Innovation projects that are more mature require more financial slack per dollar of R&D invested to achieve the same probability of successful innovation as innovation projects that are less mature.*

# CHAPTER 4: EMPIRICAL METHODS

## Sample and Data Collection

I test my hypotheses using R&D and financial panel data from international, publicly-traded biotech firms operating in the U.S from 1993-1999. R&D project-level data consists of the outcome of each drug in development with respect to its regulatory approval testing throughout each stage of FDA clinical testing (phase I, phase II, phase III and market approval phase). These data were obtained from the IMS R&D Lifecycle database. To determine the technological diversity of each firm's patent portfolio I follow Quintana-Garcia and Benavides-Velasco (2008). I utilize the US Patent and Trademark Office (USPTO) CASSIS Database to obtain a yearly posting of the total number and type of patents owned by a sample of US-based biotech firms. I obtain supplementary patent information (the three-digit USPTO classification) from The National Bureau of Economic Research Patent Citations Data File. After combining the three datasets I was left with 761 total observations of the initial 1,225 drugs in development. Additional firm financial data were obtained from COMPUSTAT on the Wharton Research Data Services website (WRDS). After removing observations with missing performance data I was left with 354 total drug observations in the clinical stages of FDA approval.[2]

## Dependent Variable

The dependent variable is coded as a dichotomous variable (pass/fail) with respect to the performance of each biotech drug at each stage of the FDA clinical testing process. The dependent variable is a yearly measure of whether the drug advanced to the next

[2] Many observations were dropped when obtaining performance data from WRDS because the UWM subscription did not go back far enough and I had to utilize a dataset previously downloaded by Dr. Levitas.

stage (coded '1' if the drug advanced to the next stage from 1993-1999, and '0' otherwise). Hence, each drug can have as few as one (fail in phase 1) observation, up to as many as four observations (passes phase 1, phase 2, phase 3, and market approval phase). Hereafter, we will refer to the dependent variable described above as *the probability of advancing.*

**Independent Variables**

***Financial slack-R&D Ratio.*** Prior research indicates that financial slack is a resource that must exist *in excess* of some minimal level of foreseeable need (e.g., Bromiley, 1991; Miller & Leiblein, 1996; Mishina *et al.*, 2004). Working capital available is thought to be an effective measure of available cash and working capital demanded is thought to be an effective measure of the foreseeable need for cash (Bourgeois, 1981). Hence, working capital available minus working capital demanded is a reasonable measure of cash that exists in excess of foreseeable need (Moses, 1992). Following prior research (e.g., Brealey & Myers, 1996; Mishina *et al.,* 2004; Moses, 1992), I calculated financial slack as the difference between working capital available and working capital demanded. I defined working capital available as a firm's current assets and working capital demanded as a firm's current liabilities (Brealey & Myers, 1996; Mishina *et al.,* 2004; Moses, 1992).

However, as investments in a portfolio accumulate, only the proportion of the total investment that must remain idle as a safeguard needs to be reduced for a portfolio effect to occur (see the "Financial slack-R&D ratio" section in Chapter 3 for a more complete discussion of this point). In my study, financial slack represents the amount of the investment that must remain idle, while R&D spending represents the overall scale of a firm's investment in innovation. Because I seek to identify portfolio effects associated with R&D activities, I must determine whether the level of financial slack needed to optimize innovation outcomes is affected by changes in the scale of innovative activity. In measuring this variable, I am not concerned with the degree of efficiency or success associated with firm innovation, but simply the overall scale of R&D activity relative to the level of financial slack. Following prior research (e.g., Barker & Mueller, 2002; Ito & Pucik, 1993), I use total R&D spending as an indication of this scale. I measure the financial slack-R&D ratio as follows:

$$\frac{(Current\ Assets - Current\ Liabilities)}{Total\ R\&D\ Spending}$$

***Number of R&D Projects.*** I follow prior research (*e.g.,* Fontana *et al.,* 2006) and calculated the number of R&D projects as a firm-level variable measured by the total number of drugs in any stage of development (preclinical through market approval phase) that a firm has pending in the FDA approval process at time *t*.

***Technological Diversity.*** Patent applications are an effective measure of the technological competencies that a firm has achieved (Breschi *et al.,* 2003; Verspagen, 1997). Applying for a patent means that the firm has (or is near to) overcoming the technical barriers that restrict competency in the field (Breschi *et al.,* 2003). To determine the degree of technological diversity across the range of a firm's innovative know-how, I follow the procedure initially proposed by Jaffe (1986). Following Quintana-Garcia and Benavides-Velasco (2008), I use the three-digit USPTO classification as the basis for calculating technological diversity. The technological fields in my sample are indexed by USPTO classification such that j=1, …, 50. $N_{ij}$ represents the number of patents that the i[th] firm holds in category $j$, such that $\sum N_{ij} = N_i$. A Herfindahl concentration is then obtained for each firm and year giving a firm-level measure of technological diversity

$$1 - \sum \left(\frac{N_{ij}}{N_i}\right)^2$$

However, contemporary scholars argue that the procedure proposed by Jaffe (1986) may be biased downward for firms with few total patents (e.g., Hall, 2002; Garcia-Vega, 2006). Hall (2002) initially proposed the following variation of the Herfindahl index to adjust for the downward bias on firms with few total patents. Following Hall (2002) and Garcia-Vega (2006), I calculated the variable *technological diversity* thus

$$Technological\ Diversity = \left[1 - \sum \left(\frac{N_{ij}}{N_i}\right)^2\right] \left[\frac{N_i}{N_i - 1}\right]$$

***Project Maturity.*** The independent variable *project maturity* is measured by the progress the drug has achieved in completing FDA approval testing at the time of the observation. Project-level variables are generated indicating three levels of maturity based on the drug's position in the clinical FDA approval process. For example, a drug in phase 1 of development at the time of observation is coded "1" under the phase 1 variable and "0" under all successive project maturity variables. Drugs in phase 1 testing comprise the youngest maturity group and drugs in phase 2 comprise the middle maturity group. Due to a limited number of observations in the latter stages, observations in phases III and in the market approval phase were combined to make up the group of R&D projects nearest to completion. No drugs can be in more than one phase simultaneously. I ran a significance test of the interaction terms (financial slack-R&D ratio and each of the three maturity variables) to determine if there is a significant difference between the coefficients.

**Control Variables**

Because innovation effectiveness is often dependent on the availability of complementary resources (Teece, 1986), I control for several important firm-level characteristics. Past research has suggested that biotech firm size can have a significant effect on FDA approval rates (*e.g.* Olson, 1997). I control for the size of the firm by incorporating the natural log of the book value of *total assets*. Past research also suggests that the agency costs of financial slack are significantly affected by the capital structure of the firm (*e.g.*, Kocchar, 1996). For this, I control for the long-term leverage of the firm by incorporating the *debt-to-equity ratio*; measured as long term debt divided by total shareholders' equity. I incorporated the variable, *total capital expenditure* to control of the firms' investments in future growth. To control for *prior performance* effects I incorporate a one-year lag measure of each firm's market-to-book ratio.

I also included several dummy variables to control for additional firm and project-level effects. Scholars suggest that the probability of successfully advancing can be influenced by the treatment class for which the drug is primarily targeted (e.g., cancer, diabetes). I therefore control for both the treatment class by including 66 project-level dummy variables for each treatment class. I similarly control for firm and year effects with seven dummy variables indicating the year the observation was recorded and 53 dummy variables indicating the firm primarily responsible for developing the drug. Lastly, I include a dummy variable coded "1" if the R&D project was confirmed to be still active at the time of the observation and "0" if the R&D project was reported as being inactive (delayed or abandoned).

**Analysis**

I am interested in the probability of successfully advancing through successive stages of the FDA clinical approval testing process among a sample of biotech drugs as explained by multiple firm-level and project-level predictors. I elected to utilize a multilevel mixed-effects logistic regression model. All analyses were performed using the -xtmelogit- command in Stata version 12.0 (StataCorp, 2007). Advantages of logistic models are that they allow for binomial response variables (e.g., the drug advances to the next stage or it does not). The multilevel mixed-effects logistic regression model also allows for multiple levels of clustering (fixed and random effects) (Stata, 2007), which helps to avoid discarding potentially significant variance (Hofmann, 1997).

**RESULTS**

The 354 observations in my sample represent 158 drugs being developed by 54 firms. Two hundred-twelve successful advances to the next clinical phase in the FDA approval process were observed. Descriptive statistics and correlations for all variables are presented in Table 1. Overall, larger firms (with greater total assets) tended to make higher capital expenditures and also pursued a greater number of R&D projects that were technologically diverse from one another. Larger firms also held a higher ratio of financial slack relative to R&D spending. Model 2 in Table 2 indicates that there is a significant negative relationship between the financial slack-R&D ratio and firm innovation. A likelihood ratio test also shows that the full model is significant ($p > chi^2 = .05$).

Table 1

Descriptive Statistics and Correlation Matrix

| | Variables | Mean | SD | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Prob of Advancing | 0.58 | 2.54 | - | | | | | | | | | | |
| 2. | Prior Performance | 4.00 | 3.08 | -0.09 | - | | | | | | | | | |
| 3. | Debt to Equity | 0.25 | 3.53 | -0.07 | -0.03 | - | | | | | | | | |
| 4. | Firm Size[a] | 8.22 | 0.88 | -0.04 | -0.02 | 0.02 | - | | | | | | | |
| 5. | Capital Expenditures | 61.32 | 117.19 | -0.08 | 0.06 | -0.02 | 0.74* | - | | | | | | |
| 6. | Active Program | 0.55 | 0.5 | -0.17* | 0.02 | 0.07 | 0.04 | 0.05 | - | | | | | |
| 7. | FS/R&D Ratio[b] | 1.99 | 1.71 | -0.15* | -0.01 | 0.02 | 0.13* | -0.09 | 0.02 | - | | | | |
| 8. | Number of Projects | 36.33 | 31.85 | -0.04 | -0.05 | 0.04 | 0.79* | 0.81* | 0.12* | -0.08 | - | | | |
| 9. | Tech Diversity | 0.64 | 0.17 | -0.08 | -0.02 | 0.11* | 0.31* | 0.27* | 0.16* | -0.01 | 0.41* | - | | |
| 10. | FDA Phase 1 | 0.28 | 0.45 | 0.05 | -0.08 | -0.04 | -0.2* | -0.1 | -0.01 | -0.05 | -0.17* | -0.08 | - | |
| 11. | FDA Phase 2 | 0.26 | 0.44 | 0.1 | -0.06 | -0.03 | -0.13* | -0.06 | -0.07 | 0.02 | -0.13 | -0.13* | -0.36* | - |

Note: N= 354; * $p$<.05.

[a] natural log adjustment

[b] multiplied by 100,000

Table 2
Mixed Effects Logistic Analysis Predicting Firm Innovation

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Prior Performance | -0.24† | -0.19 | -0.22† | -0.19 | -0.2 |
| | (0.14) | (0.13) | (0.13) | (0.13) | (0.13) |
| Debt to Equity | -0.23 | -0.22 | -0.23 | -0.23 | -0.22 |
| | (0.15) | (0.15) | (0.16) | (0.16) | (0.16) |
| Firm Size | 0.54 | 0.73 | 0.35 | 0.64 | 0.75 |
| | (0.7) | (0.67) | (0.73) | (0.68) | (0.68) |
| Capital Expenditures | -0.01* | -0.02* | -0.01 | -0.02* | -0.02† |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Active Status | -1.31* | -1.19* | -0.99† | -1.18* | -1.24* |
| | (0.59) | (0.57) | (0.58) | (0.57) | (0.58) |
| FS/R&D Ratio | | -0.48* | -1.09** | 0.17 | -0.24 |
| | | (0.19) | (0.4) | (0.83) | (0.27) |
| Number of Projects | | 0.03 | -0.04 | 0.03 | 0.03 |
| | | (0.02) | (0.04) | (0.02) | (0.02) |
| Tech Diversity | | -0.78 | -0.58 | 1.24 | -0.81 |
| | | (2.08) | (2.17) | (3.31) | (2.09) |
| Phase 1 | | 0.48 | 0.58 | 0.47 | 1.8† |
| | | (0.67) | (0.68) | (0.67) | (1.04) |
| Phase 2 | | 1.04† | 1.09† | 1.0 | 1.46 |
| | | (0.63) | (0.64) | (0.64) | (0.97) |
| FS/R&D Ratio | | | 0.03* | | |
| × Number of Projects | | | (0.02) | | |
| FS/R&D Ratio | | | | -1.02 | |
| × Tech Diversity | | | | (1.28) | |
| FS/R&D Ratio | | | | | -0.72 |
| × Phase 1 | | | | | (0.44) |
| FS/R&D Ratio | | | | | -0.22 |
| × Phase 2 | | | | | (0.16) |
| Constant | -2.63 | -3.68 | 0.44 | -4.39 | -4.34 |
| | (5.59) | (5.44) | (6.07) | (5.52) | (5.58) |
| Drug Class Effects | Included | Included | Included | Included | Included |
| Firm Effects | Included | Included | Included | Included | Included |
| Year Effects | Included | Included | Included | Included | Included |
| Log Likelihood | -177.47 | -171.91* | -169.35* | -171.57 | -170.43 |

NOTE: N=354; †$p<.10$; * $p<.05$; **$p<.01$; ***$p<.001$

Hypotheses 1a and 1b present competing ideas about the relationship between the number of simultaneous R&D projects and the level of financial slack relative to R&D spending needed to optimize the likelihood of advancing through FDA approval. On one hand, firms may experience a portfolio effect that may reduce the proportion of financial slack relative to total R&D spending needed to optimize the probability of advancing. On the other hand, firms may experience a complexity effect that may increase the proportion of financial slack relative to total R&D spending needed to optimize the probability of advancing. Empirical testing suggests that the number of R&D projects has a significant moderating influence. Model 3 in Table 2 indicates that the interaction effect of the number of R&D projects and the financial slack-R&D ratio is significant at a .05 level when all controls are included. A likelihood ratio test shows that the full model is also significant ($p>chi^2 = .02$).

The interaction effect becomes more significant (.004) when controls exhibiting multicollinearity are dropped from the model. Given the high correlation between control variables (capital expenditure, active program, and total assets) and independent variables (financial slack-R&D ratio, total R&D projects and technological diversity) multicollinearity could be problematic. In a robustness check, I re-estimated Table 2 dropping the correlated control variables. Results are nearly identical to those presented in Table 2 (significant terms and shape of the moderated relationship). I also calculated variance inflation factors and no variables had variance inflation factors over five. The main consequence of multicollinearity is to inflate standard error, thereby making hypothesis testing of the collinear variables more difficult. However, dropping one or more of the correlated variables can result in omitted variable bias, particularly if there is a compelling reason to include the variables (Greene, 2003; Kennedy, 2003). For these reasons, all control variables are included in the models reported in Table 2.

In a final robustness check, I re-estimated Table 2 including preclinical observations. Preclinical observations were initially dropped from the model because including them exacerbated the multicollinearity problem. Another problem of including the preclinical observations was that there were relatively few successes (only 4 confirmed advances out of 2,650 observations), making it difficult to consider preclinical observations in project maturity hypotheses. For these reasons, preclinical observations were dropped from the model. However, results of Models 2 and 3 are nearly identical to those presented in Table 2 when preclinical observations are included (significant terms and shape of the moderated relationship). To check for curvilinear effects I also tried running my model with the financial slack-R&D ratio variable squared, cubed, and to the fourth power. My model dropped all exponential measures of the financial slack-R&D ratio because of collinearity with the main effect. This provides no support for the existence of a curvilinear relationship between the financial slack-R&D ratio and the probability of advancing.

Figure 1 plots the relationship predicted in Model 3 in Table 2 for firms with many simultaneous R&D projects versus firms with few R&D projects. I plot the slopes at one standard deviation above and below the mean number of R&D projects for my sample. The slope is plotted such that total R&D projects equals four for firms with few R&D projects, and 68 for firms with many R&D projects. The relationship is consistent at other values of the moderator (*e.g.,* at half of one standard deviation above and below the mean).

Figure 1
Financial slack-R&D ratio and the number of R&D projects

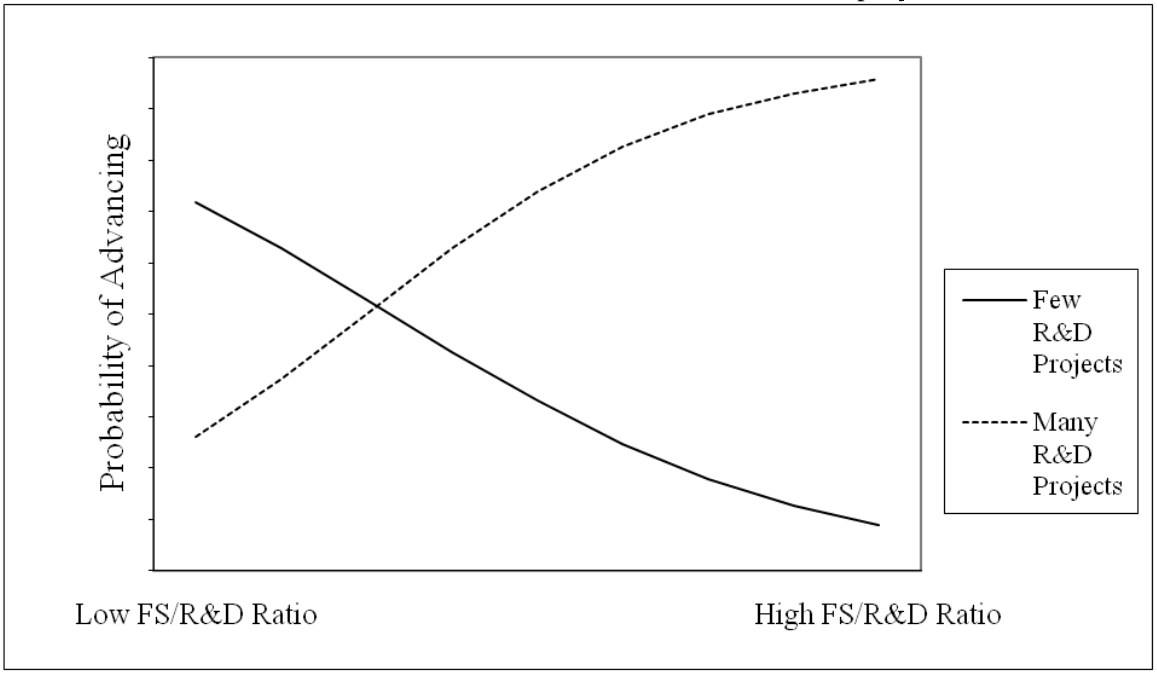


Figure 1 indicates that firms that pursue many R&D projects experience an increased probability of successfully advancing those projects when financial slack increases relative to total R&D spending. These results give support for the complexity view described in Hypothesis 1b that increasing the number of R&D projects results in significant planning and coordination challenges. A primary benefit of financial slack is the ability to cover unexpected costs that are above and beyond foreseeable expenses (Bromiley, 1991; Miller & Leiblein, 1996; Mishina *et al.*, 2004). Hence, the higher the level of financial slack that causes firms to optimize innovation outcomes, the more complex or difficult the underlying innovation is likely to be (Hall, 2002; Vicente-Lorente, 2001). The results conflict with Hypothesis 1a that pursuing multiple simultaneous R&D projects will result in a portfolio effect that decreases the proportion of emergency cash needed to optimize the probability of advancing.

Figure 1 also indicates that firms with few R&D projects experience a significant decrease in the probability of successfully advancing those projects when financial slack increases relative to total R&D spending. This is especially surprising considering the positive relationship observed for firms with many R&D projects. A negative relationship suggests that the agency and opportunity costs of a high financial slack-R&D ratio are elevated when R&D complexity is low (few R&D projects).

The moderating effect associated with the number of R&D projects is consistent with a complexity effect, but inconsistent with a portfolio effect. However, results indicate that the effect of technological diversity is more ambiguous. Hypotheses 2a and 2b also presented competing portfolio and complexity views regarding the moderating influence of technological diversity. As indicated by Model 4 in Table 2, no clear support can be found for either hypothesis 2a or 2b. I found no significant moderating effect of technological diversity on the relationship between the financial slack-R&D ratio and firm innovation.

Lastly, hypotheses 3a and 3b present divergent views about how an R&D project's nearness to completion may affect the financial slack-R&D ratio needed to optimize the probability of advancing. The coefficients of the interaction terms of the financial slack-R&D ratio and the three variables indicating firms' nearness to completion also showed no significant difference ($p>chi^2 = 0.26$). Model 5 in Table 2 summarizes these results which give no clear support for either hypothesis 3a or 3b.

Overall, results suggest that biotech firms do not experience a significant portfolio effect when increasing the number and diversity of innovation projects. However, they may experience a complexity effect which is mainly driven by the number of innovation projects in simultaneous development and not significantly affected by their degree technological divergence from one another. Project maturity does not appear to have a significant effect on the financial slack-R&D ratio needed to optimize innovation outcomes. However, the agency and opportunity costs of a high financial slack-R&D ratio appear to have a negative effect on firm innovation, but only when complexity is low (few R&D projects).

## DISCUSSION AND CONCLUSION

The main goal of this paper is to examine the effect of financial slack on firm innovation. I took a unique approach to operationalizing financial slack by measuring it as a proportion of total R&D spending. In addition to the hypothesis testing described above, there are some interesting points that emerge which may be of interest. The negative relationship between innovation and the financial slack-R&D ratio observed in Figure 1 for firms pursuing few innovation projects suggests that there are significant agency effects associated with a high financial slack-R&D ratio. However, it is unclear if firms that pursue many R&D projects also experience high agency and opportunity costs when they retain a high financial slack-R&D ratio or if these effects are prevented or mitigated by complexity. It could be that significant agency and opportunity costs still accrue for firms with many R&D projects, but the usefulness of financial slack in overcoming complexity effects offsets these costs (the positive effects of financial slack outweigh the negative effects).

Conversely, the complexity associated with pursuing many R&D projects may partially prevent the negative effects of financial slack from occurring (rather than offsetting them). Agency costs of financial slack occur when managers, believing that they are somewhat insulated from the negative consequences of bad decisions, become less inclined to expend the effort needed to make good decisions (Jensen & Meckling, 1976; Kraatz & Zajac, 2001; Williamson, 1964). However, managers with a complex R&D portfolio are likely to view financial slack resources as less of a cushion or safety net if they perceive that those resources will be necessary to successfully innovate. It is possible that this perception of necessity may mitigate the agency influences of financial slack. Hence, it is unclear if the agency effects of a high financial slack-R&D ratio are mitigated (partially prevented) by innovation complexity, or if agency challenges still occur but are offset (outweighed) by the positive effects of financial slack.

Since firm innovation is thought to be closely tied to firm performance (O'Brien, 2003), I also wanted to see if my results were consistent when using performance rather than innovation as a dependent variable. Hence, I also ran a mixed effects linear regression analysis using the same variables listed under Model 3 in Table 2, only I used performance (the market to book ratio) as the outcome variable rather than innovation. The total number of R&D projects in simultaneous development also has a significant moderating effect on the relationship between the financial slack-R&D ratio and firm performance. However, firms with many R&D projects showed a negative relationship between the financial slack-R&D ratio and firm performance (whereas a positive relationship was observed between the financial slack-R&D ratio and the probability of advancing). These findings indicate that for firms with many R&D projects the financial slack-R&D ratio could have a positive effect on firm innovation and a simultaneous negative effect on firm performance. The findings are potentially contrary to prior research suggesting a strong link between firm innovation and firm performance (*e.g.*, O'Brien, 2003).

There are two apparent explanations for how increasing financial slack-R&D ratio may simultaneously improve innovation but harm performance. First, the negative effects of financial slack may affect other areas of the firm besides R&D. For example, the agency effects of holding financial slack may not be as strong in the R&D department which tends to have more unexpected setbacks. R&D managers may view financial slack as more necessary than marketing or production managers who tend to administer more predictable costs. Hence, R&D managers may take more care in their stewardship of cash resources than managers in other departments. However, this explanation is potentially inconsistent with Figure 1 which suggests that a high proportion of financial slack has an immediate negative effect on the probability of advancing for firms with few innovation projects. This suggests that the opportunity and agency costs of a high financial slack-R&D ratio do affect the R&D department.

The second apparent explanation is that the positive influence of financial slack on the progression of R&D may take some time to affect performance, while the agency and opportunity costs of financial slack may have a more immediate influence on firm performance. The latter explanation is intuitively appealing since there is obviously some delay between the stages of successful R&D, commercialization and profit realization. However, further research is needed to identify the exact explanation for the moderating effect of the number of R&D projects.

Further research is also needed to better understand the agency and opportunity costs of financial slack in firms with many R&D projects. Future scholars may want to explore whether pursuing a high number of R&D projects actually mitigates agency effects or simply offsets them. Additionally, scholars interested in exploring the effect of proportional levels of financial slack on other areas of the firm may want to consider employing other ratios that are relevant to their subject area. For example, researchers exploring the effect of financial slack on firm growth may gain useful insights by measuring financial slack relative to total capital expenditures.

This research contributes to a better understanding of the project-level effects of financial slack on firm innovation. The findings have important theoretical and managerial implications since they help distinguish between the positive and negative effects associated with increasing financial slack relative to R&D spending. Findings also suggest that the effects associated with increasing financial slack relative to R&D spending influence firms at the project level (in addition to other potential department-level, firm-level or market-level influences).

Moreover, the results suggest that measuring financial slack as a proportion of total R&D spending may provide unique insights about the relationship between financial slack and firm innovation. As discussed in Chapter 2, managers may have difficulty using the inverse U-shaped perspective to determine the optimal level of financial slack to retain because it suggests holding a level that is average relative to competitor firms. However, financial slack holdings of competitor firms may fluctuate or be kept secret. Moreover, it is unclear how changes in the financial slack levels of competitor firms would affect the relationship between financial slack and innovation within a particular firm. The R&D strategy of the firm itself seems much more likely to impact this relationship. Hence, I suggest that firms should benchmark financial slack against a measure that is sensitive to major changes in innovation strategy (the firm's own R&D spending). More research is needed to identify a ratio of financial slack relative to total R&D spending needed to optimize innovation outcomes. Scholars must replicate similar research in many contexts and must consider many more potential moderating influences before any prescriptions that are useful to managers are likely to emerge. However, this paper provides a useful starting point that future researchers may use to more effectively determine the optimal level of financial slack. These prescriptions may be more useful because they do not require obscure, unavailable, and possibly irrelevant information (the financial slack levels of competitor firms).

The degree to which firms are able to achieve high performance is strongly linked to both the successful management of innovation (O'Brien, 2003) and the successful management of financial slack (Chakravarthy, 1986). Moreover, the strategic dynamics of financial slack are likely to have increasing contemporary relevance given stakeholder concerns about record-high levels of idle corporate cash. For example, the title from a 2013 article on Bloomberg.com warns, "Cash piles up as U.S. CEOs play safe with slow-growth economy" (Burritt, 2013). Given stakeholder concerns and the significant agency and opportunity costs associated with holding high levels of idle cash, research exploring the effects of financial slack is likely to proliferate. This type of scholarship has the potential to be a productive avenue for future researchers, particularly in the innovation context where the importance of financial slack tends to be enhanced.

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